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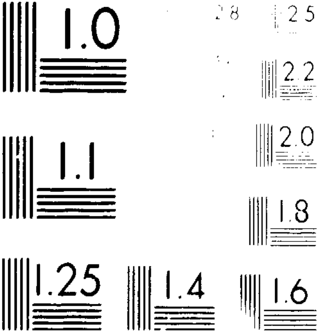
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FINAL REPORT:

CONSULTING SERVICES FOR TURKISH IRON AND STEEL COMPANY, KARABUK WORKS.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNIDO Contract T/81/105/MK

JANUARY 1983

USS UEC

PROJECT 2137

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FINAL REPORT:

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY
KARABUK WORKS

United Nations Industrial Development Organization

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January 1983

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
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SYNOPSIS

The contract provided for UEC to send an eight-man team of qualified steel plant consultants to the Karabuk Works to assist the Karabuk staff in increasing productivity, reducing costs, and improving reporting procedures. Areas of the plant included in the scope of the contract included raw material handling and treating (except coke ovens), blast furnaces and sinter plant, steelmaking, rolling mills, and energy utilization. A unique working plan comprehending three separate missions was utilized; the first mission consisted of a one-week visit to the plant in March of 1982 by the UEC team leader and a UEC home office representative to inspect the plant, to meet with the Karabuk staff to identify specific objectives, and to agree upon the specialties of the consultants to be provided; the second mission consisted of a two-month visit to the plant by the eight-man UEC team in May and June of 1982 to establish a program of goals and changes to be implemented by the Karabuk staff; and, the third mission consisted of a one-month follow-up visit to the plant in September of 1982 by the same eight-man UEC team to review the progress of the Karabuk staff and to finalize the UEC team's recommendations.

The major findings of the UEC team of consultants are:

1. Utilizing existing facility programs now underway and only minor additional facility changes, methods and procedures were developed which should result in increased raw steel production of approximately 99,000 tons per year and operating cost savings of approximately $4.5 million per year.

2) The single most immediate problem in the plant is the reduction in the quantity and heating value of the coke oven gas over the past few years because of deterioration of the facilities and the lack of proper remedial action. The lost heating value of this fuel represents an additional 4 to 6 million dollars per year.

3) Future facility programs to further increase plant production, improve product quality, and reduce costs include installation of hot metal desulfurization facilities, and the addition of oxygen roof

lances at the open hearth furnaces. A balanced plant operation with capacity to produce approximately 812,000 tons of raw steel per year as compared to 558,000 tons in 1981 is anticipated upon completion of these and other currently planned projects.

Specific recommendations for future assistance that will be required by the Karabuk staff are:

A. Immediate inspection of coke plant facilities and establishment of the minimum cost program to regain the full potential energy in the coke oven gas.

B. Training of key Karabuk staff personnel at appropriate steel plants with similar facilities.

C. Follow-up missions to the Karabuk plant by qualified operating and engineering consultants to assist in the implementation of the changes outlined in this report.

Further details on these recommendations are contained in Section 2 - Report Summary.

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1.0 INTRODUCTION

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CONSULTING SERVICES FOR
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1.0 INTRODUCTION

1.1 SUBJECT

This is the final report of the UEC consulting team that provided services for the Karabuk Works of the Turkish Iron and Steel Company as part of UNIDO Project Number DP/TUR/76/038. The work was performed under Contract Number T81/105MK. Previous reports submitted were the First Interim Report dated 29 March 1982 and the Second Interim Report dated 21 July 1982.

1.2 OBJECTIVE

The specific objective of this work was to assist the Karabuk Plant to improve their production output, reduce production costs, improve quality, save energy, and improve financial controls by applying modern procedures and technologies and instructing management in the use thereof.

A further objective was to review the current long range plan for the Karabuk plant and to recommend appropriate changes where required.

1.3 PROCEDURE

There were three visits to the plant site with backstopping and research work in the home office in the intervals between visits to collect information, verify data and prepare reports.

1.3.1 First Visit

The first visit took place 18 March 1982 to 23 March 1982 and was made by the Project Leader and UEC Home Office representative. The purpose of this visit was to determine with Karabuk management:

(A) The specific functions to be carried out by the UEC team and the priorities of the functions.

(B) The tentative schedule for all activities in the project area.

(C) The make-up of the UEC project team and the particular specialists to be provided.

(D) The status of plant facilities, management organization, and operating practices on a preliminary basis.

1.3.2 Second Visit

The second visit took place 26 April 1982 to 30 June 1982 and was made by the Project Leader and seven (7) consultants, each in a particular area of specialty. Activity of the team was in accordance with the specific terms of reference in the contract.

During this visit the consultants worked daily side by side with their counterpart Karabuk Works managers. This provided for on the job training in modern management methods and enabled the Karabuk managers to benefit from the broad technical and practical background of the consultants. Emphasis was placed on identifying areas where improvement could be attained quickly with minimum capital expenditure and the managers were assisted in installing the recommendations as they were made. This method has proven to be much more effective than for the consultant to simply act as an observer and submit a report at the end of his mission.

Each consultant prepared a list of projects on which specific action was recommended to be taken in the interval between the second and third visits. A timetable was established for completing these projects so that the effectiveness of this type of mission and of Karabuk management could be evaluated.

1.3.3 Third Visit

The third visit took place 10 September 1982 to 06 October 1982 and was made by the same team as the second visit.

Progress on the projects left to be completed between the second and third visits was evaluated and reviewed with each of the Managers. Specific action was encouraged where none had previously been taken. Technical literature, test data, drawings and other information collected in the period between visits by the UEC consultants were distributed and discussed with the counterpart managers. In addition, the second Interim Report was thoroughly reviewed with each of the managers.

Further study was made in additional areas as requested by the UNIDO/UNDP Deputy Resident Representative, the Senior Industrial Development Field Advisor and the Steel Company President in the progress review meetings.

1.4 LIAISON

Close contact with the Ankara UNIDO/UNDP Field Office was maintained by copy of seven (7) intermediate progress reports which were prepared and sent to the Steel Company President. These reports also served to highlight critical areas where action was required at the General Directorate level. (See Appendix 1).

Progress meetings were held regularly with the Resident Representatives of UNIDO/UNDP and of the Turkish Steel Company executive staff (see Appendix 2).

1.5 METHOD OF PRESENTATION

The main body of the final report is presented in separate sections, one for each UEC consultant. This will permit each section to be translated into Turkish and used by each counterpart Karabuk Department Manager in implementing the UEC recommendations within his own department.

1.6 ACKNOWLEDGEMENTS

This report was prepared by a team of consultants led by Mr. William H. Kirwan. Authors of the individual sections are:

AUTHOR	AREA	SECTION
George A. Frye	Sinter Plant and Raw Materials	3
Thomas E. Gleason	Blast Furnaces	4
Elroy H. West	Steel Producing	5
Charles P. Showalter	Rolling Mill Division	6
Robert A. Shannon	Power & Fuel	7
William F. Wenger	Accounting & Cost	8
George W. Dempsey	Organization Review	9
William H. Kirwan	General Management	10

The authors wish to express their appreciation for the cooperation and assistance given by the Managers of the Karabuk Works and the General Directorate of the Turkish Iron and Steel Works. Special thanks go to the Department Managers who worked daily with the Consultants and to those who compiled information, participated in meetings, provided drawings and charts, and acted as interpreters.

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2.0 SUMMARY

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CONSULTING SERVICES FOR
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2.0 SUMMARY

The UEC/USS team analyzed the operating and service area at the Karabuk Works that were designated in the specific terms of reference in the contract. This report contains detailed recommendations that fall into two categories plus a special recommendation for immediate assistance at the coke plant:

A. Short-term projects; and

B. Intermediate-term projects.

2.1 SHORT TERM PROJECTS

Due to severe financial and foreign currency restrictions, emphasis has been placed on the short-term (0 to 2 years) projects which require either simple practice changes or minimal capital expenditure to attain the benefits quickly. Many of the recommended projects have already been installed. The procedure used in this mission, as described in Section 1.3, has proven to be very effective and should be considered by UNIDO for use in follow-up consulting work at Karabuk and at other locations. In the period between the second and third visits Karabuk management took action on over 50% of the short-term programs developed for them.

Over 4.5 million dollars in savings will be realized, raw steel production will be increased 99,000 tons, and management's financial and operating control will be greatly improved when the short-term (0-2 years) programs are fully implemented. The primary short-term projects are listed in Table 1.

2.2 INTERMEDIATE TERM PROJECTS

The present modernization program was evaluated and some modifications are recommended. These modifications and other new projects are listed in Table 1. Completion of these listed projects should result in a balanced plant operation capable of producing 812,000 tons of raw steel per year which is 254,000 tons over the 1981 base production and 155,000 tons over the anticipated 99,000 ton improvement expected on completion of the short-term projects.

2.3 COKE PLANT

Although the coke plant was excluded from the scope of work in this contract, it has become apparent to the UEC team that unchecked deterioration of the coke ovens and particularly the oven door seals has resulted in the decision to lower the oven pressure and reduce oven door leakage and external fires. This practice allows excessive amounts of air to leak into the ovens through the door seals and oven wall cracks and has very serious and detrimental effects including:

A. Burning of a substantial portion of the coke oven gas in the ovens and gas mains reducing the quantity and heating value of the gas going to the steel plant (as a fuel).

B. Excessive oven wall temperatures resulting in spalling of the oven brickwork.

C. Burning of a portion of the incandescent coke in the ovens increases the ash content of the remaining coke.

D. Oxygen in the gas mains can create potentially explosive conditions.

Rough calculations indicate that the dollar value of the lost coke oven gas heating value is in the neighborhood of $4,000,000 to $6,000,000 per year.

Immediate assistance is strongly recommended to establish the lowest cost repair and rehabilitation program to reduce this very important fuel loss.

2.4 SUMMARY OF MAJOR FINDINGS

The following three tables summarize the major findings of the UEC team. Table 1 lists the major individual recommendations along with the anticipated benefits, current status and recommended further action. Complete details are given in the main body of the Report, Sections 3 through 10. Table 2 lists the follow-up assistance in priority order as recommended by the UEC team. Table 3 lists those recommendations on which action had been taken prior to the final review meetings and details the benefits obtained as of that date.

TABLE 1

SUMMARY OF UEC RECOMMENDATIONS, ANTICIPATED BENEFITS, AND ACTIONS REQUIRED

RECOMMENDATIONS	ANTICIPATED BENEFITS	STATUS AND ACTION REQUIRED
1. IMMEDIATE		
A. Initiate coke oven repair and rehabilitation program, beginning with correcting oven door leaks.	$4 to $6 million per year savings by increasing quantity and heating value of coke oven gas. Elimination of potential explosion hazard.	Karabuk needs immediate, expert assistance to inspect all coke oven equipment and develop a minimal-cost repair program: 2 men for 1 month.
2. SHORT-TERM		
A. Utilize existing coke crusher.	Reduce blast furnace coke rate by 15 kg/ton hot metal. Increase hot metal production by 3.7%.	Coke crusher placed in operation August 19, 1982. Sizing improved by end of September, but there was still too much +60 mm material. Crusher should be adjusted.
B. Begin production of superfluxed sinter.	Increased sinter strength and lower FeO, resulting in 19% increase in hot metal production and 153 kg/ton hot metal reduction in blast furnace coke rate.	Hazemag representative is needed to assist in starting new limestone crushing equipment.
C. Reduce coke ash by increased washing at mine.	Hot metal production will increase by 2.7% and coke rate will decrease by 2% for each 1% decrease in ash.	As a minimum the coal producing company should be required to maintain a maximum coke ash content of 21.4% which was the actual in 1981.
D. Complete work on open hearth program for scrap handling.	This project is necessary to permit the increase in ingot production from 558,500 to 657,000 tons per year.	Building reinforcement to allow 2-crane operation is in progress and should be finished by October 31, 1982. Design of scrap burning layout should be finished in November 1982. Improved scrap burning equipment should be purchased based on recommendations of a manufacturer such as Union Carbide.
E. Reduce ingot transit time.	$294,000 annual savings by eliminating 15-minute hold time on semi-killed heats. $406,000 annual savings by 30-minute reduction in transit time from closer supervision.	The hold time has been eliminated and the pouring sequence changed to give a 15-minute reduction. Better cooperation between Steel Producing, Rolling Mill, and Transportation supervision is needed for further improvement.
F. Change 34"-28" maintenance schedule.	$567,600 annual savings by reducing energy requirements for reheating cold steel.	Cooperation of the Operating and the Maintenance Departments to change their schedules is required.
G. Install mold preparation line and utilize 6 drags of ingot buggies (to reduce mold temperature).	Improved ingot quality. $938,000 annual savings from increased mold life (10 kg/ingot ton improvement).	This is a budget item for 1983. Work to be done: a. Install mold preparation tables. b. Design and install mold sprays. c. Obtain additional ingot buggies and molds.

RECOMMENDATIONS	ANTICIPATED BENEFITS	STATUS AND ACTION REQUIRED
2. SHORT-TERM (continued)		
H. Increase blast furnace hot blast temperature to 800 - 850°C.	A 1.1% increase in production and 7 kg/ton hot metal reduction in coke rate. Hot metal quality control will improve.	The present plan to increase the hot blast temperature to 1100°C should be revised to attain 800-850°C. In the foreseeable future, 1100 C will not be required. A comprehensive study by a qualified consultant is recommended.
I. Complete ore crushing and screening facilities.	A 7.5% increase in production rate and a 22 kg/ton metal reduction in coke rate.	All major items of material are on hand and completion of this project is scheduled for late 1983.
J. Train fuel engineers for all operating departments.	Energy savings through better utilization of fuels.	UEC 6-week energy course (or equivalent) to be given to selected personnel who will act as departmental fuel engineers.
K. Utilize existing natural-draft cooling tower.	Reduction of plugging and burning of cooling jackets and heat exchangers caused by solids in the river water. Blast furnace refractory life will be extended.	Karabuk management must be convinced that better quality cooling water is beneficial and take the following action: a. Inspect and repair valves, pumps, etc. b. Obtain start-up instructions from a cooling water consultant. c. Obtain advice from a water treatment company to establish a treatment program for the clarifier.
L. Recover mill scale for sinter plant use.	One-time benefit of $1.1 million from stockpile. Recurring annual benefit of $250,000.	Contract for screening of scale has been let. Work scheduled to start in October 1982.
M. Screen waste pile of limestone at the mine to recover 5 x 15 mm material for use in the sinter plant.	It is estimated that 50,000 tons can be recovered with a net value of $425,000. Will improve supply of limestone to the sinter plant and will require less crushing.	A screening contract similar to that arranged for mill scale should be negotiated.
N. Improve production and cost reporting.	Improved management control through prompt problem identification, followed by timely corrective action as required. Major benefit is stronger operating management control, maximizing steel production and quality.	Reporting practices have been improved but must be supported by controlled closing schedules. A summary monthly financial report has been developed and is available in 20 days, compared to 45 to 60 days previous to the UEC mission.
O. Revised accounting program.	Accurate and timely statistics reflecting operations/problems requiring management action.	May require on site consultants to overcome inertia at plant level and to get the program started.
P. Institute a weekly General Superintendent's staff meeting.	Improve cooperation between departments. Upgraded communications to managers will aid in the attainment of plant goals.	Implementation of this recommendation requires only the decision by the plant superintendent to hold a weekly meeting.

RECOMMENDATIONS	ANTICIPATED BENEFITS	STATUS AND ACTION REQUIRED
2. SHORT-TERM (continued)		
Q. Obtain expert assistance for new IBM computer.	Optimum results from new computer will give timely accounting reports with fewer man-hours, providing management with better tools for operations control.	A new computer is to be received in 1983. To obtain the maximum benefits, the services of a qualified consulting firm experienced in computer applications in integrated steel plants will be required.
R. Revise operating and staff organizations.	Optimization of management effectiveness at every level.	Needs decision by top management to proceed. May require services of consultants to write responsibility descriptions.
3. INTERMEDIATE-TERM PROGRAMS		
A. Maximize use of coal on boilers.	This is necessary to release coke oven gas for use in rolling mills and sinter plant.	Coal firing causes superheater tube failures and engineering assistance in modifying the superheater is needed.
B. Establish utilities distribution center.	Eliminate bleeding of blast furnace and coke oven gases. Reduce cost of electrical power by 15%. Eliminate most of the 1,700 hours of heat delays in the rolling mills each year. Estimated annual savings: $4,800,000.	Karabuk management will require the following technical assistance: a. An energy survey by a qualified consulting firm. b. Design assistance for instrumentation and control. c. Assistance in writing procedures and training dispatchers.
C. Replace oil with coke oven gas at soaking pits.	A net savings of $1,834,000, resulting from: a. Increased rolling mill production of 135,500 tons per year. b. Reduced pit bottom cleaning: $62,300 per year. c. Reduced refractory usage.	To make gas available, projects relating to coke oven door repair, use of coal on boilers, and utilities distribution, must be implemented. The installation of oil/tar burners on the open hearth furnaces would also made additional gas available.
D. Improve continuous mill and abandon 12" mill.	Eliminate total annual cost of approximately $1.5 million on 12" mill.	The 12" mill is a low-volume and inefficient operation. It should be abandoned and its product rolled on the continuous mill. To obtain adequate heating time in the continuous mill furnace, it will be necessary to convert it to oil-firing.

RECOMMENDATIONS	ANTICIPATED BENEFITS	STATUS AND ACTION REQUIRED
3. INTERMEDIATE-TERM PROGRAMS (continued)		
E. Supply mixed gas to sinter plant ignition furnaces.	Improved sinter strength. Reduced coke consumption. Reduced FeO in sinter.	Gas must be made available through implementation of recommendations for repairing coke oven doors, using coal in the boiler house, and establishing a utilities distribution center. Technical assistance may be needed in the design of the mixing station for coke oven and blast furnace gas.
F. Install hot metal desulfurization facilities.	$600,000 annual operating cost savings through a 45-minute reduction in heat time. Significant quality improvement, making product suitable for export. Will permit lower slag basicity and volume, and reduced coke rate at the blast furnace.	Hot metal sulfur cannot be reduced to an acceptable level at the blast furnaces, and the following action is required to install external desulfurization. a. Obtain the services of an engineering consultant to assist the Karabuk staff in performing basic engineering and preparation of a detailed specification for required equipment. b. Contract for supply of equipment and installation supervision. c. Develop a source of carbide. d. Provide a training program for engineers and operators.
G. Install open hearth roof oxygen lances and 100 T/day oxygen plant.	Reduction in heat time from 10 hours to 7 hours tap-to-tap. Reduce operating costs other than fuel by $1 per ton, or $500,000 per year. Reduce fuel costs by $3,747,500 per year. This is partially off-set by the cost of oxygen. This facility is necessary to convert additional hot metal projected in Improvement Plan.	Technical assistance needed to: a. Furnish design, including oxygen plant and distribution and cooling water systems. b. Supply qualified construction supervision. c. Train personnel and give assistance in converting the process to oxygen. d. Establish practices for most effective energy usage.

RECOMMENDATIONS	ANTICIPATED BENEFITS
3. INTERMEDIATE-TERM PROGRAMS (continued)	
H. Improve quality and quantity of limestone and dolomite.	Reduce heat time by 15 minutes each for improved limestone and dolomite, for a $400,000 annual savings. Reduce number of blast furnace delays caused by inadequate supply of limestone. Possible additional revenue from sale of limestone to Eregli.
I. Reduce open hearth rebuild time.	Increase annual ingot production by 37,800 tons.
J. Mechanical cleaning of soaking pit bottoms.	Labor savings of $538,000 per year.
K. Institute new quality control program.	Produce better product for domestic use and make the export of finished products feasible.

STATUS AND ACTION REQUIRED
Karabuk should have expert assistance to: a. Obtain tests and evaluate the new Balikisic dolomite mine to establish a mining plan. b. Solve the mining and delivery problems from the limestone plant. Additional mining equipment is needed.
The plan offered by UEC for keeping limestone segregated by size has been put into effect at the mine with good results. Constant managerial attention is required to keep it in effect.
Karabuk management should take the following action: a. The Karabuk masonry superintendent should visit a modern open hearth shop such as U.S. Steel's Geneva Works. b. A masonry expert from a modern, operating open hearth plant should spend approximately 3 months in Karabuk conducting a rebuilding program.
An outside purchase of mechanical cleaning equipment is required. Bids have been submitted to Karabuk management.
The quality control program recommended under UNIDO Contract No. 76/26, Project DP/TUR/72/5, should be implemented, with modifications as detailed in Section 10 of this UEC repc .. The assistance of a metallurgical expert experienced in process control (field control) should be ol ta.ned for 6 months.

SUMMARY OF RECOMMENDATIONS FOR ADDITIONAL TRAINING AND ASSISTANCE

AREA	DESCRIPTION OF TRAINING OR ASSISTANCE	NUMBER OF ADVISORS AND ESTIMATED DURATION OF PROJECT
1. Coke Ovens	Inspect coke ovens and develop a minimal cost repair program	2 consultants to visit Karabuk for one month
2. All Operating Departments	Fuel engineer training	6 week energy course to be given at Karabuk
3. Forced draft cooling tower	Technical assistance from cooling tower consultant	1 consultant for 1 month (possibly in separate visits)
4. New IBM computer	Technical assistance	1 consultant for four months to determine most efficient utilization of new equipment. (Further programming assistance may be required with purchase of new programs).
5. Boiler House	Design assistance to modify superheater section of boilers to convert to coal firing.	1 consultant - 2 months
6. Steelmaking	a. Design of desulfurization and oxygen systems. b. Masonry Department training in open hearth furnace rebuild procedures.	Six man months of consulting engineering to assist plant engineers in performing basic engineering and preparing specification. Karabuk masonry superintendent - 1 month training in modern open hearth shop. 1 consultant - 3 months at Karabuk.
7. Blast Furnaces	Develop a plan for increasing hot blast temperature to 800-850°C in lieu of 1100°C program now contemplated.	4 consultants - 3 months

AREA	DESCRIPTION OF TRAINING OR ASSISTANCE	NUMBER OF ADVISORS AND ESTIMATED DURATION OF PROJECT
8. Limestone and Dolomite Mines	Technical assistance to inspect and develop a mining plan at Balikisic dolomite mine and to upgrade operations at the limestone mine.	1 consultant - 2 months
9. Raw materials - blending yard	Expert assistance in setting stacking and reclaiming parameters, establishing testing and quality control procedures and assisting in start-up of blending yard equipment.	2 consultants - 2 months
10. General Plant		
a. Quality Control	Metallurgical expert to assist in installing the quality control program.	1 consultant - 6 months
b. English Language	Technical English training for management and engineers.	1 English language instructor
c. Modern Management Methods	A program to train employees of Karabuk to act as conference leaders. These people will then give a 96 hour course in Turkish to all management employees.	One month is needed to train conference leaders.
d. Computer	Basic computer functions for management.	Requires an instructor for 2 months to teach all involved employees.

TABLE 2

AREA	DESCRIPTION OF TRAINING OR ASSISTANCE	NUMBER OF ADVISORS AND ESTIMATED DURATION OF PROJECT
10. General Plant (Continued)		
e. Safety	Fundamentals of an effective safety program.	A concentrated course, two weeks in length, requiring an instructor for approximately 4 months. Should be followed by a consultant to analyze Karabuk operations and recommend an expanded safety department and its accompanying responsibilities.
f. Accounting, Personnel Services, Industrial Engineers and Engineers	a. Statistical Analysis b. Use of computer terminals c. Computers for Engineers	University extension courses to be conducted at plant site.

SUMMARY OF RECOMMENDATIONS WHICH HAVE BEEN ADOPTED BY KARABUK WORKS

RECOMMENDATIONS	BENEFITS
1. SINTER PLANT	
A. Revise maintenance schedule.	Machine availability increased 3.5%.
B. Improve raw material size.	Improved coke size reduced FeO in sinter by 3%. Use of 2 ore crushers has increased sinter strength.
C. Install weigh belt feeders on sinter mix bins.	Improved sinter chemistry control.
D. Install new ignition furnace.	Improved sinter strength.
E. Use roll scale in sinter mix.	One-time benefits of $1.14 million and continuing annual savings of $0.245 million.
2. BLAST FURNACES	
A. Operate coke crusher.	3.5% increase in hot metal production. 1.5% reduction in coke rate.
B. Reduce coke ash.	Reduced slag volume.
C. Remove gangue material from limestone.	Reduced slag volume.
D. Improve limestone particle size.	Increased production of hot metal.
E. Change filling sequence on No. 3 blast furnace.	Increased useful life of the bells.
3. STEEL PRODUCING	
A. Reinforce scrap preparation building.	Increased steel production by permitting 2-crane operation.
B. Mold spray design is in progress.	Improved mold life.
C. Change pouring sequence.	Reduced transit time.
D. Run trial heats with addition of burnt lime.	Lower sulfur content in hot metal.
E. Reduce air infiltration to furnaces.	Reduced heat time, lower fuel consumption.
F. Reduce fuel consumption by observing heat profile.	Lower fuel costs.
G. Assign engineer to study methods for improving door life.	Decreased air leakage and maintenance costs.
H. Work is in progress on modifying furnace roof and reducing rebuild time.	Reduced maintenance costs, greater furnace availability.

RECOMMENDATIONS	BENEFITS
4. ROLLING MILLS	
A. Assign an engineer to be solely responsible for soaking pits.	Increased production through better pit operation.
B. Eliminate hold time on all semi-killed heats.	Lower transit time, improved quality, reduced fuel consumption, and increased soaking pit production.
C. Develop and install new transit time report.	Will identify cause of transit delays and allow corrective action to be taken.
5. POWER AND FUEL	
A. A trial was made using additional mixed gas on one soaking pit.	Increased refractory life and soaking pit utilization through elimination of fuel oil.
B. Soaking pit damper repair is in progress.	Increased production from better control of pit pressure and higher preheated air temperature.
6. ACCOUNTING AND COST	
A. Prepared special report to the President displaying prior months' production, sales, and selected costs by the 20th of each month.	Provides top management with information needed to take quick action to change undesirable trends.

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SINTER PLANT

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3.0 SINTER PLANT

3.1 SUMMARY

The most important recommendations for improvement of the sinter plant and raw materials operations, along with attendant benefits, are outlined below. The report contains a detailed plan of activity required by plant personnel to achieve the desired results.

3.1.1 Addition of Flux at Sinter Plant

Add flux at the sinter plant instead of at the blast furnace.

Benefits:

(A) Increased sinter strength.
(B) Reduced coke rate in sinter plant and blast furnace.
(C) Lower FeO content of sinter.

Work to be done:

(A) Start limestone crushing equipment.

3.1.2 Increase Sinter Production

Increase sinter production to 870,000 tons per year.

Benefits:

(A) Reduced sulfur in hot metal.
(B) Increased hot metal production.
(C) Reduced coke rate at blast furnaces.

Work to be done:

(A) Reduce down-time through improved maintenance scheduling and practices.
(B) Upgrade No. 2 sinter machine.
(C) Replace No. 1 sinter machine.

Work to be done:

(A) Modernize equipment in the mine.

(B) Add crews or extend turns to build up a stockpile of crushed and screened material.

(C) Require the hauling contractor to do an acceptable job or replace him.

(D) Set up a portable screen for recovering the 5 x 15 mm limestone from the dump for use in the sinter plant.

3.2 SINTER PLANT PRACTICES AND RECOMMENDATIONS FOR IMPROVEMENT

3.2.1 Production of Fluxed Sinter

Acid sinter was being produced with an average basicity of 0.15 to 0.20. This provides little advantage to the blast furnace.

Short-term recommendations: Increase sinter basicity with the aim of putting 90% of the blast furnace limestone requirements into the sinter. This will result in a reduction in coke rates in both the sinter plant and blast furnaces.

Status at end of project: Fluxed sinter is not being produced because of delay in start-up of the limestone crushing facilities. The problem involves the arrival of a manufacturer's technician to supervise start-up and should be resolved in October 1982.

3.2.2 Sinter Production

The sinter plant is not producing enough sinter for present or future hot metal production.

The plant consists of 2 sinter strands. No. 1 machine, built in 1937, is 2 m wide, with a process area of 34 m^2. It has no cooler, and the product is conveyed directly to the hot sinter bunker at the blast furnace. When this bunker is full, the sinter machine must be stopped.

No. 2 machine is of a later vintage than No. 1 machine, and includes a rotary cooler. It is also 2 m wide, but its process area is 60 m^2.

<u>Long-range recommendations</u>: From projects under way and being planned, the hot metal production is expected to increase to 834,000 tons per year. If the improvements proposed in the second interim report are put into effect, the annual sinter production is forecast as:

No. 1 Machine	-	180,000 Tons
No. 2 Machine	-	450,000 Tons
TOTAL		630,000 Tons

This will supply only 36% of the blast furnace iron requirements, and to provide the advantages of sinter to the blast furnaces, steps should be taken to increase its production. The following alternates should be considered:

<u>Alternate A: Upgrade present machines</u>. Because of its age and serious design deficiencies, it is not economically advisable to make large-scale improvements to No. 1 machine. No. 2 machine, however, has the potential of continued operations, and changes should be made to increase its capacity and improve its performance.

By removing the hot fines screens, the machine length can be increased by at least 5 m. With additional suction and a process area of 70 m^2, a production rate of 30 tons/m^2/day can reasonably be expected.

30 x 70 x 365 x .9 = 690,000 tons per year.

Total sinter capacity:

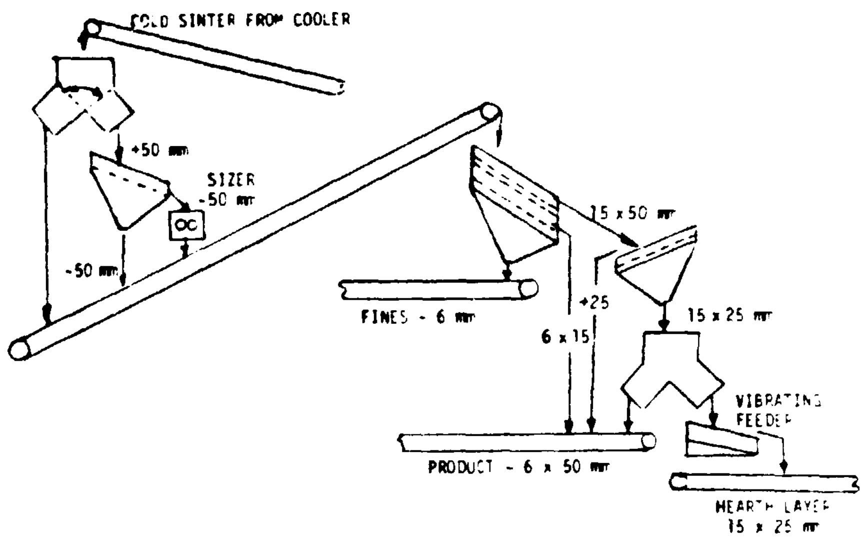
No. 1	-	180,000 tons per year
No. 2	-	690,000 tons per year
TOTAL	-	870,000 tons per year

If the process length is increased and the improvements detailed below are made to No. 2 machine, the replacement of No. 1 machine may be deferred until it is justified by future increases in hot metal production.

(1) Install a scalping screen and sizer to produce a top size of 50 to 60 mm.

Figure 3.1 shows the proposed arrangements. Limiting the top size improves burden distribution in the blast furnace, helps to reduce segregation in the stockhouse bins, and is indispensable to stable blast furnace operation.

Figure 3.1
PROPOSED SCREENING ARRANGEMENT FOR COOLED SINTER



(2) Install separate roll feeder drive and cleaner. Remove rods used to loosen bed.

The rods installed after the strike-off plate are used to improve bed permeability but have a serious effect on sinter strength by causing non-uniform horizontal burn-through. Bed permeability could be improved without this effect by installation of a separate variable-speed drive on the roll feeder. Figures 3.2 and 3.3 illustrate methods for controlling roll feeder speed based on compression height of 30 to 50 mm behind the strike-off plate. Note also that the preferred angle of the strike-off plate is 45° to 55°.

Immediate improvements can be made by replacing the badly worn drive sprockets and chain on the roll feeder. This will permit early removal of the rods used to loosen the bed. Their removal should be effected as soon as possible.

Figure 3.2

BED DEPTH DETECTION AND CONTROLLING EQUIPMENT

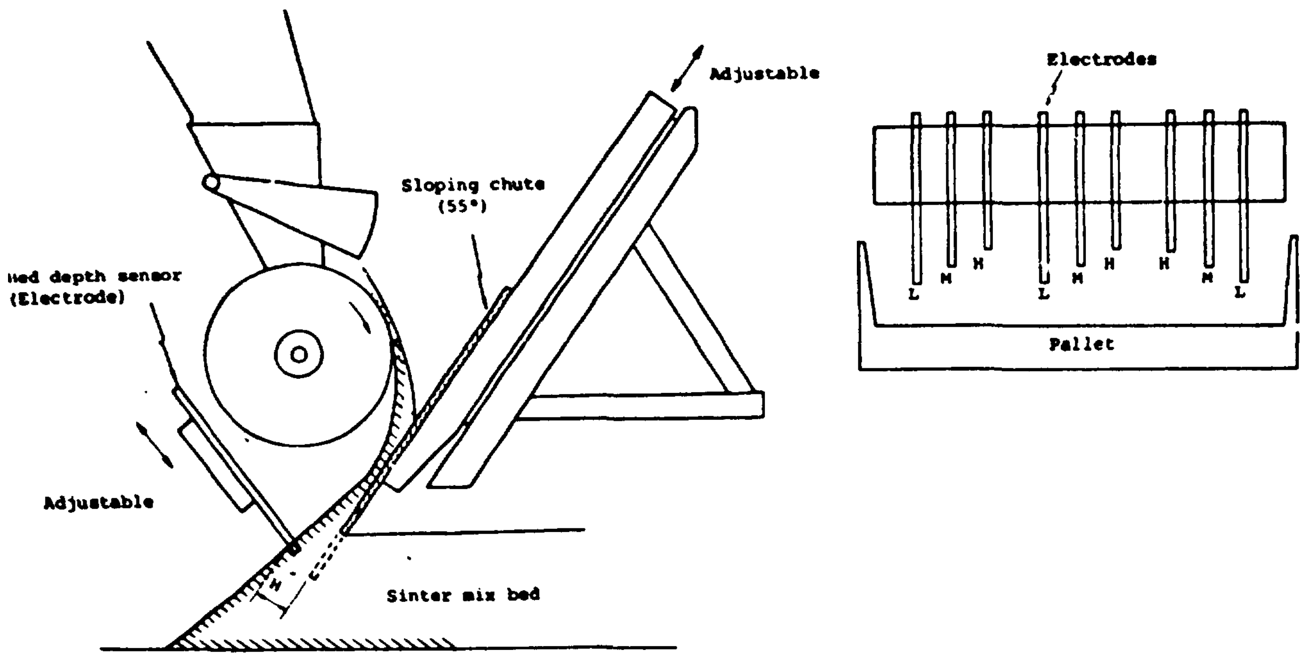
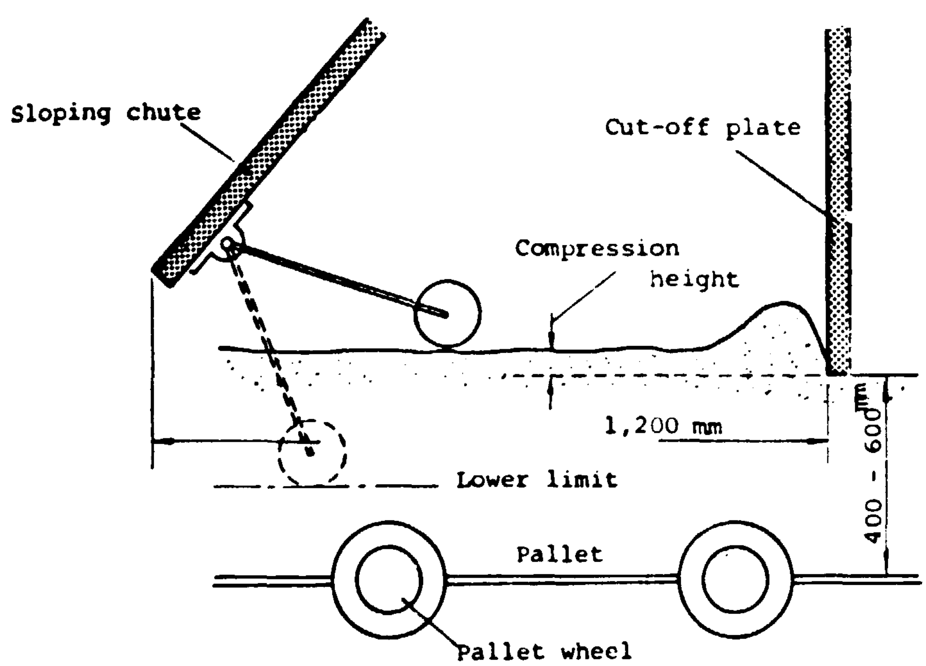


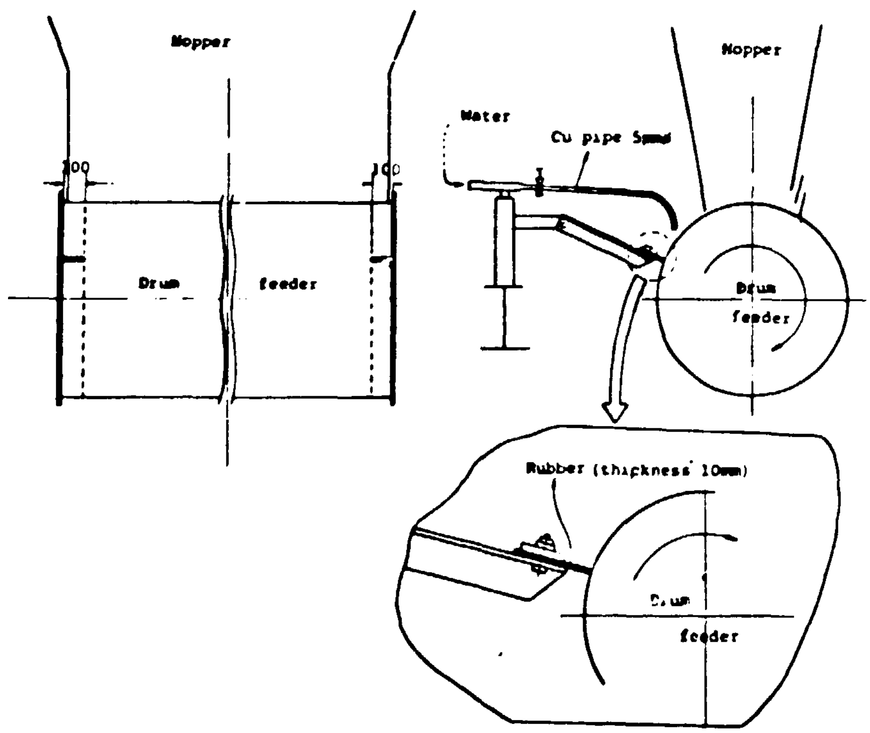
Figure 3.3

BED DEPTH DETECTING
AND CONTROLLING EQUIPMENT



A decrease in bed height along the sides of the pallet is caused by material build-up at the sides of the roll feeder. This results in air leakage, reduced production, and increased power consumption by the I.D. fan. A cleaner to prevent build-up is shown in Figure 3.4.

Figure 3.4



(3) Replace pallets.

If No. 2 sinter machine is expected to continue producing economical quantities of sinter, the pallets will have to be replaced or modified to provide an effective seal. It is believed that with some additional engineering a spring-loaded seal similar to that shown in Appendix 3.2 could be installed.

(4) Reduce conveyor maintenance requirements.

Conveyor maintenance and clean-up time will be reduced if the bed plates (that is, the plates between the carrying and return sections of the conveyor) are removed from conveyors carrying fine material. This can be accomplished by replacing worn tail pulleys with the self-cleaning type shown in Appendix 3.3. The plates can then be removed, eliminating build-up under the idlers and dangerous cleaning operations. Material which spills to the underside of the conveyor will be discharged at the tail pulley, thereby simplifying clean-up.

(5) Waste gas dedusting.

Expenditures in this area may be justified on the basis of reduced fan wear. An electrostatic precipitator is highly recommended but may be difficult to install because of space limitations. A more efficient mechanical separator should be considered. Another possibility would be to install a second waste gas collector main the same diameter as the existing one and to connect alternate windboxes into it. This would reduce the gas velocity to the point where a large amount of entrained particles would fall out and be removed through hoppers and double dump valves installed at the bottom of the duct. An added benefit would be that the mechanical separators on the individual windboxes would no longer be required, thereby eliminating a source of high maintenance and air leakage.

Alternate B: Replace No. 1 Sinter Machine. A 90 m^2 machine with 90% availability should produce about 890,000 tons per year, or slightly more than the combined output of the present machines after improvements are made. Major design considerations for a new machine are set forth in Section 3.4.1.

3.2.3 Instrumentation

The instrumentation is inadequate for effective process control. There are practically no instruments on No. 1 machine, and additional controls are needed on No. 2. Coke is the only raw material weighed. There are no scales for return fines or sinter product.

Short-term recommendation: Install weigh belt feeders on sinter mix bins to improve process control.

Status at end of project: The feeders have been installed and are operating in manual mode, providing a much more uniform raw material feed. Further benefits will be attained when the circuit to the control room -- permitting remote settings -- is completed.

Long-range recommendations: In order to obtain maximum production and quality, the control system should consist of the following as a minimum:

(1) Automatic temperature control for ignition furnace. Higher ignition temperature raises the combustion temperature in the upper bed sections and widens the high temperature zone, thus increasing the product yield. On the other hand, it retards coke combustion and lowers the flame front speed and bed permeability. Once optimum temperature is determined, it should be automatically maintained.

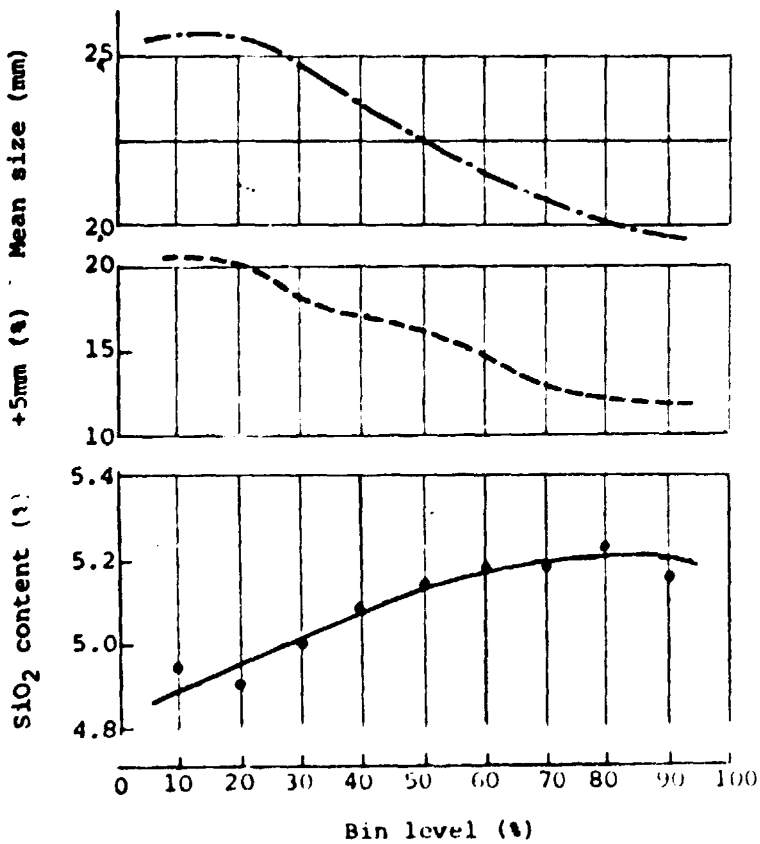
(2) Accurate indication of windbox temperatures and vacuums. Burn-through should occur at a point 90% to 95% of the machine length, and a sufficient number of thermocouples must be installed to accurately determine the point of maximum temperature. Vacuum gauges are necessary to indicate changes in bed permeability which require corrective action. Control of the vacuum under the ignition hood at approximately 2 mm wg is essential for good ignition.

(3) Fines level control. The return bin should be mounted on load cells or suitable probes should be installed to facilitate adjustment of the discharge feeder to maintain a nearly constant level. This will avoid sudden and large changes in the return fines rate, which upset the sintering process.

(4) Roll feeder hopper level. As the level of a storage bin falls, coarse particles surge out and the mean particle size increases. This segregation and the resultant change in size and chemistry can be minimized by maintaining a reasonably constant bin level. The effect of bin level on blended ore characteristics is shown in Figure 3.5.

Figure 3.5

EFFECT OF BIN LEVEL ON BLENDED ORE PROPERTIES



Probes which indicate the level should be installed in the hopper so that the operator can make appropriate adjustments in feed rate.

(5) Scales.

(A) Sinter product: for cost and productivity control.

(B) Total ore: for use in controlling coke and flux proportions.

(C) All raw material bins: to control percentage of each material in mix.

(6) Moisture Control. Moisture should be automatically controlled as a pre-set percentage of total ore. Some success has been achieved with neutron-absorption type meters, but automatic moisture detectors are generally not reliable and it is recommended that moisture determinations be made manually.

(6) Protective Devices.

(A) Sensing elements should be installed on all large motors and fans which will sound an alarm or shut down the equipment if excessive temperature or vibration develops.

(b) Zero speed switches should be located on all process equipment in the material flow system and wired so that when a unit stops all equipment ahead of it also stops.

3.2.4 Testing Practices

Sinter and raw material testing is inadequate to provide acceptable control of chemistry. Samples are taken once per shift, with a complete analysis run once per day. Shatter index is used to determine sinter strength. There are no moisture or reducibility tests. Sinter chemical analyses are taken twice per day.

Long-range recommendations: In order to provide adequate control information to the sinter plant and blast furnace operators, tests should be taken as shown in Table 3.1.

Table 3.1

MATERIAL	SAMPLING FREQUENCY	ANALYSIS ITEM	ANALYSIS FREQUENCY
Sinter	1 per 2 hours	Chemistry	1 per 4 hours
		Size	1 per 2 hours
		RDI	1 per 2 days
		SI	1 per 2 hours
Crushed Coke	1 per shift	Size Moisture	1 per shift
Limestone Dolomite	1 per day	Size	1 per day
		Chemistry	1 per month
Sinter Mix	2 per shift	Moisture	2 per shift
Blended Ore	1 per day	Chemistry	1 per day
Ore Fines	1 per day	Chemistry	1 per month
		Size	1 per 10 days
Scale	1 per day	Oil	1 per 5 days

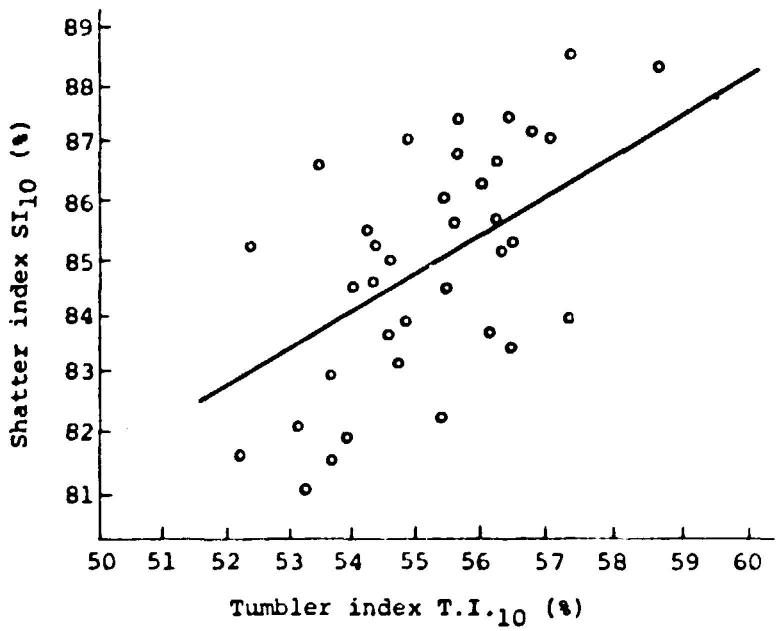
RDI = Reduced Degradation Index
SI = Shatter Index

Samples should be collected from the conveyor by automatic sampler, and preparation and analysis should be in accordance with established standards.

The shatter index, which is used to measure sinter strength at Karabuk, is an acceptable method. The relationship between shatter index and the more widely used tumble index is shown in Figure 3.6.

Figure 3.6

RELATIONSHIP BETWEEN SHATTER INDEX AND TUMBLE INDEX



Tests are of value only as they are used to control the operation, and care must be taken not to overreact to minor or transient deviations. A good rule is to take corrective action when one sample is greater than 3 standard deviations from the mean, or when 2 consecutive samples are more than 2 standard deviations from the mean.

A typical sample of the relationship between process changes and their effect is given in Table 3.2.

Table 3.2

PROCESS ELEMENT	CHANGE	EFFECT	
Bed Depth	± 10 mm	T.I. of Sinter: Mean Size of Sinter:	± 0.4% ± 0.47 mm
Machine Speed	± 0.1 m Per Minute	Mean Size of Sinter:	± 0.23 mm
Coke Addition	± 0.1%	FeO in Sinter: T.I. of Sinter:	± 0.4% ∓ 1.4%
Ignition	± 5 m^3	T.I. of Sinter	± 1%

3.2.5 Ignition Method

The ignition method is poor. The furnaces and burners are not capable of supplying the required flame pattern or retention time, and blast furnace gas is the only fuel available. Its calorific value is too low for efficient ignition of the solid fuel.

Short-term recommendation: install new ignition furnace.

Status at end of project: A new ignition furnace has been installed on No. 2 machine. A significant improvement in ignition was apparent and contributed to the reduced FeO content of the sinter as long as a reasonable supply of gas was available. In mid-September, problems developed with the blast furnace gas holder which caused the gas pressure to vary over a wide range, sometimes reaching a low of 60 mm wg. Because of the resulting low gas velocity through the burners, nozzles became plugged with gas residue, further restricting the flow. Ignition is extremely poor, with the surface of the bed being only calcined.

Long-term recommendation: Supply mixed gas for the ignition hood.

This is the most urgent problem presently existing in the sinter plant and, if left unsolved, plans for increased hot metal production will fail. Mixed gas with a calorific value of 1,500-2,000 Kcal/Nm^3 must be provided. The required volume for the present machines follows.

Assuming a raw material density of 1.75 and a yield of 55% for super-fluxed sinter:

<u>No. 1 Machine:</u>

18 tons per m^2 per day
Speed: 0.75 m per minute

2 m wide x 0.75 m/minute x 2 minute ignition = 3 m^2

$$\frac{8{,}500 \text{ Kcal/m}^2 \times 3 \text{ m}^2}{1{,}500 \text{ Kcal/Nm}^3} = 17 \text{ Nm}^3\text{/minute (ignition zone)}$$

<u>No. 2 Machine:</u>

30 tons per m^2 per day = 2.65 tons raw mix per minute

2 m wide x 2.52 m/minute x 2 minute ignition = 10.1 m^2

$$\frac{8{,}500 \times 10.1}{1{,}500} = 57.2 \text{ Nm}^3\text{/minute (ignition)}$$

$$\frac{4{,}000 \times 10.1}{1{,}500} = 26.9 \text{ Nm}^3\text{/minute (anneal)}$$

TOTAL - BOTH MACHINES = 100 Nm^3/minute

Using a CV of 900 for blast furnace gas and 3,800 for coke oven gas, the required ratio becomes:

3,800 (% COG) + 900 (% BFG) = 1,500

BFG = 18/29 = 62%; COG = 38%

Required volume:

Blast furnace gas: 0.62 x 100 = 62 Nm^3 per minute
Coke oven gas: 0.38 x 100 = 38 Nm^3 per minute

The power and fuel section of this report contains recommendations for making the required volumes of gas available to the sinter plant.

3.3 RAW MATERIAL PRACTICES AND RECOMMENDATIONS

3.3.1 Ore

The major problems with the existing ore system are:

(1) There is not enough storage area to keep the various ores separate. "ixing and wide variation in chemistry results.

(2) Crushing and screening facilities are inadequate, resulting in excessive fines in the lump ore to the blast furnaces and too much oversize in the sinter plant material.

(3) Rail movements are not accomplished in a timely manner because of lack of equipment and poor scheduling practices.

(4) Because high alumina ores become sticky when wet, they are difficult to screen. To prevent blanking, it has been the practice to install 15 mm screens during the winter, which can be 5 or 6 months long.

Short-term recommendations: The ideal ore size for sintering is 0.25 to 6 mm, but in actual practice -8 mm is acceptable. Larger particle sizes cause uneven ignition, and because of their greater heat capacity, take longer to reach agglomeration temperature. They also make it difficult to achieve a strong bond because of their low surface contact. The following corrective action is recommended.

(1) Keep two crushers in service at all times and install the third, which is part of the modernization program, as soon as possible. This requires that an adequate supply of spare parts be kept on hand and that maintenance be scheduled on non-operating turns.

(2) Do not change screens from 10 mm to 15 mm in winter. Some possible solutions to the problem of screening wet ore are:

a. Install chains which will vibrate against the screen element and help to keep it open.

b. Use rubber or polypropylene screens, which are flexible and somewhat self-cleaning.

c. Use gas flame to heat the screens. This, of course, cannot be done if rubber decks are used.

d. Bins should be designed for bulk flow, and mechanical vibrators and live bottoms used. Lining the discharge section with high density plastic is very effective in preventing "rat-holing" in the bins.

e. Under extreme conditions, it may be necessary to restrict or discontinue the use of high alumina ores.

Status at end of project: Two crushers are in operation, and the material produced averages 95% -8 mm.

Long-range recommendations: The completion of the ore crushing and screening facilities presently under construction will provide an adequate amount of properly sized ore. The greater screening area which will then be available, and application of recommendations regarding the handling of wet ore, should make it no longer necessary to change to 15 mm screens in the winter, allowing this very undesirable practice to be discontinued.

The ore requirements for producing 834.000 tons per year of hot metal are as follows:

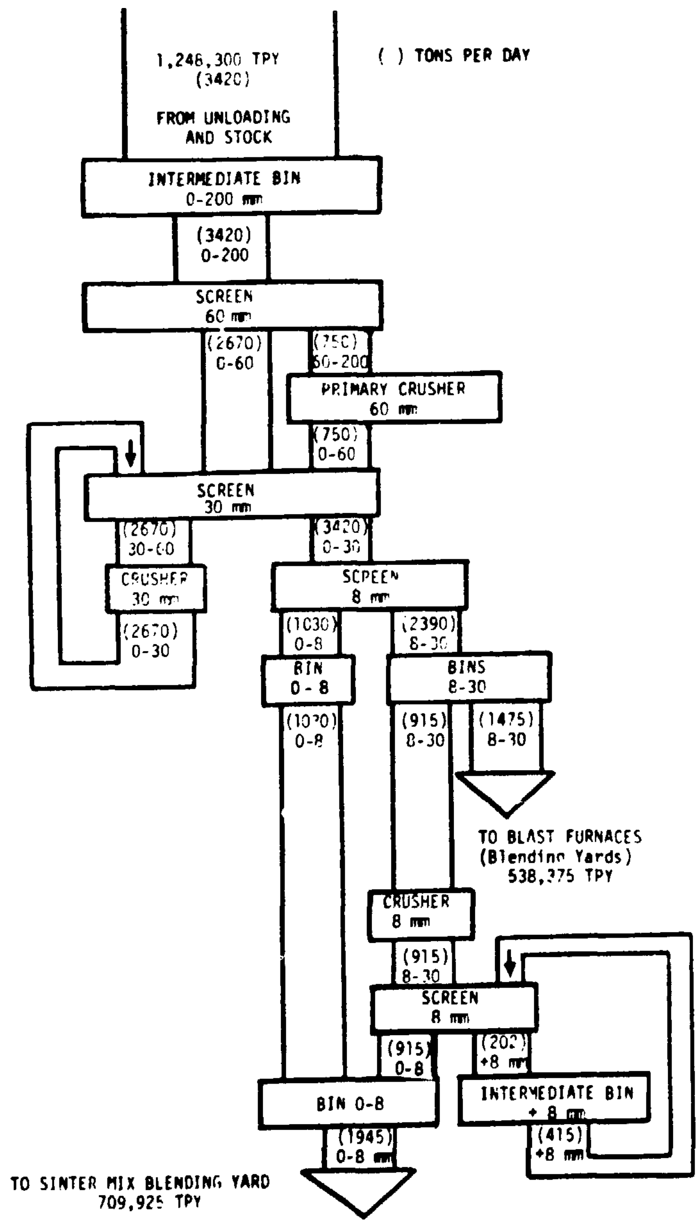
	Tons/Year	Kg/Ton Hot Metal
HOT METAL PRODUCED	834,000	
Fe Content	94.5%	
Fe in Hot Metal	788,000	
SINTER IN CHARGE	870,000	1,043
Fe Content	45%	
Fe in Sinter	391,500	
PELLETS IN CHARGE	150,120	180
Fe Content	66.8%	
Fe in Pellets	100,000	
Fe REQUIRED FROM LUMP ORE	296,200	
Fe Content	55%	
Lump Ore Required	538,500	646

Assuming approximately 850 kg ore per ton of sinter, the ore fines required for sinter are 709,000 tons per year.

The ore crusning and screening flow is shown in Figure 3.7. The expected size distributions are based on analyses made by U.B.M. Rheinstahl in 1974, and some changes in ore size may have occurred since then.

Figure 3.7

ORE FLOW SHEET



3.3.2 Coke

The sinter plant receives -40 mm coke and screens it into two fractions, -10 mm and +10/-40 mm. The +10 mm is crushed to -10 mm in a gyratory crusher with a capacity of about 17 tons per hour. At present most of the coke arrives in the -10 mm size. When the new crushing facilities at the coke plant are put into operation, the coke size to the sinter plant will be 0 to 25 mm.

Crushing from -10 mm to -3 mm is done in 4 roll crushers which can handle about 7 tons per hour each. At a projected sinter production of 1,250,000 tons per year and a coke rate of 70 kg/T-S, 87,500 tons of coke per year will be needed. Allowing one crusher down for repairs at all times, this amount of coke can be produced by the remaining 3 operating 2 turns per day, 5 days per week. Although there is ample time available for maintenance, very little work is being done and the crushers were found to be in an extremely bad state of repair. As a result, the coke breeze contained as much as 60% +3 mm material, causing high coke rate (75 kg/T.S.) and high FeO (20%) in the sinter.

Short-term recommendations: Improve crushing efficiency by:

A. Installing a magnetic separator in the coke handling system to prevent metal from entering the rolls and causing damage.

B. Improving screen maintenance to reduce the amount of +12 mm material being delivered to the crusher.

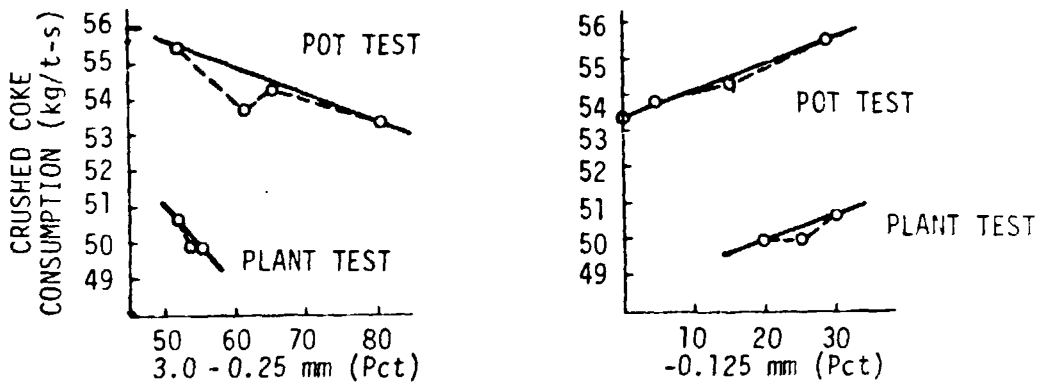
C. Installing a portable grinder for grinding crusher rolls in place.

Status at end of project: Rebuilt rolls have been installed in 2 of 4 crushers, and scrapers and screens have been repaired. The operators are maintaining close roll settings, which has greatly improved the coke size. The coke rate is now estimated at 65 kg/T-S, and the FeO has been reduced to 16%. There is still no continuing program for preventive maintenance and unless one is installed, the system will soon regress to its original state of disrepair.

Long-range recommendations: We cannot overemphasize the importance of coke size on the sintering process. It is generally recognized that the most desirable coke breeze size is 0.25 to 3.0 mm. Figure 3.8 shows experimental and plant results using varying percentages of overand undersize material in the coke breeze.

Figure 3.8

RELATIONSHIP BETWEEN
CRUSHED COKE SIZE AND CRUSHED COKE CONSUMPTION



The improved size distribution decreases the FeO content of the sinter and reduces the coke consumption in the sinter plant and blast furnace, with a large reduction in cost.

To prevent overgrinding, it is recommended that a screen be installed ahead of the crushers to remove -3 mm material and convey it directly to product. Because of the difficulty in preventing blanking off of the screens by moist coke fines, a special piano-wire screen must be used. For this application, we would specify the screen deck as follows:

> Ludlow Saylor Astroloy stainless steel Hi-T or equal screening medium, having 0.12" x 12" openings with .072" diameter wire. This screen is manufactured by FMC Corporation, Material Handling Equipment Division, 529 Reading Avenue, Suite C, West Reading, Pennsylvania, USA. When ordering the deck, it will be necessary to furnish the specifications of the screen in which it will be installed.

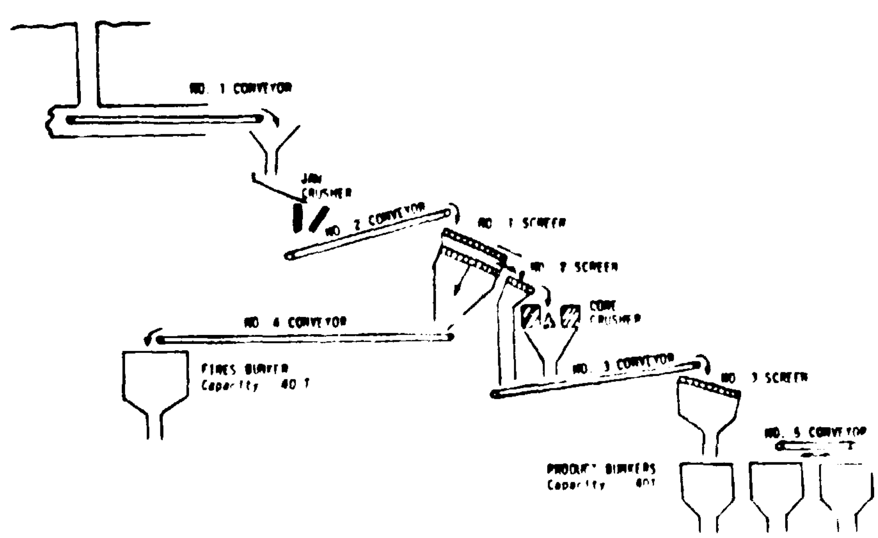
The roll crushers which are presently in use are capable of producing the required size if properly maintained, but the maintenance department is apparently unable, or unwilling, to perform the required maintenance. If at some future date the roll crushers are replaced, first consideration should be given to the installation of a rod mill. It should be located in a position that would allow 2 of the present crushers to be retained for use during periods of rod mill maintenance. It would be approximately 1.5 meters in diameter by 2.4 meters long to produce 30 TPH at 90% - 3 mm. Its cost at 1982 prices is about $220,000.

3.3.3 Limestone

Production. The limestone mine has a design capacity of 100 tons per hour but presently is producing only about 15,000 tons per month on a 2-shift, 6 days per week schedule. The arrangement at the plant is shown in Figure 3.9.

Figure 3.9

CRUSHING AND SCREENING ARRANGEMENT AT LIMESTONE MINE



No. 3 screen separates the material into +40 mm and -40 mm fractions. A typical analysis of these fractions is given in Table 3.3.

Table 3.3

SIZE ANALYSIS

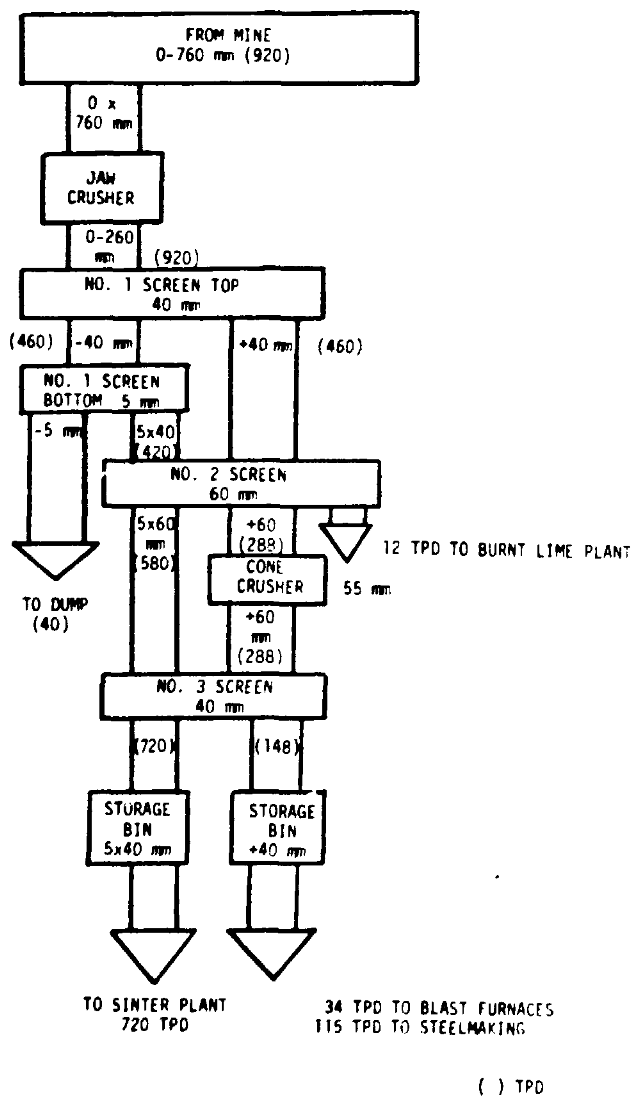
	-40 mm Fraction	+40 mm Fraction
-5 mm	3.88%	
5 x 15 mm	18.33%	
15 x 40 mm	77.77%	50.00%
40 x 60 mm		41.75%
+60 mm		8.25%

The equipment at the mine is generally quite old (1963-1972 vintage) and in a poor state of repair. In addition, there is no stockpile of limestone, and when breakdowns occur it is necessary to curtail the production of pig iron.

Limestone requirements for the production of 834,000 tons per year of hot metal are shown in Figure 3.10.

Figure 3.10

LIMESTONE FLOW SHEET



Handling at the Mill

Limestone is delivered by truck to bunkers at the plant from which it is taken to the consuming departments by rail wagon. The 15 x 40 mm goes to the blast furnace, and the +40 mm goes to the steel works. In the past, the 2 sizes were often mixed and reduced efficiency of both departments resulted. This situation has been corrected through recommendations made in the Second Interim Report.

When fluxed sinter production begins, 5 x 40 mm limestone will be supplied to the sinter plant, and 40 x 70 mm to the blast furnaces and steel works. It will go to the sinter plant from underground bunkers in the blast furnace stockyard areas. These bunkers are also used for coke and only about 120 m^3 or 168 tons can be allocated to limestone. Removal is by means of a traveling scraper with a capacity of 112 TPH of limestone.

The underground hoppers are filled from small trains of railroad wagons, each wagon having a capacity of 10 m^3 or about 14 tons.

Crushing will be done by a Hazemag hammer mill with a capacity of 25 TPH in closed circuit with a Magenson sizer.

Discharge is by way of a 70 TPH screw conveyor to the belt conveyor feeding the sinter plant bins. The 3 sinter plant bins have a combined capacity of about one day's requirements.

When hot metal production reaches 834,000 tons per year, an estimated 720 tons per day of limestone will be needed for the sinter. To supply this amount of limestone, the underground bunkers will have to be filled 5 times per day, and 51 rail wagons will need to be dumped. It is impractical to consider this amount of movement of material into an already congested area. In addition, the Hazemag crusher operating 16 hours a day (allowing 8 hours for maintenance) can produce only 400 tons per day. The sinter plant will have to be stopped if there is a delay in the limestone crushing system exceeding about 20 hours.

Recommendations

(1) Begin an immediate program of improving equipment at the mine. Crews should be added to establish a

stockpile of screened material. The availability of this stockpile will make it unnecessary to screen material during extremely wet weather when a large amount of fines is carried over. An additional benefit could be gained from increased capacity by selling limestone to the Eregli mill. Trucks which bring Brazilian ore to Karabuk could be used to take limestone back rather than return empty.

(2) There are approximately 200,000 tons of 0 x 15 mm limestone in the dump at the mine which should be rescreened at 5 mm. It is estimated that 25% of the pile or 50,000 tons of 5 x 15 mm can be recovered for use in the sinter plant. A portable screen could be used. A harp wire screen is the most efficient type for removing very fine material, particularly when moisture is present.

The book value of the limestone is $9.50 per ton, and assuming a screening cost of $1.00 per ton, the net recovery is $425,000.

(3) It is most important that nearly all of the blast furnace limestone requirements be supplied in the sinter. As discussed above, this is not possible with the present facilities. We strongly urge that additional crushing equipment be installed at the blending yard and that at least 70% of the limestone be placed in the bed. This will greatly improve chemical control of the sinter product and, with reduced consumption at the sinter plant, its bins will contain 3.5 days supply.

3.3.4 <u>Dolomite</u>

Dolomite is mined at the Balikisik mine located approximately 15 km from the Karabük Steel Works. The mine is producing 250 to 300 tons per day on an 8 hours per day, six days per week schedule. Twenty-one rail wagons, each holding 25 tons, are loaded per week. The dolomite has the following average chemistry:

SiO_2	1.35%
CaO	32.0%
Mgo	18.0%

The stone is processed through a jaw crusher with an inlet of 35 cm and an outlet of 7.5 cm. It is then screened into three fractions 25 x 75 mm, 75%; 10 x 25 mm, 15%; and -10 mm, 10%. The +25 mm material is transported by truck to bunkers from which it is loaded into railroad wagons and delivered to the steelmaking plant. The other two sizes are wasted. The 10 x 25 mm product can be fed to a hammer mill, which is connected in closed circuit to a screen, with the capability of producing 10 TPH of -3mm dolomite. Bunkers are under construction for use in loading this material into railroad wagons for blending in the sinter mix bed. It will be conveyed to the stacker from 3 underground hoppers having a combined capacity of 105 tons.

<u>Recommendations</u>

(A) Research and operating data indicate that reducing the sinter magnesia content improves cold strength but should be kept above 1.5% to maintain reducibility and high temperature properties.

Figures 3.11 and 3.12 show the undesirable effect of increased dolomite levels on coke rate and sinter strength. Magnesia should, therefore, be held to a maximum of 1.5% in the sinter.

Figure 3.11

EFFECT OF DOLOMITE REDUCTION ON DRY COKE RATE

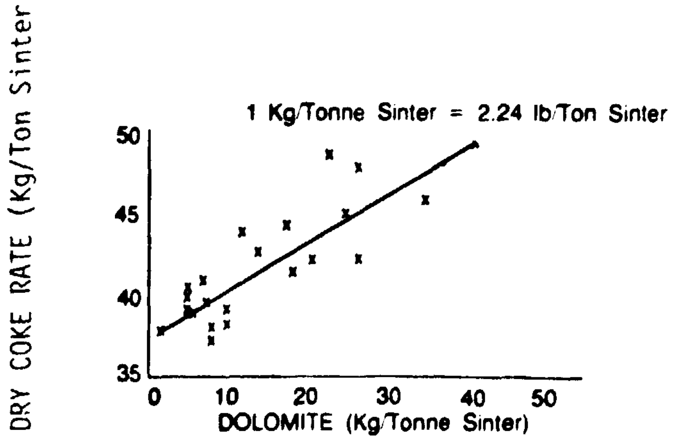
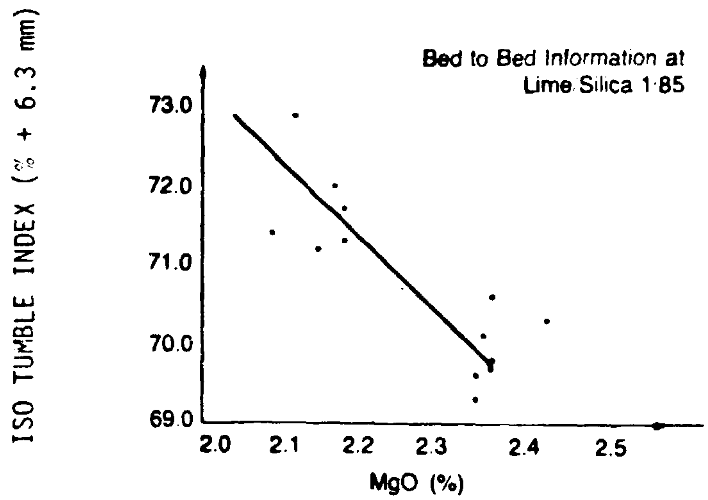


Figure 3.12

EFFECT OF INCREASING MgO (%) ON ISO TUMBLE INDEX



3.3.5 Roll Scale

Roll scale which should be used in the sinter plant is being wasted.

Based on iron units alone, roll scale has a value of approximately 3,410 TL per ton. 30 tons per day are being wasted and 50,000 tons are stored in the ore yard, occupying valuable space.

Short-Term Recommendations

Arrange to have roll scale screened to remove scrap and other debris and add to sinter mix. The high oil content and adverse effect on FeO makes it desirable to limit the amount of roll scale to a ximum of 10% of the raw mix.

Status at End of Project

Bids have been received from contractors and roll scale is expected to be available for use in October, 1982.

Long Range Recommendations

After present stock pile is consumed, the screening operation should continue in order to prepare the current production for use. It will be highly beneficial to the sintering process to blend roll scale with the ore in the blending yard when that facility is complete.

3.3.6 Flue Dust

Provisions are being made to add flue dust to the blended mix when this facility is in operation. Until then, there is no convenient method to get it into the sinter plant and there is no way to control its feed rate. For these reasons, it is recommended that flue dust be stocked until the blending yard is finished.

Additional analyses will be needed at that time. Presently only alkalinity determinations are made semi-monthly. The total, Na_2O + K_2O, varies from 0.54 to 1.63, with a five-month average of 1.16. Because of the high levels of alkalinity present in the ores, it may not be advisable to use flue dust.

3.4 EVALUATION OF EXPANSION PROJECTS

3.4.1 New Sinter Machine

At the time of this report, a Romanian manufacturer is the probable supplier of the new sinter machine. Following is a comparison of his preliminary specifications and our recommendations as set forth in our second interim report.

ITEM	RECOMMENDATIONS	ROMANIAN SPEC.	COMMENTS
Machine Size	3 x 30 meters	3 x 30 meters	
Sinter Bed Height	40 cm	40-50 cm	
Hearth Layer	Depth 2-4 cm Feed spout	2-4 cm Roll feeder	A roll feeder will have higher initial cost and require more maintenance than a spout.
Pallets	Material: Cast steel	Not specified	
	Seals: Spring loaded	"Mobile hanged steel plates"	The proposed design is a modified T-bar seal depending on gravity and windbox vacuum for its effectiveness. It should provide an adequate seal if properly maintained, but the spring loaded type is preferred.
Grate Speed	1.5 to 6 meters per min.	Not specified	
Windbox Suction	Design 2100 mm wg. at windboxes: 1320 mm wg.	1400-1500 mm wg. 1200 mm wg.	This is not enough vacuum for a 500 mm bed depth. Experience indicates that 3 to 3.5 mm wg. is needed for each mm of bed depth. At a 500 mm depth, the vacuum must be at least 3 x 500 = 1500 mm wg.
Performance Guarantee	30 tons/m^2/day Size: 6 x 50 mm Max.: 7% - 6 mm	Not specified	
Sinter Mix Feed	Method: Roll feeder Drive Speed: Controlled by ht. of mix behind strike-off plate Material: Expanded metal cover	Roll feeder Drive Speed: Controlled by ht. of mix behind strike-off plate Not specified	See Page 6 for additional recommendations.
Roll Feeder Hopper	Mount on load cells Feed by oscillating conveyor	Not specified Not specified	The load cells provide level control, see Page 12, and the oscillating feed maintains a level surface thereby reducing size segregation.
Mixing Drum	Install larger primary mixer and remove secondary mixer	Replace both primary and secondary mixers	While there are advantages to be gained from a secondary mixing drum, it would be difficult to justify the increased initial cost and higher maintenance requirements, particularly since there is not enough space to permit it to be installed at ground level. A single drum should be adequate if correctly designed to give a retention time of at least five minutes. The inlet should contain lifters for mixing the material while the outlet s smooth for pelletizing. Major moisture additions are made in the mixing section with trim water added n the outlet portion. The interior should be lined with expanded metal to reduce wear on the shell.

ITEM	RECOMMENDATIONS	ROMANIAN SPEC.
Waste Gas Ducts	Two refractory lined ducts Dust removal by double dump valve	Two refractory lined ducts Dust removed through water sealed dust legs and mechanical scraper
Windbox Damper	Install only under ignition hood	Under ignition hood and in last two windboxes
Waste Gas Cleaning	By electrostatic precipitator Outlet dust loading $0.1\ gm/Nm^3$ max.	Electrostatic precipitator Outlet loading not specified
Waste Gas Fan	Type: Radial or backward curved blade with replaceable wearplate Double inlet Speed. 1000 RPM	Double inlet preferred
Ignition Furnace	Temperature: 1250-1300°C Ignition time: 2.0 minutes Provide anealling zone Fuel gas CV: 1500 $KCal/m^3$ Ignition intensity: 8500 $KCal/m^2/min$. Consider use of preheated combustion air from first zone of cooler	The fuel will be a mixture of blast furnace and coke oven gas
Machine Discharge	There should be a surge hopper following the sinter breaker discharging to the cooler by a variable speed vibrating feeder	Not specified
Hot Fines Screens	There should be no hot fines screens	There are no hot fines screens

COMMENTS

There are no sinter plants in the U.S. using this system. Drag chains are generally difficult to maintain. Karabuk engineers should visit Iskenderun Works to be certain that design problems on a similar system installed there have been corrected.

In order to ensure proper sizing, permissible outlet dust loading must be specified.

A fan of this size must be double inlet to avoid excessive end thrust. The low speed should be specified to reduce wear on the blades.

More detailed specifications are needed on the ignition hood design. See calculation of gas requirements on Page 16.

3.4.2 Blending Yard

According to the UBM proposal, the blending yard will have a volume of 73,000 m^3, or 146,000 tons of material at a density of 2. The sinter plant requirements to produce 870,000 tons of sinter per year is 2400 tons of mix (ores plus 70% of flux) per day.

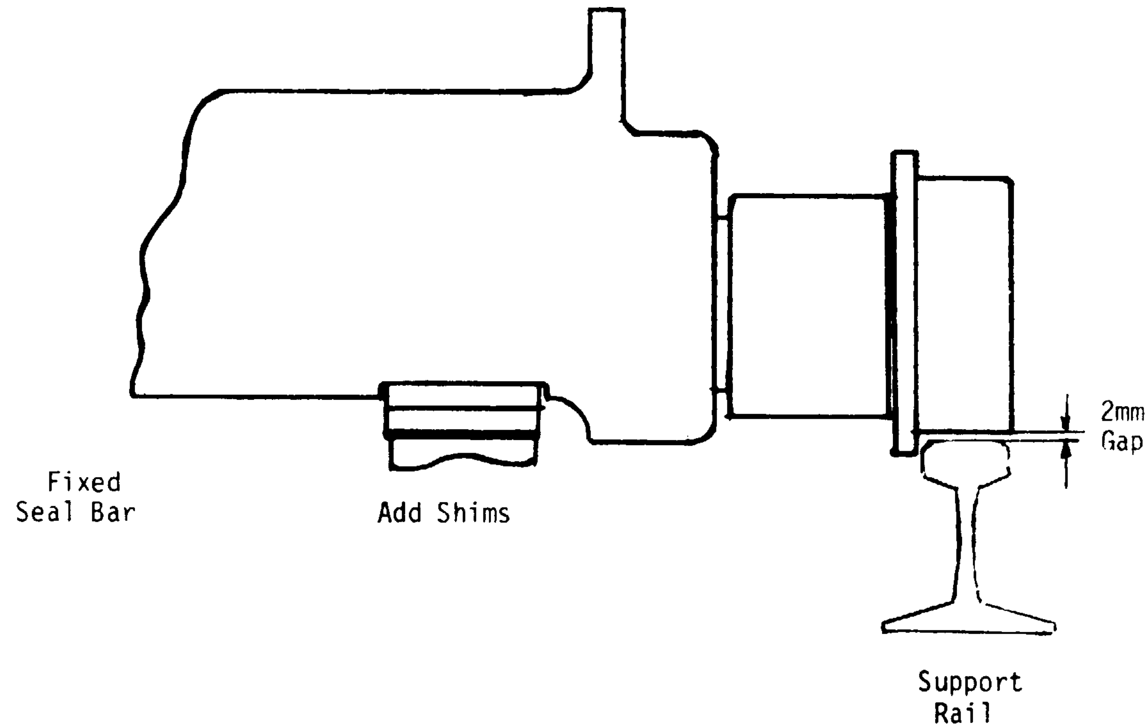
The proposed yard has adequate capacity for sinter mix and iron ore blending for the long range production goals.

Recommendations

A. For maximum benefit, it is most desirable that most of the fluxes be added in the blending yard. It is uncertain whether dolomite will be used in the future, but if it is, there will not be enough bins to add both limestone and dolomite to the bed.

B. Additional limestone crushing facilities are needed which should be installed either at the blending yard or at the mine.

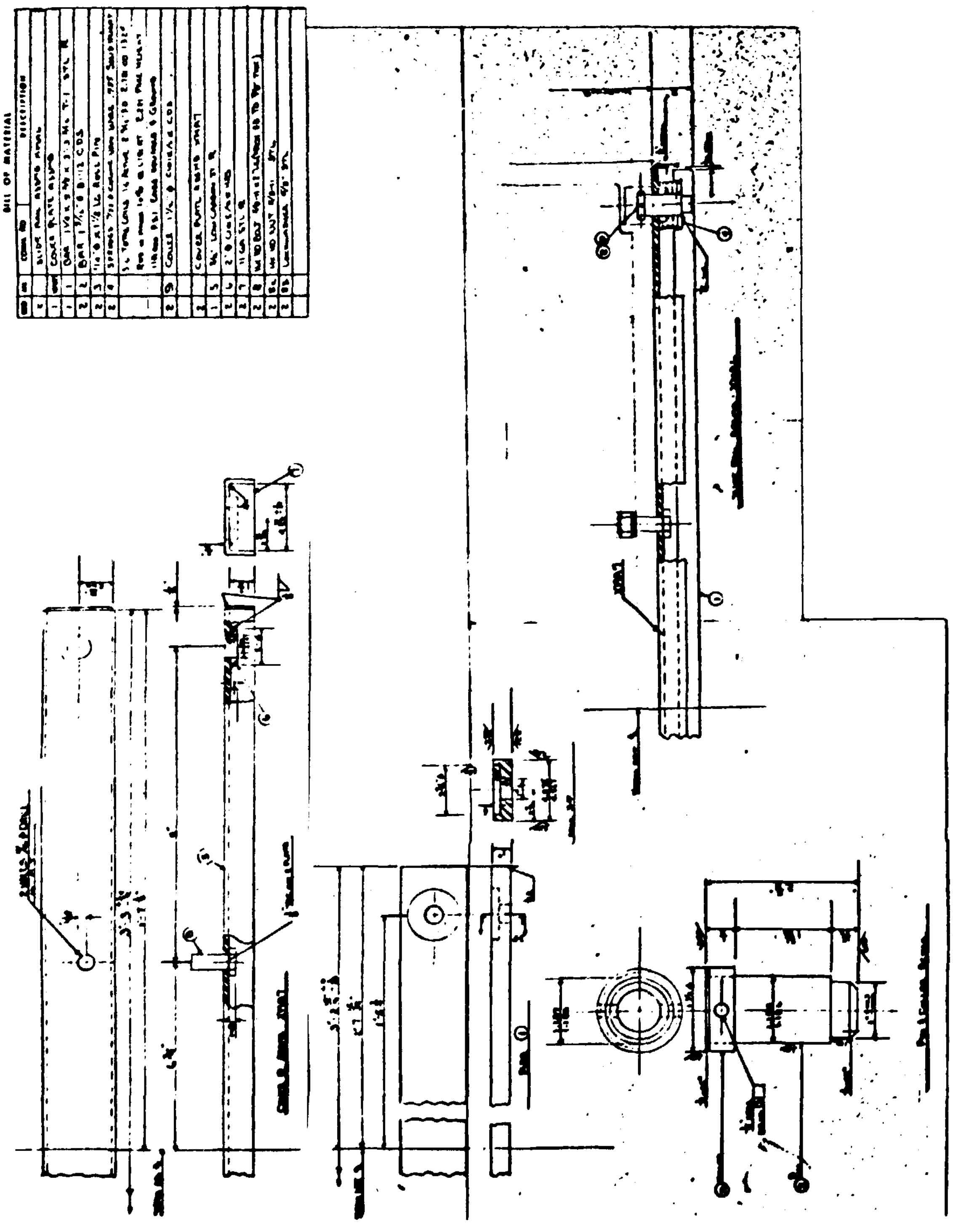
C. There is no plan for blending, testing and reclaiming practices to be followed when yard is placed into operation. It is strongly urged that expert assistance be obtained to establish operating and control parameters prior to start-up.



NOTE: Material for seal bars should be 0.5 - 0.6 carbon steel, 70 Kg/Sq mm tensile.

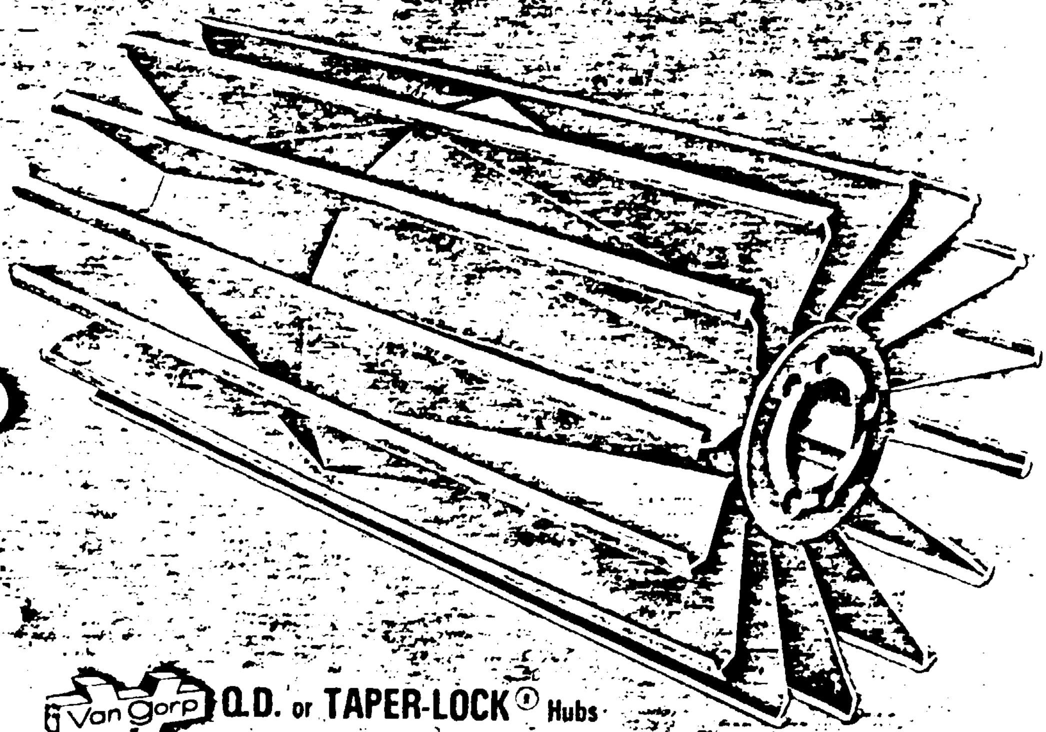
PALLET SUPPORT AND SEAL MODIFICATION

NO. 2 SINTERING MACHINE - SPRING-LOADED SEAL



APPENDIX 3.3

TURN-CLEAN®
PULLEYS



Van Gorp Q.D. or TAPER-LOCK® Hubs

Van Gorp

THE PULLEY PLACE!®

VAN GORP CORPORATION
SUBSIDIARY OF
EMERSON ELECTRIC CO.
BOX 123, PELLA, IOWA 50219
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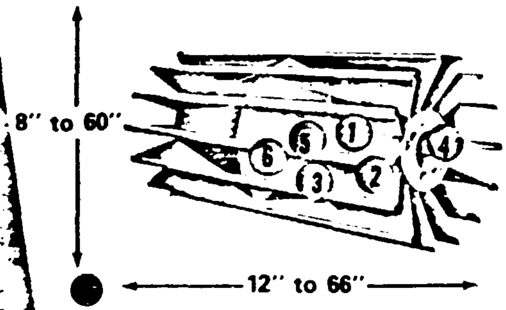
EMERSON

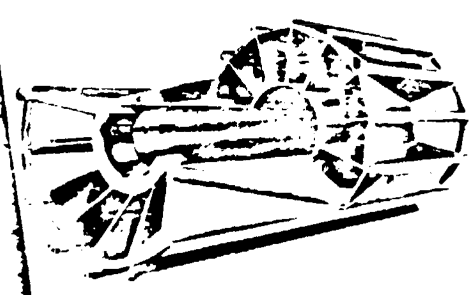
7 ways to cut costs...



1. **SELF CLEANING ACTION** – Rotation of the pulley automatically starts the self-cleaning action discharging foreign material to the side of the conveyor.
2. **PREVENT BELT MISALIGNMENT AND WEAR** – No more belt misalignment because individual wing construction reduces the possibility of any material build up between the belt and pulley.
3. **PROTECTED WINGS** – Half oval bars are welded to each wing and are the only pulley part which makes contact with the belt. This rounded surface prevents excessive belt strain or wear and gives maximum traction.
4. **DODGE TAPER-LOCK® HUBS OR Q.D. HUBS** – All pulleys are made with TAPER-LOCK® or Q.D. Hubs which permit the simplest, surest and most modern installation. Hubs are inset from the pulley end and this inset permits the bushing to be easily removed in small confined space. See page nine for keyway location.
5. **RUGGED FOR LONG LIFE** – Individual gussets are welded continuously to each wing and the hub forming a strong water tight, double-cone design. TURN-CLEAN Pulleys have a thick wall tube which extends from hub to hub. Each wing is welded on both sides to the tube. The tube supports the wings and this structural design eliminates the possibility of metal fatigue which could cause gusset and wing breakage.
6. **FOUR DIFFERENT CROWN FACE S ECTIONS**
   - Style A – Standard crown face h own of 1/8".
   - Style B – Straight face, no crow...
   - Style C – High crown face has a crown of 1/4".
   - Style D – Suggested for bucket elevators using a straight face in the center with a crown face only 3" in from each side of pulley.
7. **SIZE SELECTIONS – GOOD SERVICE** Van Gorp Pulleys are available in the most complete range of standard sizes offered by any manufacturer, with diameters from 8" to 60" and face widths from 12" to 66". Custom pulleys can be manufactured to your specifications.

Van Gorp

PROTECTS YOUR INVESTMENT



CUT - AWAY VIEW

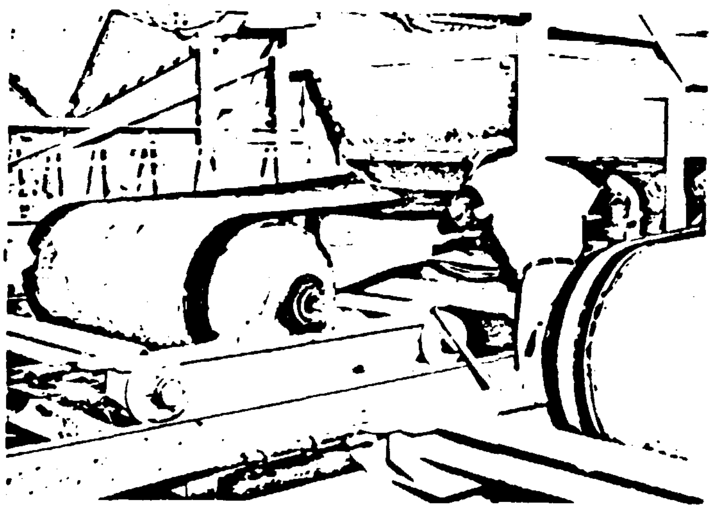
SPECIFICATIONS

Pulleys are of all welded steel construction. Outer bars have long radius surface for maximum traction and minimum belt wear. All pulleys are jig welded and accurate concentricity is assured because the half oval is hydraulically pressed against the exterior wing edge and then the two pieces are welded together.

A circular reinforcing ring is used on all 24" dia. x 38" face, K35 or EX wing pulleys and larger.

TURN-CLEAN® Pulleys

TURN-CLEAN® PULLEYS
Reduce Cleaning Problems



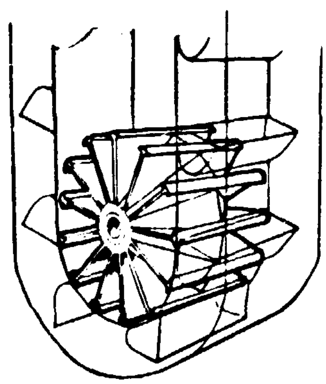
The Turn-Clean Pulleys can be interchanged with the solid face pulleys you now have in service.

Turn-Clean Pulleys are a safety measure — reducing the need for dangerous cleaning. Materials will not remain on the pulley when a Wing Type Pulley is installed on your conveyor.

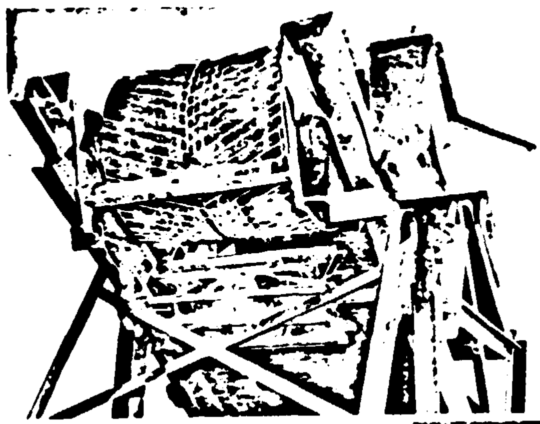
The Turn-Clean Pulley actually outlasts a solid faced pulley. Belt and pulley life are extended by reducing the grinding and crushing action.

. . . On bucket elevators

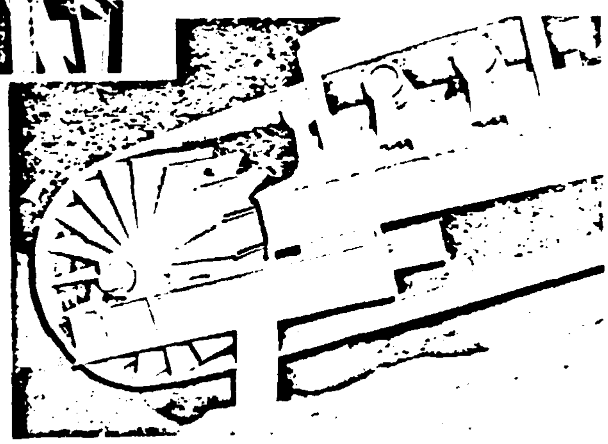
The Turn-Clean Pulley eliminates crushing materials between the pulley and back of the belt in the boot of a bucket elevator. There is no accumulation or build-up in the area of contact due to the conical shape of the pulley body. The belt and pulley surfaces are continuously clean . . . no sticking of substances which normally packs in the boot. The Turn-Clean Pulley is also an invaluable aid in breaking up ice and frost.



TURN-CLEAN PULLEYS
Protect your Conveyor Belts



16 x 32 snub pulley used in a 30" wide, 600' c - c cable conveyor used to handle clay over burden.



30 x 38 tail pulley used in a 38" wide, 210' c - c channel frame conveyor handling lime dust.

As the conveyor operates, material falls from the top or tension side of the belt. With a continuous rim pulley, the overflow is crushed and ground into the belt, damaging its covering. As this material builds up on the pulley it causes greater tension and stress on the belt.

With a Turn-Clean Pulley in the conveyor, the action of the conical body directs the spillage away from the belt. This is especially advantageous in handling moist or sticky substances.

Gravity take-up 12 x 20 bend pulleys and 20 x 26 take up pulley being used in a 24" wide 170' c - c Warren Truss conveyor handling aggregate.

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

BLAST FURNACE REPORT

- CONTENTS -

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

4.0 BLAST FURNACE REPORT

4.1 SUMMARY

A general description of the blast furnace plant facilities is presented as they exist today.

The blast furnace plant operational results are poor when compared to the average American or worldwide experience in terms of production rate, coke rate, hot metal quality, and cost. The objective of the blast furnace section of this report is to define the problems and the necessary countermeasures required to correct them, whether it be by way of facility or operational changes.

The primary problems were found to be associated with raw material quality, instrumentation, process and quality control, cooling water quality, and equipment condition.

The required countermeasures to overcome these problems are discussed in detail from both a practical and theoretical point of view.

A number of proposed operating practices and design changes have been recommended that will enhance the overall performance of the blast furnace plant.

The major improvements that will be obtained were found to be incorporated into the already authorized improvement projects, which are called the Authorized Improvements Program in this report. Because of the great significance of the completion of these projects on the blast furnace performance statistics, a chart has been prepared (Appendix 1, Table 1) showing the expected results as each project is completed. The production rate increases, the coke rate decreases, and hot metal chemistry and temperature improvements can be clearly seen. Hot metal cost information is not included but can be calculated from this data by the Karabuk industrial engineers.

Using the 1981 actual results as the base case, completion of the Authorized Improvements Program will produce a production rate increase of 50% (775 MTHM per day) and a coke rate decrease of 25% (237 kg per MTHM). The hot metal temperature increases by 45° C and the hot metal silicon decreases from 1.61 to 1.20%. There is a decrease in the hot metal sulfur from 0.077 to 0.064 and the variation in the sulfur analysis will be reduced. The external desulfurization of hot metal will still be required.

The production increase from 1,510 MTHM per day to 2,285 MTHM per day will require an examination of the adequacy of other blast furnace equipment. For example, additional hot metal and slag ladles and locomotives may be necessary. Improved furnace top sealing equipment, hot blast valves, water quality and utility supply must be investigated. Also an important consideration is the disposition of the increased tonnage of hot metal. The Blast Furnace Plant will no longer be the Plant bottleneck.

The Turkish Iron and Steel Company deserves credit for a well-planned Authorized Improvements Program. It is now necessary to expedite the construction and commissioning of these projects so that the significant benefits can be realized quickly.

The writer wishes to thank the Blast Furnace Plant personnel, all of whom have cooperated so willingly with the preparation of this section of the report; especially Mr. Aytekin Temizer-Manager, Ferit Tireng-Chief Engineer, Metin Kurt-Chief Engineer Sintering and Erdogan Tolan-Process Engineer.

4.2 GENERAL DESCRIPTION OF PLANT

The blast furnace department at the Karabuk Works consists of the following major facilities:

4.2.1 Iron Ore and Limestone Handling

A. Railroad delivery system to plant for ore; limestone by truck.

B. Ore storage yard.

C. Ore yard adjacent to blast furnaces with two ore bridges.

D. Car dumper being constructed.

E. Screening and crushing station being expanded.

F. Ore blending yard being constructed.

G. Ore bunkers under an elevated trestle, common to all furnaces.

H. Ore wagon trains and transfer car servicing the elevated trestle.

I. Stockhouse larry cars weighing and delivering raw materials to the furnace skip buckets.

4.2.2 Coke Handling

A. Conveyor belt from coke batteries and/or coke crushing plant.

B. Coke bunkers at each furnace to supply skip buckets via vibrating screens at No. 3 furnace and stationary sloping screens at No. 1 and No. 2 furnaces.

4.2.3 Sinter Handling

A. Conveyor from No. 2 Sinter Machine to sinter bunkers.

B. Transfer car and/or wagon train from No. 1 Sinter Machine hot sinter loadout bin to sinter bunkers.

4.2.4 Blast Furnaces

A. No. 1 furnace:

4.57 m hearth diameter
325 m^3 working volume
8 tuyeres
2 bell top
Cooling plates in bosh
No stack cooling

B. No. 2 furnace:

Same as No. 1 furnace

C. No. 3 furnace:

7.4 m hearth diameter
818 m^3 working volume
16 tuyeres
2 bell top
Cooling plates in bosh and stack

4.2.5 Stoves

A. No. 1 and No. 2 furnace stoves:

3 stoves each furnace with 6,300 m^2 heating surface per stove

B. No. 3 furnace:

3 stoves of 27,500 m^2 heating surface each

4.2.6 Gas Cleaning

All have dust-catcher, water spray cooling tower and electrostatic precipitator. There are a total of five towers and precipitators downstream of a common gas header.

4.2.7 Casthouses

All have one tap hole, one slag notch which is used, 60-ton open top hot metal ladles, 18-ton slag ladles, and a slag granulation pit.

4.2.8 Water Cooling System

A. A once-through service water system is used to supply the furnace and stove cooling elements from water pumped directly from a nearby river.

B. A recirculating water system is used to supply water to the gas cleaning system. The water enters at the water spray gas cooling towers, then flows to a settling basin, two thickeners, and a forced air cooling tower.

4.2.9 Double Strand Pig Casting Machine

4.2.10 Blowing Equipment

Two turboblowers are available with a capacity of 106,000 Nm^3 per hour each to supply the No. 3 blast furnace, one operating and one standby. Three turboblowers with a capacity of 52,500 Nm^3 per hour each supply No. 1 and No. 2 furnaces, two operating and one standby.

4.3 PROBLEM AREAS AND PROPOSED COUNTERMEASURES

4.3.1 Raw Materials

In general, the most significant problems arise from the inferior quality of the raw materials supplied to the blast furnaces. The authorized projects will correct some, but not all, of these problems.

In order of priority, the problem areas are discussed below.

A. High alkali input - 13.4 Kg/MTHM and 25.0 Kg/MT slag

Alkali input is measured in two ways, per MTHM and per ton slag. The alkali per ton slag is the most significant, as at least 75% of the alkali removal must be done via the slag. The alkali input in the base case is 13.4 Kg per MTHM and 25.0 Kg per MT slag. The authorized improvements program lowers the alkali input to 9.8 Kg per MTHM and 22.1 Kg/per MT slag. This improvement results from lowering the coke rate and the replacement of sinter by pellets as production increases. The fluxed sinter and improved size consist of the ferrous materials and pellet usage are the significant factors in alleviating the alkali problem.

B. Low reducibility of ferrous charge material.

Acid sinter is being produced with an FeO content of at least 20.0% resulting from a large proportion of the feed being magnetite fines and the consumption of excess coke fines. The particle size of the sinter is too large as is the lump ore resulting in too little a surface to volume ratio for efficient reduction. Since the interim mission, the FeO in the sinter has decreased 4.0% via improved ignition and coke sizing.

The substitution of fluxed sinter for acid sinter will reduce the FeO content of the sinter from 20% to about 10%. The lump ores will all be sized between 8-30 mm. This will increase the surface to volume relationship and provide improved gas to solid contact for improved reducibility. The fluxed sinter will have a smaller particle size than the acid sinter. The chemical and physical properties of the pellets will enhance gas-solid contact and reducibility.

C. Fines in the ferrous charge material.

Approximately 8% of the ferrous material charge is mixed ore or run-of-the-mine. The sinter contains excess fines primarily due to poor bonding of the sinter which is impeded by oversize ore and coke fines and poor ignition on the bed. Ferrous material screening in the stockhouse is not provided.

The improvements to the crushing and screening station will eliminate the usage of mixed ore in the blast furnaces. This problem will not be completely eliminated because sinter and ore fines will be generated in transit between the crushing and screening station and the sinter plant screens. However, stockhouse screening would be a high capital cost project and is not recommended at this time.

D. High alumina input - 18% in slag.

Although the ferrous material is higher than desirable in Al_2O_3, the major problem, at 7.0% alumina content, is the coke. This highly refractory compound enters the slag as the coke ash is released in the hearth area of the furnace. This creates a viscuous hearth slag which cannot be overcome by superheating the slag, because the high alkali input prohibits operation at high flame temperature and slag temperature. The premature precipitation of crystals from this comparatively cold and refractory slag can readily create casthouse problems because of the poor fluidity characteristic of the slag in the iron trough and runners.

Despite a significant decrease in the coke rate, the alumina content of the blast furnace slag cannot be decreased below 17% as the slag volume is also decreasing. Reducing the ash content in the coke is the only way to get the Al_2O_3 content below 15%, which may be considered as a reasonable content in blast furnace slag. The coke ash used in the base case and in all projected cases is 21.47%. If this were to be lowered to 12.0%, the Al_2O_3 would be at the acceptable 15%, when the authorized projects are completed. If the combined % of Al_2O_3 and MgO is limited to a maximum of 22.0%, alkali removal will be enhanced while the slag viscosity problems are minimized. As the alkali input per ton of slag is reduced, the blast furnace slag temperature may be increased. This provides important relief from the high Al_2O_3 viscosity problem.

E. High slag volume - 534 Kg/MTHM.

The high ash content of the coke (21.46%) and the high gangue content of the sinter plant ferrous fines cause a requirement to melt a large volume of slag. This increases the coke rate and, in turn, adds additional gangue components, along with the alkali, to the furnace charge. The degree of Si reduction in the blast furnace is proportional to the SiO_2 input and the retention time in the furnace. The high coke rate increases the retention time of the SiO_2. For these reasons, it is not possible to reduce the Si content in the hot metal to an acceptable level but, at the same time, the high Si in the hot metal increases the coke rate.

The adverse effect of the high percent of coke ash on attempts to reduce the slag volume is quite clear. However, the introduction of fluxed sinter, higher hot blast temperature, upgraded lump ores and pellets reduce the coke rate and gangue material input to the furnace. As a result, the slag volume is decreased by 17% upon completion of the Authorized Improvements Program.

F. Coke quality.

Low strength, large particle size and high ash content are the general characteristics of the coke as delivered to the blast furnaces.

The poor strength is tolerable at this time because the coke rate is high and, regardless of strength, there is enough coke in the charge to maintain bed permeability. However, as coke rate is reduced, high wind volume maintained and higher flame temperatures used, the problem will become more significant.

The large particle size of the coke, estimated to be 65% + 75 mm and 25% + 200 mm, makes burden charge distribution control very difficult. The large pieces entering the combustion zone impede the raceway penetration, thereby limiting the wind volume rate.

The high ash content, as described above, introduces alkali, alumina and excess gangue, all of which are undesirable. The alkali is particularly troublesome. A high recirculating alkali load within the furnace itself creates significant restrictions on the wind volume rate and/or the flame temperature.

The most effective method to improve coke quality would be to reduce the coke ash. The benefits have already been defined and the Turkish Iron and Steel Management are taking action toward this objective. Putting the existing coke crushing plant into operation is also planned so that the coke sizing problem will be eliminated. However, the low strength characteristic of the Karabuk coke will be a continuing problem and will become increasingly more important as the coke rate decreases.

The base case coke has a Trommel Test rating of 70%, but this cannot be related to the ASTM Stability Test rating. Karabuk Works should establish a coke strength testing procedure which would enable them to quantify the benefits of improved coke strength. For example, there is a well-established relationship between ASTM stability and furnace performance. For Karabuk Works, which upon completion of the authorized projects will be operating with a wind volume restriction, a 1% increase in the ASTM coke stability will reduce the coke rate by 3 Kg/MTHM and increase production by 0.5%. As a practical matter, an increase in stability to a rating of at least 50 may be necessary just to support the improved furnace operation resulting from the benefits of the Authorized Improvements Program.

4.3.2 Instrumentation

In general, the instrumentation for the blast furnace and hot blast system operation is not adequate. It is not possible to make a judgment on the integrity or reliability of the equipment or the competence of the instrument maintenance people. However, it is noted that many essential instruments are not available and many that are available are not functioning properly.

The primary problem with instrumentation is on the No. 1 and No. 2 blast furnaces. Since the No. 1 blast furnace reline is scheduled for late this year or early next year, the evaluation of the instruments that are required, shown on the following page, is for the two smaller furnaces only.

It is recommended that funds for the instrumentation shown on the following table, and new stove burners and combustion air fans for the Nos. 1 and 2 blast furnaces (including electrical equipment) be provided from the Stove Modernization Program. However, at this time the schedule for the disbursement of the loans and approval for the scope of work has not been completed.

NO. 1 AND NO. 2 BLAST FURNACES

BLAST FURNACE PROPER	UNIT		QUANTITY	COMMENT
Blast Volume	Nm^3/Min.	Recorder	1	Downstream of snort valve
Hot Bla't Pressure	Kg/cm^2			Hot blast main near bustle pipe
Top Pressure	mm H_2O	Recorder	1	
Stockline Level	m	Recorder	2	
Furnace Top Temperature	°C	Recorder Alarm	1	
Blast Moisture Flow	Kg/Hour	Recorder	1	
Blast Moisture Control	G/Nm^3	Recorder	1	On hot blast side of stoves
Top Gas Analyzer	$CO-CO_2-H_2$	Recorder	1	
Inwall Temperature				

HOT BLAST SYSTEM				
Blast Furnace Gas Pressure	mm H_2O	Recorder	1	
Cold Blast Pressure		Recorder	1	Discharge of turbo sufficient
Hot Blast Temperature		Recorder	2	

STOVES				
Dome Temperature Thermocouple	°C	Indicator	3	Alarm
Dome Temperature Rayotube	°C	Recorder		
Chimney Temperature	°C	Recorder	3	Alarm
Gas Volume Flow	Nm^3/Min.			
Air Volume Flow	Nm^3/Min.			
Chimney O_2 Analyzer	O_2 %	Recorder	3	
Mixer Valve Position		Indicator	1	

4.3.3 Process and Quality Control

In general, the bedding and blending yard will be the project that will be of the most help in process control. However, there will be a long time period during which fluxed sinter will be produced without the benefit of the blending. Control of the flow of the various grades of iron ores to the sinter plant will be very important. The sinter must be sampled frequently and the basicity reported to the blast furnace in time to allow for adjustments to control the slag basicity.

A. Hanging

This occurs frequently -- several times each day, with the exception of the No. 1 blast furnace, which is operating at 75% of normal wind volume to protect the stack shell. Control is by wind volume reductions and hot blast temperature reductions if the furnace hearth appears to be hot enough. Recirculation of alkalies must contribute heavily to the tendency toward hanging.

The reduction of alkali input, the improved sizing of the ferrous materials, and the increased reducibility of the sinter will reduce the tendency toward hanging. Stockline level recorders should be installed and used on all furnaces as well as furnace top gas pressure recorders. These are the instruments that most accurately predict when a hanging condition is developing and give the furnace operator the opportunity to lower the flame temperature or reduce the wind volume slightly to prevent the hanging. These are the two most common countermeasures but others such as filling sequence changes or burden ratio changes can also be effective.

B. Thermal Balance

The furnace hearth heat level varies frequently and rapidly. Control is by hot blast temperature adjustments and extra coke charges. The parameters used for thermal condition judgment are the silicon and sulfur content of the hot metal and the appearance of the hot metal and slag in the casthouse. Burden rate adjustments are used infrequently. Hot metal temperature and slag basicity, the two most important parameters for thermal control, are not known on a cast-to-cast basis. As a result, wide variations are constantly occurring in the silicon and sulfur content and in the temperature of the hot metal.

Furnace hanging and changes in ferrous material chemistry and sizing and coke moisture content changes at No. 3 furnace are the primary causes of thermal imbalances. Since the coke rate will remain relatively high, it is recommended that the moisture in the blast be used as the primary control for slag and iron temperature and that the hot blast remain constant at the maximum allowable temperature. The higher carbon rate assures enough reducing gas so that lowering the moisture, when the hearth is tending to get colder, will not seriously decrease the reducing power of the gas. If the hot metal temperature is dropping rapidly, extra coke charges should be used. When the temperature is rising, there is no problem with additional moisture. It will lower the flame temperature and at the same time generate extra reducing gases which will increase the production rate. In the ideal situation, small adjustments to the burden ratio are the best method of thermal control but the effects require a much longer time.

Slag basicity control is important; and since nearly all the flux material enters the furnace with the sinter, the sinter should be sampled every two hours and analyzed every four hours.

It is recommended that immersion dip thermocouples be used for accurate temperature measurement of the hot metal on each cast and that the slag analysis be taken along with the hot metal analysis. Presently, the slag analysis is available only on the following day. In the event that it is not possible to get a complete slag analysis, it is suggested that the SiO_2 and S be analysed for each cast. Then, with the temperature known, the SiO_2 and S analysis alone will give fairly accurate knowledge of the basicity of the slag.

C. Alkali

An alkali balance is made each day and cleaners are used to minimize the recirculating load. The cleaner consists of 16,000 Kg of quartize, 1,050 Kg of calcium chloride and 10,000 Kg of coke totally containing 95% SiO_2. Recently, this cleaner is charged to No. 3 blast furnace three times per week but is not being used regularly on No. 1 and No. 2 furnaces.

The reduction of the alkali input has been described in the Countermeasures-Raw Materials Section and the usage of cleaners can be effective at times in flushing the recirculating alkalies out of the furnace via the slag. However, since the alkali input still remains extremely high, the adverse affect on process and quality control must never be taken lightly.

The following operating conditions must be monitored closely to keep the recirculating alkali load under control:

(1) The flame temperature must be kept relatively low. This is particularly true if the furnace top pressure is low as on the Karabuk blast furnaces.

(2) The molar basicity of the slag is more important than the percentage basicity. For this reason, it is better to limit the percentage of MgO in the slag. In so doing both alkali and sulfur removal will be enhanced.

(3) Removing raw limestone from the blast furnace will help the alkali removal. Limestone lowers the temperature at which alkali silicates can be reduced and thereby generates a greater recirculating load.

D. Hot Blast Temperature

Operating consistently at the maximum hot blast temperature is difficult because of the frequent thermal changes occurring within the blast furnace that require flame temperature adjustment. The lack of stove and combustion control instrumentation also limits the ability to operate at the maximum temperatures. There is no moisture addition equipment available at the No. 1 and No. 2 furnaces and the reliability of the No. 3 furnace equipment is questionable.

If it is agreed to keep the hot blast temperature at the constant highest allowable temperature, the firing rate of burners must be closely controlled. Air-to-gas ratio control is required, and the temperature measuring devices must be functioning properly. It will be desirable to increase the frequency of stove changes, but this is generally adjusted to the burner firing capacity. The Stove Modernization Project is proceeding, and it is recommended that the stove burners and combustion air fans for the Nos. 1 and 2 blast furnaces, including all auxiliary electrical and instrument equipment, be designed and purchased as soon as possible.

4.3.4 Water Quality

Two separate water systems service the Blast Furnace Plant:

A. Gas Washer Water

The heart of this recirculating system is the pump house which is operated by the blast furnace and consists of the following four sets of pumps:

(1) 3 Gas Washer Supply Pumps - 2 Operate and 1 Standby

These pumps receive water from the forced air cooling tower and pump 1,100 Nm^3/hour to four of the five gas washing towers. One of the towers is normally down for maintenance work. The dirty water returns to a settling basin near the pumphouse.

(2) 3 Slurry Pumps - 2 Operate and 1 Standby

These pumps receive water from the settling basin and pump the slurry water into the bottom cones of two thickeners. The clear water overflow from the thickeners returns by gravity to the pumphouse.

(3) 3 Cooling Tower Pumps - 2 Operate and 1 Standby

These pumps boost the clarified water to the cooling tower from which it returns to the gas washer supply pumps and completes the cycle.

(4) 2 Electrofilter Pumps

These pumps operate intermittently using well water to wash the electrofilter plates.

The functioning of the gas washer water system is questionable. A capacity problem does occur occasionally when the turbidity of the river water gets too high. It then becomes necessary to divert some of the water from the No. 1 and No. 2 gas washer towers directly to the river. More efficient gas cooling is required. Gas cleanliness seems to be satisfactory.

B. Service Water

This once-through water system is not satisfactory. Subsequent to even normal rainfall, the turbidity of this river water rises rapidly. At one time during this mission a stack cooling plate on No. 3 blast furnace was burned for this reason. Three hours downtime were required to replace the cooling plate and another three hours delay was necessary while waiting for the turbidity to decrease.

It is hard to understand why more cooling plates and tuyeres are not being burned. The frequency of burning hot blast valves is the only obvious problem resulting from this cooling water. However, I believe that the efficiency of the refractory cooling is suffering, which could cause the requirement for a premature relining of the No. 3 blast furnace.

As the production rates of the blast furnaces increase, the cooling efficiency of the refractories will become much more important. The temperature of the cooling water is not as significant as the clarity of the water. For this reason it is recommended that the hyperbolic cooling tower be put into service. The problem with the cooling water system is under the responsibility of the Power House Department, so this problem is discussed in another section of this report.

4.3.5 Condition of Equipment

A. Blast Furnace Gas System

There is excessive leakage in the blast furnace gas system, including the large bell seating surfaces, small bell packing, furnace top piping ducts, furnace top bleeders and the No. 3 blast furnace dirty gas valve. The blast furnace gas is not being cooled sufficiently so that excessive water vapor and entrained moisture are being carried into the stove, coke oven and boiler burners.

Recommendations are as follows:

1. Karabuk Works should carry out a detailed study to improve the design of the large bell and hopper to improve the sealing. A detailed report on this subject was presented for reference.

2. The top temperature of the furnaces should be more closely controlled. Temperature excursions above 500° C are frequent. High coke rates make top temperature control more difficult. A reliable water spray cooling system which injects water directly into the furnace should be utilized to control the top temperature to 300°C maximum.

3. Any furnace top piping duct leakage should be detected at once and repaired on the next shutdown.

4. The No. 3 furnace dirty gas valve must be sealed after each usage. Asbestos and water glass was suggested for this.

5. The installation of orifice plates and the supply of additional cooling water will lower the blast furnace gas temperature and increase the production rate. Design concepts for this installation were presented.

B. Hot Blast System

The hot blast valves are a major maintenance problem and will continue to get worse as the hot blast temperature increases.

Stove refractory problems in the form of deteriorating combustion chamber walls and checker plugging are evident.

Tuyere stock leakage is evident and cannot be tolerated when the hot blast temperatures are increased. Tuyere burning occurs approximately once a week per furnace.

UEC comments and recommendations are as follows.

1. Hot blast valve design and manufacturing quality control is not good. A detailed report was presented explaining modern design concepts and giving an evaluation of some up-to-date American and European valves.

2. The combustion chamber of No. 2 stove on No. 3 furnace is undergoing a 2-3 month repair which began September 15. The other two stoves may fail in a similar manner, as they are of the same vintage. More observation and inspection of the stoves is necessary.

3. It appears that some degree of checker plugging is occurring on the No. 1 and No. 2 furnace stoves. Pressure taps have to be installed at the bottom of the combustion chambers to confirm this.

4. The tuyere stock design must be reviewed and the blowpipes must be lined with refractory as the hot blast temperatures are increased.

5. Improved tuyere design, manufacturing quality control, and improvements in water turbidity are needed to reduce the frequency of tuyere burning.

4.5 PROPOSED OPERATING PRACTICES AND MINOR DESIGN MODIFICATIONS

Certain operating practices and minor design modifications have been recommended during the mission. Some have been completely or partially executed while others require additional discussion, study, engineering work, or equipment receipt. They are listed in this section of the final report as a matter of record.

4.5.1 Coke crushing: Karabuk Works are now supplying the manpower.

4.5.2 Reduction in coke ash: Turkish Iron and Steel Company management has arranged this, beginning in September.

4.5.3 Standardize coke strength testing: it is recommended that one of the internationally accepted testing procedures be used in order to more precisely evaluate coke strength as produced and predict the benefits or penalties in future operational changes.

4.5.4 Remove gangue material from blast furnace limestone: this has been done.

4.5.5 Reduce the limestone particle sizing by maximizing the 25-40 mm size to the blast furnaces: this has been done.

4.5.6 Plan to remove almost all limestone from the furnace charge when fluxed sinter becomes available: this is planned.

4.5.7 Screen additional iron ore when the portable roll scale screen is idle to minimize charging mixed ore to the blast furnace.

4.5.8 Change the filling sequence on No. 3 blast furnace by putting the ore on the small and large bells first. This will minimize the abrasion and provide better sealing, both of which will contribute to longer useful life of the bells.

4.5.9 Consider activating the movable armor on No. 3 blast furnace after the crushed coke and fluxed sinter are being charged.

4.5.10 Increase the blast tuyere speed to at least 200 m per second on No. 3 blast furnace. Eight 4-1/2" tuyeres and eight 5" tuyeres must be used. UEC was advised that this practice increased tuyere burning in the past. It was agreed to try it again, after the fluxed sinter is being used.

4.5.11 Make burden balance calculations at least once a month and at any time there is a substantial change in the charge materials.

4.5.12 Compare the burden balance calculation results with the actual operating results to discover any discrepancies such as material analysis, material weights, etc.

4.5.13 Increase the hot blast temperature and add moisture to the cold blast as soon as possible. No action has begun.

4.5.14 Put the blast moisture sampling outlet on the hot blast main near the bustle pipe. This will give an early indication of any hot blast gate or seat water leakage: Awaiting 3.5.13.

4.5.15 Increase the flame temperature and slag basicity slowly as the alkali input per ton of slag is decreasing.

4.5.16 Improve the design of the stockline level indicator device.

4.5.17 After the fluxed sinter is being charged. cast the furnaces eight times per day and discontinue flushing.

4.5.18 Try to improve the quality of the cooling water to the most critical circuits, which in order of priority are:

A. No. 3 blast furnace hot blast valves.

B. No. 1 and No. 2 blast furnace hot blast valves.

C. No. 3 blast furnace tuyeres.

D. No. 1 and No. 2 blast furnace tuyeres.

4.5.19 Install orifice plates in the five downlegs between the gas washer towers and the electrostatic filters while providing for dirty water disposal and mist suppression. This project will increase furnace top pressure by 0.1 Kg/Cm^2 and increase production by 2.0%. Better gas cooling will result and less moisture will be carried over to the stoves and boilers with the blast furnace gas. Leakage in the blast furnace gas system must be stopped before this project is considered.

4.5.20 Install continuously draining barometric legs at the low points in the blast furnace gas headers near the stoves. This will eliminate the moisure that is now entering the stove burners. They should also be installed in the central plant gas main. Design concepts were presented.

4.6 EVALUATION OF THE AUTHORIZED IMPROVEMENTS PROGRAM

GENERAL

An independent detailed evaluation of the authorized improvements has been completed and the results are shown in Appendix 1 - Table 1. The 1981 yearly average actual performance results were used as the base case. The 1981 performance can be considered as a normal operation with the exception of the low production rate on No. 1 blast furnace, because of the poor condition of the stack, and the eight day outage to change the large bell on No. 3 blast furnace. An adjustment was made in the Table to compensate for these two abnormal conditions.

The improvement projects are listed from left to right in accordance with the time sequence in which they are expected to be commissioned. If this sequencing changes the final result will remain the same. The performance values are listed in accumulative fashion but, by taking the difference in the accumulated values, the benefits gained by each individual project is readily obtained.

Table 1 is titled "Blast Furnace Authorized Improvement Program". The benefits from this program can be defined by comparing the base case values with the values shown after the completion of the program.

The Program provides for a 50% increase in hot metal production, up to 834,000 MTHM/year, and a 25% decrease in coke rate, down to 740 Kg/MTHM. Hot metal silicon and sulfur content is lowered and the hot metal temperature is increased. The Authorized Improvements Program planned is well-suited to the existing conditions at Karabuk Works. Money is not yet available for the hot blast temperature increase and the top pressure increase.

The Program may be defined by the following Projects:

A. Coke Crushing
B. Fluxed Sinter
C. Car Dumper Installation
D. Hot Blast Temperature Increase to 800-850°C
E. Ore Crushing and Screening
F. Increase Blast Furnace Top Pressures by 0.1 $Kg/Cm/^2$
G. Reline No. 1 blast furnace
H. Receipt of Pellets - 150,000 MT per year
I. Bedding and Blending Yard for Ferrous Materials

A brief description and the status and the benefits of these projects is as follows:

4.6.1 Coke Crushing

The facility is available for operation. Karabuk Works Management have made arrangements for manpower. The coke will be sized to 25-60 mm. Raw material distribution control will be improved and result in improved permeability in the furnace stack. The penetration of the raceway will be extended further into the furnace. Production will increase 3.5% and the coke rate decrease 1.5%. This operation began in late August but the specified sizing is not being attained.

4.6.2 Fluxed Sinter

The limestone crushing equipment has yet to be checked out. The changeover to fluxed sinter will begin in January. This is a major improvement. 300 Kg/MTHM of limestone will be removed from the furnace charge and replaced with lime in the sinter. The sinter reducibility, strength and sizing will be improved. Production will increase 19% and the coke rate decrease 16%.

4.6.3 Car Dumper Installation

This facility includes ferrous material surge storage in the ore yard for incoming trains, ten additional storage bunkers adjacent to the ore yard, and a new car dumper. The completion date is May, 1983. This facility in itself does not provide any benefits but it is necessary to support the increased production rate resulting from the other projects.

4.6.4 Hot Blast Temperature Increase to 800-850° C

This is the maximum hot blast temperature that can be utilized without some form of hydrocarbon injection at the tuyeres. A project is now authorized and underway to upgrade the hot blast systems to an 1,100° C hot blast rating. However, in the meantime, certain equipment can be installed quickly to attain the 800-850° C temperatures.

From Table 1 it can be seen that other process changes take place as the hot blast temperature is increased. Blast moisture is used on No. 1 and No. 2 blast furnaces and its usage increased on No. 3 blast furnace. The flame temperature is increased, the hot metal temperature is increased and the slag basicity ratio goes up to 0.90. Operation at the higher hearth temperature and slag basicity is made possible by the reduction in the alkali input which results from the 16% reduction in coke rate from the use of fluxed sinter. The average hot metal sulfur is reduced and more importantly the range of sulfur variations will be greatly reduced as the higher hearth temperature and slag basicity will stabilize the thermal balancing.

4.6.5 Ore Crushing and Screening

This project includes the additions of crushing and screening equipment to the existing system and eventually interfaces with the conveyor system to the bedding and blending yard. Upon completion of the project all lump ore will be sized to 8-30 mm. It is now necessary to charge some mixed ore directly to the blast furnaces. The additional crushing capacity will eliminate this problem. Completion of the construction work is planned to be finished prior to the bedding and blending yard. This will be June, 1983.

The elimination of the -8 mm fines will enhance gas-solid contact and reduce the coke rate by 20 Kg/MTHM. The improvement to the stack permeability will permit a 5% increase in the wind volume rate. The combined effects result in a production increase of 7-1/2%.

4.6.6 Increase Blast Furnace Top Pressure by 0.1 Kg/Cm^2

This project requires the installation of orifice plates in the gas downlegs between the gas washers and the electrostatic filters. Engineering concepts were presented. There is no financing provided for this project at the present time. As shown in Table 1, production can be increased by 2% while the blast furnace gas cooling efficiency will be improved. Furnace top and piping duct leakage must be eliminated first.

4.6.7 Reline of No. 1 Blast Furnace

This furnace has been operating since 1972. The stack lining is in poor condition. External water spraying is being applied to the riveted stack shell. Excessive steam generation, despite the water coverage on the hot spot areas, indicates that the wind volume must be kept at about 25% below normal with a proportional loss of hot metal production. The reline is scheduled for January 1983.

The furnace will be relined from the hearth up in-kind and the stoves will be repaired. The outage is expected to be only 38 days.

Table 1 shows the hot metal tonnage from No. 1 furnace to again equal that of No. 2 furnace. Also, an adjustment was made in this column to show an improvement to the percent of on-blast time for the No. 3 blast furnace to compensate for the large bell change in the base case.

It should be noted that, at this point in time, the wind volume has reached the capacity of the turboblowers. This means that additional hot metal production can only be generated by coke rate reductions and flame temperature increases. The higher temperatures will provide improved thermal balance and lower hot metal sulfur.

4.6.8 Receipt of Pellets

Karabuk Works has been alloted 150,000 tons of pellets from the Divrigi Plant. These pellets will have excellent physical and chemical properties. Ten percent (10%) lump ore in the burden will be replaced by the pellets. The improved reducibility can be utilized to reduce the coke rate, slag volume, and silicon and sulfur content of the hot metal. A 5% increase in production will result without increasing the wind volume.

Additional benefits resulting from the usage of these pellets include reductions in the alkali input and the alumina content of the slag.

If possible, it would be highly desirable to increase the allotment of these pellets to the Karabuk Works.

4.6.9 Bedding and Blending Yard for Ferrous Materials

The completion date for this project is not known at this time. The foundations for the stacker and reclaimer rails are placed.

The Bedding and Blending Yard will provide two major advantages. It will provide a needed surge capacity for sinter plant fine ores and it will eliminate the chemical variations in the blast furnace charge materials.

It is very difficult to quantify the benefits from such a facility. As a result this project was not included in Table 1. However, it is a very desirable project and its contribution to the overall Authorized Impovements Program should not be overlooked. The greatest benefit will be in providing chemical consistency to the furnace charge materials, which will greatly improve the process control. The surge storage capacity that it provides will insure the continuity of the ferrous material flow from delivery to the crushing and screening plant to the sinter plant and finally to the blast furnace. As production capacity increases, this becomes more and more important.

4.7 DISCUSSION OF ADDITIONAL IMPROVEMENT PROJECTS

Table 1 shows that, upon completion of the Authorized Improvements Program, the hot metal production and coke rate statistics as compared to the base case are as follows:

	Base Case	Authorized Improvements Program
Total Hot Metal/Year	551,246	834,000 MTHM
Total Hot Metal/Calendar Day	1,510	2,285 MTHM
No. 3 Furnace Hot Metal/Calendar Day	832	1,226 MTHM
Total Coke Rate	977	740 kg/MTHM
No. 3 Furnace Coke Rate	971	738 kg/MTHM

There are additional improvement projects that are in the planning stage which when commissioned, will result in additional production increases. At the present time, the only one of these projects that has financial support is the hot blast temperature increase to 1100° C. However, this requires brick replacement in all stoves and hydrocarbon injection in the tuyeres. It is therefore not considered in the Authorized Improvements Program. This group of improvement projects may be grouped and considered as the next step, as follows:

4.7.1 Additional Proposed Improvements Projects

A. Hot Blast Temperature - 1100° C

B. Hydrocarbon Injection to the Tuyeres for Flame Temperature Control

C. New Sinter Machine Replacing the No. 1 Sinter Machine

D. New Turboblower

E. No. 3 Blast Furnace Top Pressure - 1.2 Kg/cm^2 Maximum

F. No. 3 Blast Furnace Screening of Ferrous Materials

G. New Pig Machine

H. Import Enough Coal to Produce High Strength Coke

With the important assumption that the coke strength can be improved sufficiently to support this program, an approximate evaluation of the benefits can be made. The results for No. 3 furnace only are in Appendix 2. Oil was selected as the hydrocarbon.

No. 3 blast furnace is producing 1,785 MTHM per calendar day and the total production from the three blast furnaces is 1,030,000 MTHM per year at the completion of this program.

The Additional Proposed Improvements Projects do not spend any money for improvement projects on No. 1 and No. 2 blast furnaces, except for the increase in hot blast temperature. This is good judgment. The hot metal production is now exceeding 1,000,000 MT per year and the Ultimate Program will replace the open hearth furnaces with a Basic Oxygen Furnace (BOF) Shop. At that time, a modern blast furnace should replace the No. 1 and No. 2 blast furnaces.

An evaluation of the Ultimate Program is beyond the scope of this mission.

Table 1.

BLAST FURNACE AUTHORIZED IMPROVEMENTS PROGRAM

ITEM		BASE CASE: 1981 ACTUAL – Furnace No. 1	Furnace No. 2	Furnace No. 3	Total or Composite	IMPROVEMENT PROGRAM PROJECTS – Coke Crushing	Fluxed Sinter	Increase Hot Blast Temperature Furnace No. 1 2 3	Ore Crushing and Screening	Increase Top Pressure by 0.1 kg/cm²	Reline No. 1 Blast Furnace – Furnace No. 1	Furnace No. 2	Furnace No. 3	Total or Composite	Receipt of Pellets: 150,000 Tons Per Year – Furnace No. 1	Furnace No. 2	Furnace No. 3	Total or Composite
Working Volume	m³	325	325	818	1,468			800 800 850										
Hearth Diameter	m	4.57	4.57	7.40														
NTHM Per Year		113,655	134,142	303,449	551,246	571,225	679,265	689,120	742,045	757,010	183,960	183,960	425,955	793,875	193,450	193,450	447,100	834,000
NTHM Per Day		311	368	832	1,510	1,565	1,861	1,888	2,033	2,074	504	504	1,167	2,175	530	530	1,225	2,285
NTHM Per Day Per m³ Working Volume		0.96	1.13	1.02	1.03	1.07	1.27	1.29	1.38	1.41	1.55	1.55	1.43	1.48	1.63	1.63	1.50	1.56
On-Blast Time	Percent	98.7	99.0	94.8	96.4	96.4	96.4	96.4	96.4	96.4	98.9	98.9	96.8	97.7	98.9	98.9	96.8	97.7
Coke Rate (Dry)	kg/NTHM	954	973	971	977	962	809	802	780	780	782	782	778	780	742	742	738	740
Carbon Rate	kg/NTHM	767	751	749	754	742	624	619	602	602	603	603	600	602	573	573	569	571
Coke Ash	Percent				21.46	21.46	21.46	21.46	21.46	21.46				21.46				21.46
Sinter	kg/NTHM - Pct	962 59	930 60	1127 66	1046 64	1046 64	913 51	878 48	815 45	799 45				771 43				734 42
Lump Ore	kg/NTHM - Pct	262	252	512	397	397	322	318	987	998				1021				853
Mixed Ore	kg/NTHM - Pct	393	377	57	204	204	561	623										
Total Ore	kg/NTHM - Pct	655 41	629 40	569 34	602 36	602 36	833 49	941 52	987 55	998 55				1021 57				853 48
Pellets	kg/NTHM - Pct																	180 10
Total Ferrous Material	kg/NTHM - Pct	1617 100	1559 100	1696 100	1648 100	1648 100	1796 100	1819 100	1802 100	1797 100				1792 100				1767 100
Measured Wind Volume	Nm³/Hour	44,339	50,184	96,445	190,968	194,787	194,787	190,000	200,000	204,000	52,500	52,500	106,000	211,000	52,500	52,500	106,000	211,000
Hot Blast Moisture	g/Nm³	12	12	19	16	16	16	27 27 34	31	31	27	27	34	31	22	22	29	26
Measured Wind Efficiency	Nm³/NTHM	3,378	3,238	2,633	2,927	2,880	2,422	2,328	2,276	2,276	2,470	2,470	2,109	2,275	2,351	2,351	2,010	2,165
Hot Blast Temperature	Degrees C	605	699	708	685	685	685	828	828	828	800	800	850	828	800	800	850	828
Flame Temperature	Degrees C	1,995	2,074	2,038	2,039	2,039	2,039	2,067	2,067	2,067	2,067	2,067	2,067	2,067	2,097	2,097	2,097	2,097
Limestone	kg/NTHM	347	320	327	330	327	15	15	15	15	15	15	15	15	15	15	15	15
Slag Volume	kg/NTHM				534	529	468	491	473	473				464				438
Slag Basicity					0.75	0.75	0.79	0.90	0.88	0.88				0.88				0.86
Hot Metal Temperature	Degrees C				1,390	1,393	1,400	1,415	1,415	1,415				1,415				1,435
Hot Metal Si	Percent				1.61	1.59	1.29	1.28	1.25	1.24				1.24				1.20
Hot Metal S	Percent				.077	.076	.083	.064	.070	.071				.076				.064
Alkali Input per NTHM - HM Slag					13.4 - 25.1	13.3 - 25.1	11.2 - 23.9	11.1 - 22.6	10.8 - 22.8	10.7 - 22.6				10.6 - 22.8				9.8 - 22.1
Sulfur Input per NTHM - HM S'eq					7.96 - 14.9		8.3 - 17.7	8.6 - 17.3	8.6 - 18.1	8.7 - 18.4				8.8 - 18.9				7.83 - 17.9

Table 2.

ADDITIONAL PROPOSED IMPROVEMENT PROJECTS
NO. 3 BLAST FURNACE ONLY

	MTHM DAY	COKE RATE Kg/MTHM	OIL RATE Kg/MTHM	FUEL RATE Kg/MTHM	C RATE Kg/MTHM	BLAST H_2O g/Nm	WIND VOLUME Nm /HOUR	FLAME TEMPERATURE °C
A. Hot Blast Temperature 1100°C	1,226	613	80	693	543	29	101,000	2,108
B. Hydrocarbon to Tuyeres (Oil)								
C. New Sinter Machine	1,336	587	80	667	523	29	106,000	2,108
D. New Turbobower								
E. Furnace Top Pressure 1.2 Kg/Cm^2	1,638	587	80	667	523	29	130,000	2,108
F. Stockhouse Screening Ferrous Material	1,758	565	80	645	506	29	135,000	2,108
G. New Pig Machine								
H. High Strength Coke								
AFTER ADDITIONAL PROPOSED IMPROVEMENT PROJECTS	1,758	565	80	645	506	29	135,000	2,108
AFTER AUTHORIZED IMPROVEMENT PROGRAM	1,226	738	0	738	569	29	106,000	2,096
BENEFITS OF ADDITIONAL PROPOSED IMPROVEMENT PROJECTS	+ 532	-173	+80	-93	-63	--	+29,000	+12°C

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

STEEL PRODUCING

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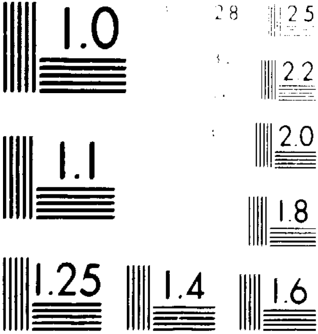

1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

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5.0 - STEEL PRODUCING

5.1 INTRODUCTION

The steelmaking facility is rated at 600,000 tons per year of semi-killed open hearth product. The actual annual production has decreased from a high of 642,474 tons in 1974 to 558,493 tons in 1981, largely because of an increase in average hot metal sulfur from .045 in 1974 to .077 in 1981, and .081 for the first 8 months of 1982. (See Appendix 1.) As expansion facilities from the blast furnace improvement program are brought on-stream, signficantly more hot metal will be available for conversion to ingots. This metal will still be high in sulfur (predicted average of .065), resulting in far from desired open hearth preliminary bath sulfurs.

The primary emphasis of the steelmaking review addresses action necessary to improve steel production and quality.

5.2 SUMMARY

The most significant recommendations for improving the steel melting operations are summarized below, along with the expected benefits. The report contains detailed findings with supporting data and outlines methods and plans for accomplishing desired results.

5.2.1 Reduce Levels of Sulfur in Hot Metal and Mold Iron

A. Short-term: Use more limestone and burnt lime to work sulfur during refining, and reduce final ladle sulfur levels.

B. Intermediate-term: Complete studies, design, and installation of an external desulfurization facility.

Benefits

1. Increased steel production.

2. Improved steel quality to reach competitive exportable sulfur levels.

3. Reduced bottom maintenance from long heat times.

Work to be Done

1. Provide more burnt lime and increase raw limestone additions on high sulfur heats.

2. Install desulfurization facility. While this represents a significant capital investment, it is absolutely mandatory if conversion of the added hot metal from the modernization program is to be accomplished. The installation of an effective desulfurization facility should be the highest priority in the steelmaking plant.

5.2.2 Increase Ingot Production

5.2.2.1 Reduce heat time by a total of 1 hour, 53 minutes, per heat, which will result in an additional 99,000 ingot tons per year from 1981 base to 657,000 ingot tons per year, as an intermediate step to coincide with the ore crushing and blast furnace modernization programs.

Benefits

1. Increased ingot production.
2. Reduced operating costs.
3. Reduced energy costs.

Work to be Done

1. Reduce tap-to-start-charge time by using more 85% magnesite bottom repair material and reducing bottom repair delays.

2. Reduce furnace cold air infiltration by cold and hot gunning regenerative chambers.

3. Reduce fuel consumption by 8% by following firing profiles and reducing fuel rate during exothermic heat cycles.

4. Improve limestone sizing. (Has been accomplished.)

5. Install checker blowing program.

6. Reduce rebuilding time by improved rebuild practices.

5.2.2.2 Improve Scrap Handling Practices

Benefits

1. Increased ingot production.

Work to be Done

1. Complete stiffening of new Stockyard Building A.

2. Clean up both Building A and stockhouse by removing all non-steelmaking raw materials.

3. Develop proper burning layout, establish inside scrap inventories and prepare detailed plan for scrap handling and burning operations.

4. Improve burning equipment and facilities.

5.2.2.3 Install Oxygen Plant, Distribution, and Furnace Oxygen Lance Facilities

Benefits

1. Increased ingot production, to an annual rate of 812,500 tons, using 4 furnaces averaging 7:00 hours tap-to-tap. This is 155,500 additional annual ingot tons above the first improvement levels in Paragraph 5.2.2.1 above.

2. Decreased ingot production costs.

3. Decreased fuel input by 40%, resulting in a $3,747,500 annual fuel savings.

Work to be Done

1. Install a 100-tons per day oxygen plant.

2. Design and install main oxygen distribution system (approximately 750 m).
3. Design, purchase, and install oxygen piping, controls, and lances for each furnace.

4. Train employees and convert from non-oxygen to oxygen blowing furnace practices when facility is completed.

5.2.3 Improve Steel Quality

Benefits

1. Quality to reach exportable levels.

2. Reduced ingot cracking.

3. Reduced mold and stool consumption of 10 kg/ton, resulting in annual savings of $938,000.

Work to be Done

1. Maintain 6 55-cm^2 mold strings in service at all time.

2. Complete mold preparation facilities.

3. Install mold cooling sprays.

4. Reduce sulfur level in ingots and molds.

5. Reduce transit time. (See Section 6, Item 6.5.7.)

6. Investigate improved mold designs and run trials of fluted and corrugated molds.

5.3 DESCRIPTION OF FACILITY

The steel producing facility consists of 6 reasonably standard 150-ton furnaces designed in a European configuration for what is termed a lowto intermediate-tonnage shop. There are no railroad tracks on the charging floor level, and hot metal is added from the back of the furnaces by ladle cranes. The cold charge is placed by 3 overhead charging cranes which reach back to the scrap stock area, pick up a standard charging box, and swing it 180° to the furnace for charging. The cold charge material is set up at this level by 3 stockhouse cranes in a usual scrap yard and stockhouse area. The pouring aisle consists of 3 combined ladles and hot metal charging cranes, supplemented by 2 ladle stand cars (electric-operated, one direction gantry cranes which can each support and move a steel ladle to effectively accomplish teeming). Appendix 10 describes the furnace and auxiliary equipment in more detail.

5.4 ANALYSIS OF PRESENT PRACTICES

5.4.1 Raw Materials

A. Raw Limestone, Burnt Lime, and Dead Burned Dolomite

The chemical composition of raw limestone is good; however, there is too much fine material in the open hearth limestone.

There is insufficient burnt lime available to properly work the high sulfur contained in the hot metal, and this requires considerable additional heat time.

The quality of dead burned dolomite (used in preponderance as the bottom maintenance material, both for hot and cold surfacing) is below standard. This, coupled with high silicon in hot metal, results in excessive bottom repair delay time. The average tap-to-start-charge time for January through August 1982 has been 1 hour, 53 minutes. An accepted standard in the USA for this size furnace is 45 minutes.

Table 5.1, page 10, compares the quality of Karabuk dead burned dolomite with that of the Geneva Works of USS.

The dolomite quarry at Balikisik, 22 km from Karabuk, which has provided the majority of raw dolomite for calcining at the steel producing facility, has been depleted. Another quarry, 1 km away, is being opened and will provide the raw dolomite. This new facility, as it is now being developed, has drawbacks which are having serious repercussions in the steel producing department.

While the new quarry dolomite boundaries are generally defined, no tests and evaluations have been made. The absence of these tests has made it difficult to open up the quarry with a satisfactory mining plan. The net result of this has been that:

1. There is not enough raw dolomite being produced currently.

2. The SiO_2 in the burned dolomite is significantly higher, reaching 5% in 1982. This aggravates already serious dolomite problems.

3. There are no wagon drills available, and the drilling is being done with hand-held jackhammers. The result is short holes because of limitations in steel bit lengths. The employees drilling are working a face with over 100% grade and are tied-off with hand lines. These are very unsatisfactory quarry operating methods.

Recommendations

Raw Limestone

A trip to the limestone quarry revealed that +40 mm limestone was being separated, then recombined, with no size differentiation between open hearth and blast furnace limestone. The practices were changed and the open hearth now receives +70 mm to +40 mm stone. The open hearth limestone is much improved, and a further improvement to eliminate fines generated during wet weather should greatly reduce the fines carried over into furnace regenerator system. This improvement will save 15 minutes per heat, or $200,000 annually.

Burnt Lime

The production of more burnt lime is very important, and any dolomite kiln capacity available should be used in producing burnt lime to add to the 10 tons per day from the old lime furnace.

Availability of additional burnt lime depends largely on reducing the quantity of burnt dolomite presently used, thus making additional dolomite kiln capacity available for production of burnt lime. Thus far in 1982, all dolomite kiln capacity has been necessary to meet burnt dolomite requirements.

According to the raw materials manager, there is burnt lime available for purchase in Safronbolu (12 km from Karabuk).

Burnt Dolomite

The use of greater quantities of 85% MgO material, both for new furnace bottoms and for hot repairs, is necessary to reduce tap-to-start-charge delays and will further reduce the burnt dolomite required.

UEC's consultant spent considerable time and effort in evaluating the physical and chemical qualities of burnt dolomite, and the furnace construction and calcining practices. It was hoped that this process could be signifi- cantly improved. An effective, modern facility was visited in the State of Utah, USA, which provides burnt dolomite to the Geneva Works of USS.

In order to give some concept of the magnitude of the problem in Karabuk, the following comparison is made for January-August, 1982.

	Average Heat Size MT Per Heat	Tap to Start Charge Minutes Per Heat	Dead burned Dolomite kg/Ton	High MgO Material kg/Ton
Karabuk Works	150	113	75.2	1.22
USS Geneva Works Provo, Utah, USA	314	40	21.5	.6

It is the opinion of UEC's consultant that the burnt dolomite produced at Karabuk is 25-30% as effective as that seen in the plant in the USA. The above consumption figures bear out the estimate. The impact on heat time is serious.

It is estimated that 60 minutes per heat could be saved at Karabuk by reducing the excessive delays caused by bottom maintenance.

The use of 85% MgO powdered magnesite has actually increased this year; but as the dead-burnt dolomite quality has deteriorated, there is no apparent reduction in bottom maintenance delays. There are two additional actions that should be taken:

(1) Put in an entire furnace bottom using 85% magnesite.

(2) Use 95% MgO chromate-bonded wet mix material to install a full bottom; also, try it for hot repairing some deep holes.

The chemical composition of the burnt dolomite is similar to that used in the USA; however, it does not appear to be equal in physical properties.

Based on the above, it is suggested that consideration be given to upgrading the calcining furnaces. They should be fired approximately 150° C hotter and may require more combustion air. As the discharge belts are rubber, some alterations to them may be required.

A core drilling test and evaluation program for the Balikisik quarry should be implemented immediately. Determinations of ways to reduce the SiO_2 in raw dolomite need to be made.

A detailed mining plan should be prepared and adopted to allow for more efficient development of the new face.

The quarry chief mining engineer has made many short-term improvements and has leased additional loading equipment, but he needs help in long-range planning and development to solve the problems of burnt dolomite quantity and quality.

As there is no other present dolomite source, and with additional requirements coming from the blast furnace improvement program, this is a plant problem which needs immediate corrective action.

A more aggressive operating practice towards fettling and bottom repairs is needed. This is delay time, and minimum acceptable standards should be established. Every employee working on furnaces should be aware of the importance of properly draining, repairing and making up furnaces and maintaining tapholes. The melters and department supervisors should place more emphasis on this phase of steelmaking, and reduced tap-to-start-charge times will result. Performance should be checked daily.

Table 5.1

ANALYSIS OF RAW AND BURNT DOLOMITE

RAW DOLOMITE FOR CALCINING:

	SiO2	CaO	MgO	Ignition
1982 - JAN	2.10	30.77	19.44	44.44
FEB	2.33	31.12	19.21	45.21
MAR	1.90	31.18	19.69	45.14
APR	1.91	31.40	19.79	45.13
Average	2.04	31.12	19.53	44.98

DEAD BURNED DOLOMITE

	SiO2	CaO	MgO	Alakali	Ignition
1982 - JAN	4.59	54.03	35.11	5.00	1.18
FEB	5.65	54.92	35.37	3.48	.73
MAR*	5.14	53.64	35.13	4.57	1.38
APR**	4.80	53.90	35.54	4.26	1.42
Average	5.05	54.12	35.29	4.33	1.18

	SiO2	CaO	MgO	R203	Ignition	Fe
Geneva Works, USS	1.8	54.12	35.70	1.00	1.14	4.8**

* Includes some raw dolomite from Eflani Quarry.
** Practices add 6% Fe_2O_3 to material before sintering.

B. Hot Metal

The hot metal sulfur is too high to make quality ingots. The silicon is also too high, and the chemistry swings are too large for good steel melting practice. In addition, the casting temperature is too low.

An analysis of all casts made of No. 3 blast furnace for silicon and sulfur for January-September 23, 1982, shows that the average silicon was 1.20%, with ± 0.50% swings in silicon frequently occurring.

Figure 5.1, on page 12, shows hot metal sulfur and silicon in percent distribution curves.

Actual sulfur levels are probably not this high in any other open hearth facility in the world. Hot metal sulfurs in this range would result in rejection by cast.

The open hearth furnace is not an efficient way to reduce levels of sulfur of this magnitude. Removal of percentages above .04 is done at a high cost and at a significant loss of production.

Recommendations

Hot Metal Sulfur - Short-term: With the completion of the ore crushing phase of the blast furnace improvement program, the hot metal sulfur should drop from the .080 average thus far in 1982 to the .065-.070 range. The average silicon should drop from 1.61 in 1981 to 1.25, approximately, and the amplitude of chemistry swings should be reduced significantly. These changes should result in improved predictability and more consistent melting practices with some improvements in heat time and quality.

The short-range improvement is centered around increased use of both raw limestone and burnt lime.

The steel producing division is reasonably successful in removing sulfur when additional care is taken in working heats. An example of this is shown for rail final ladle sulfurs of .033, average, as compared to shop average of .044 for 383 regular heats. These results were recorded for 7 rail heats produced during May and June 1982.

The data are summarized in Appendix 4. An empirical relationship based on segregating the 383 heats shows the following:

The expected sulfur drop from the first test to ladle sulfur by adding a given number of boxes of limestone is as follows:

Boxes of Limestone or Burnt Lime	Expected Reduced Sulfur
0	- .01
1	- .015
2	- .020
3	- .025
4	- .030

A practice of increasing limestone and burnt lime as furnace additions, reducing ore charges, giving additional care to working heats, etc., results in benefits for rail heats but may be impractical and too time-consuming for all heats. For example, if the first sulfur test were .070, an addition of 3 boxes of burnt lime or limestone, with proper temperatures, would result in final ladle sulfur of .045. The first test of sulfur could then be used to predict controlled final sulfur, and consistent use of such practice could result in lower sulfurs and better quality ingots.

During periods of very high blast furnace sulfurs, as are now frequently occurring, management could choose to work, for example, 25% of the heats, with higher burnt lime additions, to produce proportionally lower sulfur heats for potential export business.

The steel producing managers are capable of managing such a program as an interim practice until external desulfurization facilities become a reality. It is also relatively easy to predict what the additional burnt lime and raw limestone requirements from such practices might be. This could require outside purchase of burnt lime.

Consistent attention by melters and shop management is required to ensure continuing success from the above practices.

Hot Metal Sulfur - Intermediate-term: As stated repeatedly in this section, it is mandatory to significantly reduce the hot metal sulfurs to improve product quality to exportable levels and to improve operating performance in the steel producing department. The intermediate solution is to design and install an adequate external desulfurization station.

While several methods of desulfurization are currently available, UEC recommends a calcium carbide reagent system. Mr. Ali Corban from the steel producing department has comprehensive references comparing techniques and also concludes that a carbide system will yield the best overall results.

It is most important to point out that soda ash, another method, is very damaging to basic mixer linings and to open hearth furnace refractories because of active acid slags formed by soda ash. The Karabuk facility already has many other difficulties in bottom maintenance, and soda ash desulfurization should not be used.

Feasibility

A preliminary survey of the No. 1 mixer area was made by Refix Candarli and Ali Coban of Karabuk's steel producing department and UEC Consultants T. E. Gleaon and E. H. West, and the following facts were established:

1. There is room inside the building to place a desulfurization station.

2. The 100-ton No. 1 mixer crane has time to perform the additional work. An earlier industrial engineering study determined a 30-40% crane workload. This was verified by the UEC Consultants' observations.

3. The blast furnace hot metal will be about 45° C hotter than present after completion of the modernization phase, and this will offset desulfurizing temperature losses.

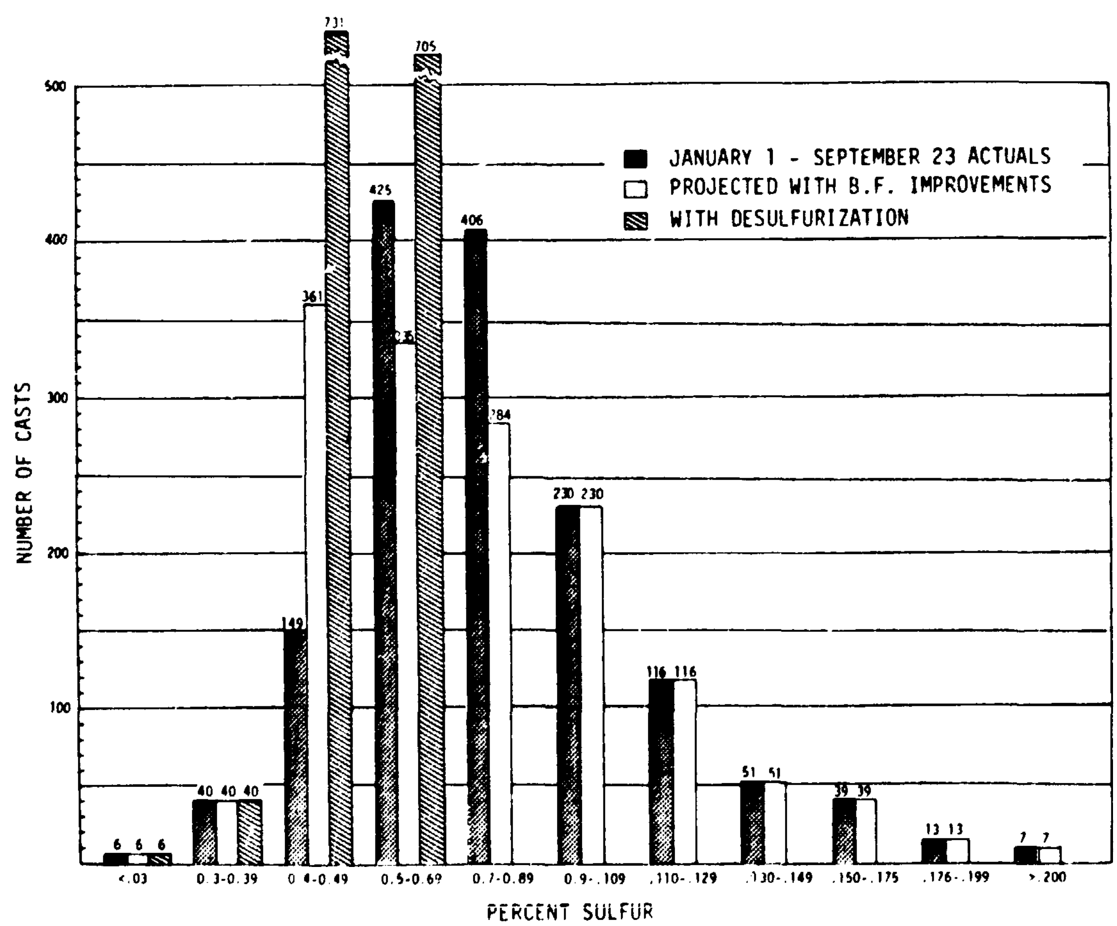
4. While it would be desirable to have a separate building for a desulfurization facility, the tremendous capital required for building space with adequate crane capacity weighs heavily in favor of using the presently adequate No. 1 mixer building. There is also very limited room between the blast furnace and steel shop for a new building.

5. The design should include: a hooded calcium carbide lance for insertion into blast furnace ladles, a mechanical slag skimmer to remove the slag to slag pots, an appropriate lance and carbide storage area, and proper fume control equipment (including a baghouse built outside the mixer building). Estimated capital investment for this facility is $3,000,000. (See Appendix 3.)

Design Criteria

1. All hot metal over .060 sulfur will be desulfurized to an aim of .045. The actual January 1-September 23, 1982, data on No. 3 blast furnace adjusted for the expected .015 improvement in average sulfur, is shown in Figure 5.3. It indicates that approximately 55% of the hot metal will be desulfurized, or 373,000 tons at completion of the ore crushing facilities at the blast furnace.

PERCENT SULFUR BY CAST BEFORE AND AFTER DESULFURIZATION



2. All mold and stool iron over .050 sulfur should be reduced to .035 maximum. Through proper handling by transportation services, it should be possible to selectively burden blast furnaces as "as cast" low sulfur mold and stool iron. This will eliminate the need for desulfurization of most of this material and reduce the movement and switching requirements.

3. It is estimated that 3-4 kg calcium carbide mixture per ton metal will be required to reduce the average initial .09 sulfur to average final sulfur of .045. This is in the range of 45% process efficiency and should result in lower operating costs than the more typical installations starting with .04 sulfur and finishing .01 to .015.

Benefits

While most of the benefits from hot metal desulfurization will result from improved quality, an estimated heat time improvement of 45 minutes should result. Limestone consumption should also be reduced by 10 kg per ton.

The facility modernization program for Karabuk thus far has been involved with raw materials handling and processing through the blast furnace operations, and no technical improvements are presently planned for the steel producing department. As the planned increase in hot metal tonnage becomes available, external desulfurization will make it possible for the steel melting facility to convert the additional tonnage.

C. Scrap Handling and Preparation

The scrap handling, preparation, and charging system has generally limited steel production. The flexibility in adjusting charges does not cover the ranges necessary to obtain full advantage of the open hearth process.

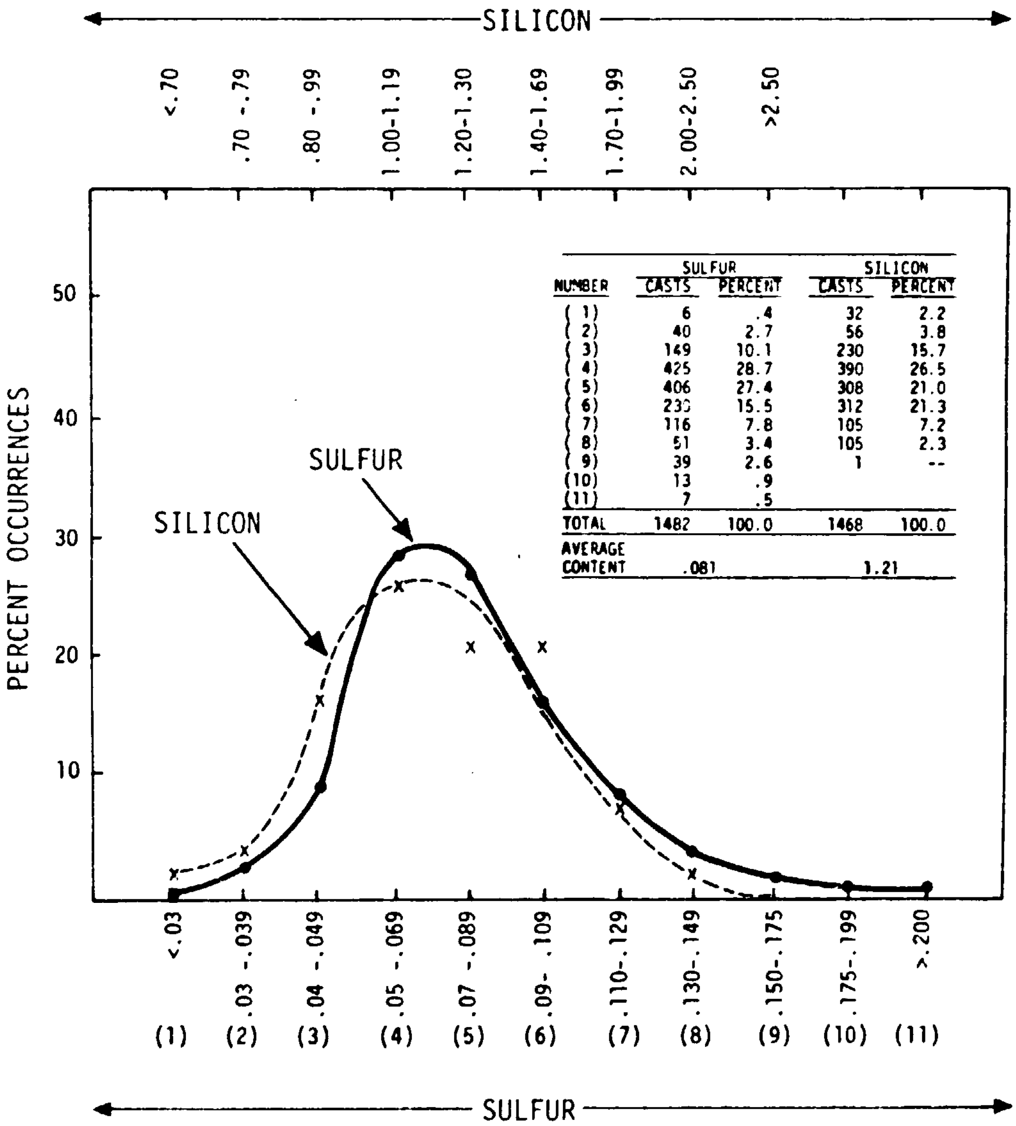
The new scrap preparation area (Scrapyard A, approximately 18 m x 150 m) is limited in production because only one crane can be operated at a time. Although there are two cranes on the runway, the building lacks sufficient structural stiffness to permit them to operate together.

There is no scrap stock available for immediate loading.

Figure 5.1

HOT METAL - NO. 3 BLAST FURNACE

January 1 - September 23, 1982



NUMBER	SULFUR CASTS	SULFUR PERCENT	SILICON CASTS	SILICON PERCENT
(1)	6	.4	32	2.2
(2)	40	2.7	56	3.8
(3)	149	10.1	230	15.7
(4)	425	28.7	390	26.5
(5)	406	27.4	308	21.0
(6)	230	15.5	312	21.3
(7)	116	7.8	105	7.2
(8)	51	3.4	105	2.3
(9)	39	2.6	1	--
(10)	13	.9		
(11)	7	.5		
TOTAL	1482	100.0	1468	100.0
AVERAGE CONTENT	.081		1.21	

The stockhouse (area where scrap is loaded into buggies and set up on back furnace charging platform) is not utilized properly for material handling.

600 m^2 of ideal prepared scrap storage area is tied up by the material used by the Mechanical Maintenance Department.

Considerable furnace rebuild material and debris are taking up space in a crane loading area.

The cutting beds in the burning yard are not layed out for maximum efficiency.

The priority for locomotive crane service given the outside scrap yard (Scrap Yard B) needs to be consistently higher. This is particularly important until the building problems in Scrap Yard A are solved.

The cutting torches and oxygen, acetylene, and propane accessibility needs to be improved. There is no adequate burning method for skulls from iron ladles and thimbles.

Scrap burning personnel are used for bloom conditioning of rail steel.

Recommendations

Detailed analyses of scrap burning and handling were made and instructions for improving practices were given to personnel o~ June 15, 1982, during the first mission. These instructions fully outlined in Appendix 5, with salient points described bel

1. Complete new scrap preparation building, to allow for 2-crane operation; layout burning beds; and replace all of rails inside the area.

2. Remove maintenance parts from stockhouse and establish an inside inventory of 1,000 tons prepared steel scrap and 1,000 tons molds and stools and/or pig iron.

3. Raise the priority for locomotive crane service and maximize scrap preparation outside to help provide needed scrap until the 2-crane operation is functioning. An ultimate prepared scrap inventory of 10,000 tons should be maintained.

4. Make an industrial engineering study of methods and flow of rail bloom scarfing.

D. Inventories

There are no prepared stock inventories of the following raw materials to allow short-term adjustments to cover unexpected supplier outages: raw limestone, prepared scrap, broken molds and stools, basic grade pig iron, and raw dolomite ready for calcining.

Recommendations

Establish, provide, and maintain inventories on hand inside the plant for the following raw materials: 2,000 tons raw limestone, 2,000 tons raw dolomite for calcining, 10,000 tons prepared steel scrap, and 5,000 tons molds and stools or pig iron. A definite plan is necessary over a period of time to accomplish this program.

5.4.2 Furnaces

The furnaces proper, while of good construction and reasonably well maintained, have conditions limiting production and affecting quality or cost as follows.

A. Air Infiltration

The air infiltration levels of the furnaces are too high, with an undesirable effect on heat time. Inspection through front checker bulkheads shows a large amount of cold air coming in through loosely laid brick, wall and ceiling intersections, and at refractory patches. This is also true on newly rebuilt furnaces and gets progressively worse during campaigns.

Recommendations

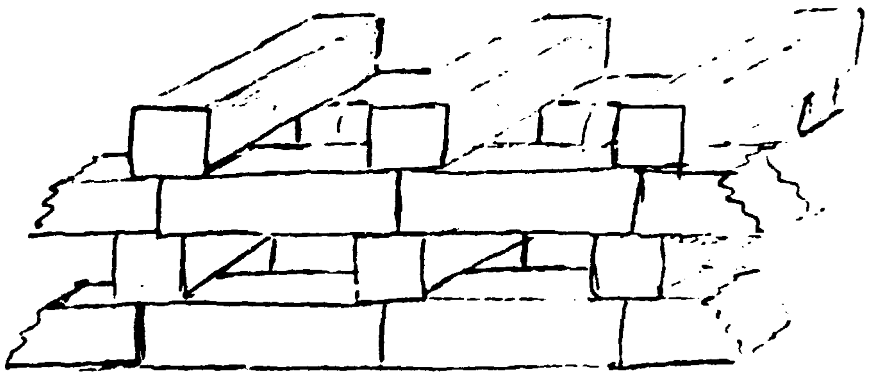
The easily recognizable trouble spots causing infiltration should immediately be filled with plastic chrome mud (prepared at steel producing mud milling location) and heavy clay slurry brushed over all refractory surfaces known to cause air leakage. A much better solution is to use the nozzle mix refractory gun now owed by Steel Producing and completely spray the inside of the regen- erator during each furnace rebuild. The air infiltration can be reduced 40%, which will reduce heat time by at least 15 minutes and result in an annual savings of $200,000.

B. Checker Conditions

During the second half of campaign, after each slag-out rebuild, the checkers are badly plugged, extending heat time. No checker blowing practices presently exist.

The checker brick are 106 mm x 106 mm x 32 cm and are laid in a so-called "European pattern" with 21 cm x 21 cm openings in alternating rows, as shown below in Figure 2.

Figure 5.2



The combustion gases can flow back and forth between the courses, as opposed to the USA practice of having a fixed direction of travel from top to bottom of checker. From 40-80% replacement of checker brick is made every rebuild.

Two different quality checker bricks are used, with a better quality used on the top 3-4 courses and a lesser quality brick used on the remaining courses. The checker brick quality is inferior to checker brick used in the USA.

Recommendations

A checker blowing program should be established and the furnace should be blown every 2 weeks, starting 150 heats after rebuild and continuing to the next rebuild at approximately 250 heats.

As compressed air is available for blowing furnace bottoms at the charging floor level, it could be used for trials and then permanently piped for easy accessibility.

Samples of checker brick were taken to the USA for testing and the significant values are shown below.

	KARABUK WORKS				
	Top Brick		Lower Checkers		USS
	Specs.	Test	Specs.	Test	GENEVA WORKS
Porosity	20% Maximum	19%	20% Maximum	28%	13%
Cold kg/cm^2	250	150	180	75	303

The porosity is very high and the cold strength only 25-50% as high as the Geneva Works checker brick. A USS ceramics engineer evaluated the Karabuk checker brick as minimum insulating quality, undesirable for a high-heat transfer checker brick.
An aggressive, controlled program should be carried out to upgrade and improve the checker brick. As the chemistry is similar, reducing porosity, increasing strengths, and consistent pressing and firing practices need to be accomplished. Karabuk has two well-trained ceramic engineers who can carry out this program.

This will reduce heat time 15 minutes, for an annual savings of $200,000.

C. Fuel Use

The fuel is fired at almost constant Kcal/hour input and is consequently overfired during the exothermic refining period, increasing damage to expensive furnace refractories and i -creasing energy costs.

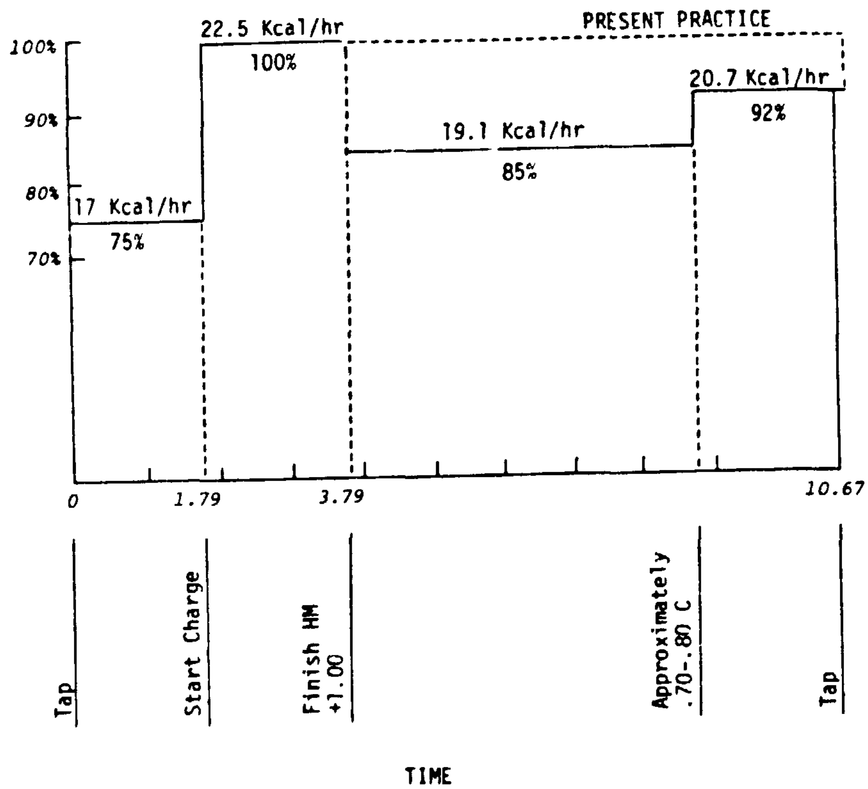
There is no effective organization to assist the steelmaking manager with the important combustion function, operationally and/or on an energy cost basis. Thus, the very important function of combustion management is not performed.

Recommendations

The fuel should be reduced 15%, from 22.5 Kcal/hour input to 19.5 Kcal/hour, commencing one hour after the hot metal is added and continuing until approximately .70 to 1.00 carbon in the bath. A suggested firing profile, shown in Figure 5.4, should be posted on each furnace and the melters should check frequently to verify that it is adhered to.

Figure 5.4

FIRING PROFILE



An 8% reduction in fuel will sav` .got ton, or US $826,000 annually. Addition actory will also result.

Establish a combustion engineer and appropriate department permanently assigned to steelmaking and responsive to the manager of steel producing. The functions to be performed are described in Section 7 by the UEC combustion expert and are essential to the improvement of steelmaking performance and quality. Cost improvement and energy savings will also result.

D. Furnace Door Condition

Furnace door life is well below standard, no door life records are kept, and unnecessary furnace delay time results from excessive door changes.

Recommendations

Assign one of the open hearth engineers the definite responsibility for door life. Establish a reasonably accurate method of determining door life. It will vary significantly by door position, and records should reflect this.

A test and evaluation of various types of door refractory materials and methods should be made and relative life by each practice evaluated. Improvements will result if a consistent program is developed and performance is monitored.

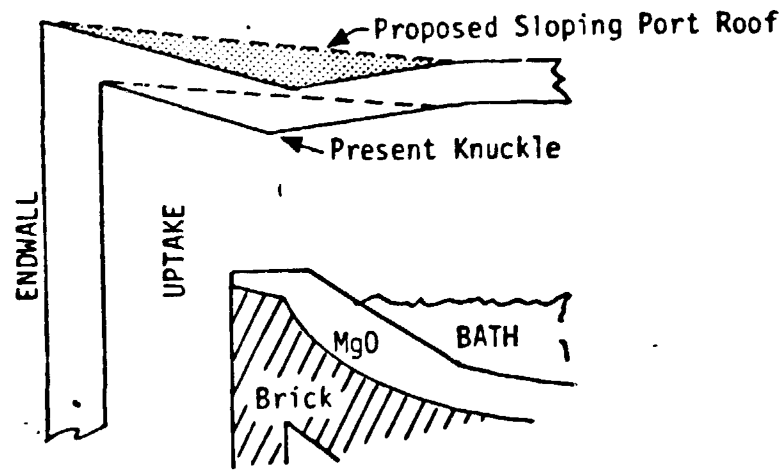
E. Furnace Design

The furnace design restricts the area from top of furnace bridgewall and uptake from 12.057 m^2 in the combustion chamber to 5.100 m^2 past bridgewall and through uptakes. The ratio of these aras is 5.100/12.057, or .423. This severely reduced area is not good design. The result is a very abrasive and concentrated hot combustion gas stream, causing very high refractory erosion from roof knuckles, over port walls, and end walls. It creates higher than desirable furnace pressure at the outstream end of the furnace, which contributes to high refractory costs. The restrictions also cause the furnace draft system to use a large part of the available stack draft to get the air into the furnace and products of combustion up the stack. When a furnace is new and the gas passages are clear of dirt, there is sufficient excess energy to overcome these restrictions without difficulty. However, as the campaign progresses, the uptake restrictions use draft energy that could otherwise go for maintaining proper furnace drafts. If these restrictions were removed, the period of good furnace performance would be extended.

Recommendations

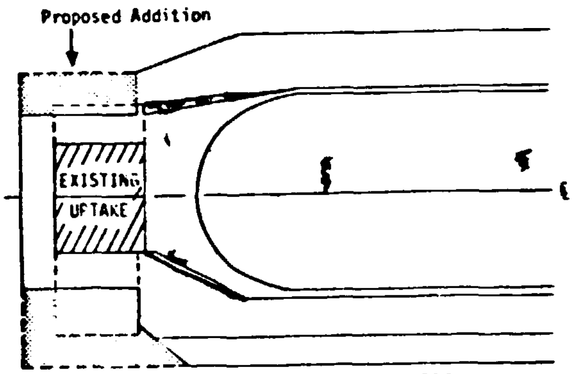
The knuckle should be removed and a straight line sloping from main roof to end wall should be installed. This is simple to install after minor steelwork modifications and it will reduce refractory hours spent laying roof and improve roof life.

Figure 5.5



This type of revision was made on open hearth furnaces in the USA 30 years ago. The necessary steelwork should be modified to lengthen the uptake to the full furnace width.

Figure 5.6



This will relieve the abrasive action on refractories, improve combustion, and decrease furnace pressures which are now excessive. Some engineering will be required for this project and significant refractory savings will result.

Sources of 60% MgO direct-bonded roof brick should be developed. Considerable material savings are possible by reducing MgO content 10%. Most roof applications use 60% MgO brick, even for oxygen roof lance furnaces. If 60% direct-bonded roof brick is not available, 60% MgO chemically-bonded brick should be tried on the furnace roof.

Sixty percent MgO direct-bonded brick would be much more abrasive-resistant on uptakes and port ends, particularly for the Karabuk furnace design.

Panels of the suggested brick should be put in and good records kept for proper economic and operating evaluation. The refractory ceramic engineers can accomplish the evaluations.

5.4.3 Use of Slag Pots

The Karabuk steel operation is still handling both flush and tap slags in slag pots carried by railroad slag pot cars. The normal amounts are 1 to 2 pots flushing and parts of 2 pots during the tap. The front flush slag pots are taken out from under the furnace, turned on a 90° turntable, and pulled by steam engine out of the basement area in front of the checker bulkhead to the slag dump. Dumping is tedious; it is done by unhooking each car, blocking it, and using the engine to pull the pot with a cable.

The slag track extends into the pit from one end of the shop, and tap slag pots are transferred by ladle cranes through the pit to pot cars.

This is a costly method of handling slag and was abandoned in the USA in 1952-53.

Recommendations

It is recommended that slag pots be eliminated and slag be flushed on the ground under the furnace for flush slag and into pit for tap slag. All handling of slag is to be done by 2 977-K tractor loaders and hauled by 2 20-ton heavy-duty mine-type haulage trucks.

Steel plate walls are fastened to supporting furnace structure to contain the flush slag, and it is loaded and hauled after each heat.

A "pot" hole is dozed up in ladle overflow area in pit, and the tap slag overflows into the depression and also is loaded and hauled after each heat.

The benefits are annual savings of $1,391,000 in slag handling, with some unmeasured reduction in furnace delays from reduced slag pot handling delays. The economic development for the above savings is in Appendix 6.

5.4.4 Mold Life

There are not enough 55 x 55 x 205 cm molds in service. The steel producing department has had difficulty maintaining 5 strings of this size, and the resulting mold consumption is too high. With the addition of the rail production, 5 strings are not enough in this size.
Mold consumption data for 55 x 55 x 205 cm molds is as follows:

	kg Molds Per Ton Ingots
1979	12.6
1980	14.3
1981	17.2
January-August 1982 ..	24.1
1979-80 Average	13.5
Potential Improvement.	10.6

Sulfur content in mold iron has increased from .047 in 1974 to .08 in the first quarter of 1982. This has a definite impact on increased mold failures.

While the aim is 5 strings of 55 x 55 x 205 cm molds (90% of production), the plant has been as low as 3 strings in service.

The molds have been cycled as frequently as 8 hours between pours. This use of hot molds is very damaging to mold life and contributes to cracked ingots and poor quality steel.

There is no adequate place to clean molds, and there are no mold spraying facilities at the present time.

A complete mold life improvement study has been given to the steel producing department, and agreement reached that the recommendations, if followed, will solve the problems. Specifically, this study recommends to install mold cleaning platforms, to increase the mold complement to 6 strings and to install mold cooling sprays. This project will reduce mold and stool consumption by 10 kg per ton, which will result in an annual savings of $938,000 and have a desirable affect on ingot quality.

A. Recommendations

1. Improvement of mold life is another reason for immediately proceeding with desulfurization facilities. A 15% savings in mold consumption should result from reduction of premature mold failures.

2. The current improvement plans in the blast furnace predict a hot metal sulfur of .065 with the installation of ore screening facilities scheduled for 1983. This should have some beneficial effect on mold life.

3. The steel producing department should have 6 strings of molds now for the product mix and another string when producing significant rail tonnages. This will require some additional ingot buggies.

4. The best solution is to construct a mold spray system to reduce mold temperature between pours. The spray system would probably reduce the required mold complement by one string. Six strings could then sustain the present product mix plus added rail tonnage. This would save the added cost of one mold string. Figures 5.7, 5.8, and 5.9 show design suggestions.

5. The most recent plans are to construct mold preparation tables inside the little-used track in the stripper building. This is the best, most economical solution to this problem and it should be done immediately.

B. Benefits

The installation of the recommendations above will result in mold savings of 10 kg per ton ingots. By using present mold costs minus outside scrap replacement as scrap mold credit on 1981 tonnage figures, this represents $938,000 annual savings in operating costs. Based on this savings, the construction costs will soon be recovered.

Significant quality savings will be as follows:

1. Reduced ingot cracking from pouring into hot molds.

2. Significantly better surface by greatly reducing mold smear (cast iron from mold pulling out and adhering to ingot surface). Considerable mold smear has been observed on ingots at the stripper.

C. Timetable

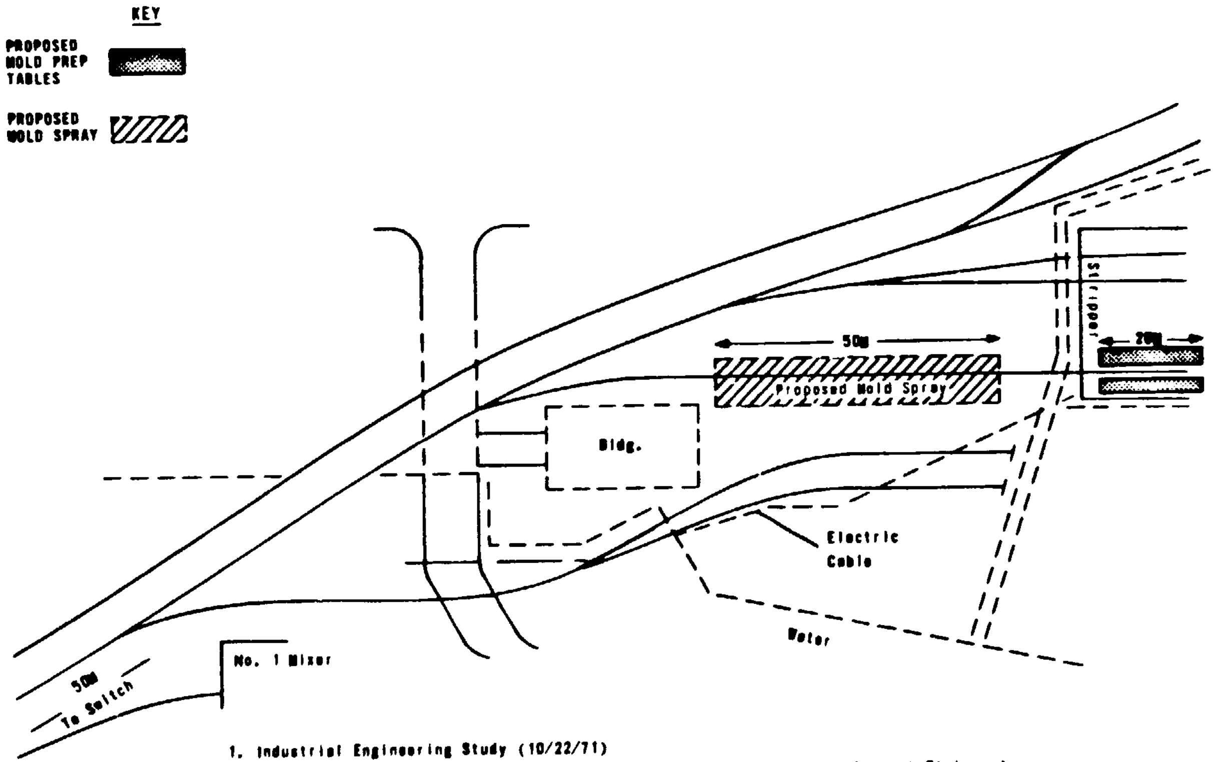
The plant staff is presently working on a desulfurization project. The installation should be completed one year after authorization.

Part of the buggies for the 6th string can be provided by reducing the number of buggies out of service in the maintenance shop (25 buggies, or 21.2% of the complement). A 15% outage for maintenance can be attained with good maintenance and followup programs. A previously submitted request for authorization for additional buggies should also be approved. This should be accomplished in 1985.

A mold spray system should be designed and constructed immediately. This project should be ready for operation by May 1, 1983. Design and cost studies should be completed by December 3, 1982.

Figure 5.7

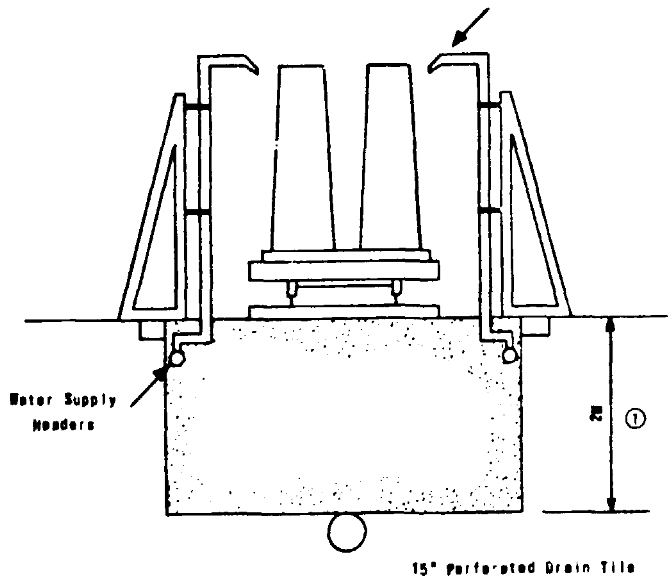
SUGGESTED LOCATION FOR MOLD SPRAYS



1. Industrial Engineering Study (10/22/71)
   Recommended Mold Preparation Platform (A Bldg. With Crane Outside Present Stripper).
2. Steel Producing Subsequently Recommended Mold Preparation Table be Placed Inside Stripper Area on Single Track. Plant Manager Approved for Steel Producing to Construct With Existing Manpower by Letter on 7-13-81.
3. Mold Preparation Tables Have Now Been Placed on the 1983 Budget List.
4. Mold Sprays Should Be on Proposed Mold Preparation Track Outside Building.

Figure 5.8

SKETCH OF MOLD SPRAY DESIGN *



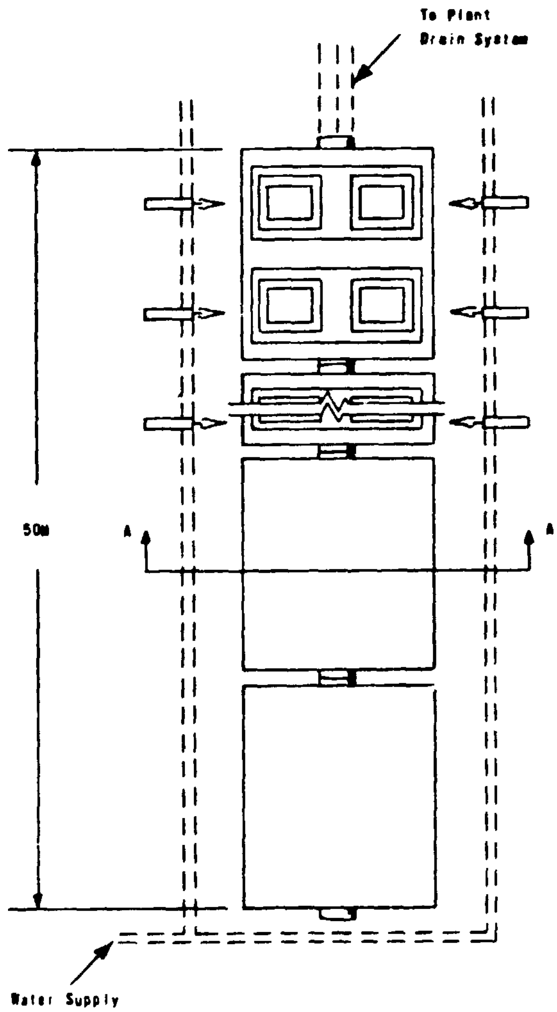
SEC. A.-A.

① Depth May Be Less To Fit Drain System Grade

* Not to scale

Figure 5.9

PLAN OF MOLD SPRAY *



* Not to scale

5.4.5 Other Practices

A. Furnace Rebuilds

The furnace rebuild time is excessive. The 24 rebuilds completed during 1981 and 8 months of 1982 averaged 25 days per rebuild. All had 40-80% checker replacement, but checker work does not pace a significant portion of the critical path. (See Appendix 2 for detailed record of rebuilds for 1981 to date.)

- Furnace rebuild time can be reduced by setting acceptable down-time objectives, by using a modified critical path method on each rebuild, and by careful coordinating between the various maintenance organizations and the steel producing department. Improved planning meetings, checklists, and as done inspections by all contributing departments, are required.

An industrial engineering study, made previously, referred to 13 and 16 days as recommended times for minor and major rebuilds, respectively. If 16 days were used as an acceptable rebuild average, this would reduce 9 days per rebuild based on historical data from Appendix 2. Translated into furnace operating hours and ingot tons, this represents an additional 37,800 tons annually. Methods studies of improved practices should be completed and use made of this equipment to speed up critical jobs.

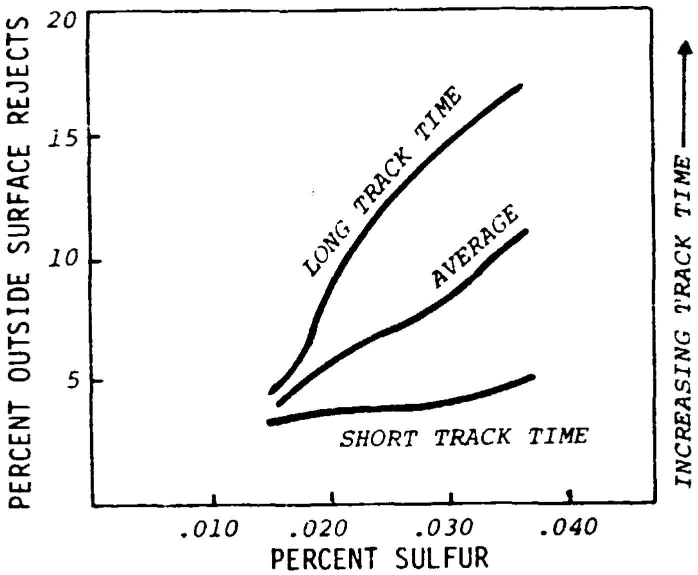
B. Ingots With Cracked Surfaces

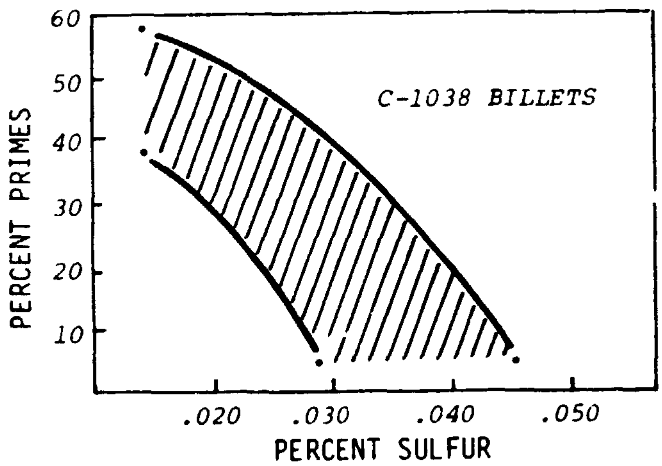
The ingots consistently have cracked surfaces, a condition which occurs more frequently on the higher sulfur analysis heats.

The cracked ingots are largely caused by higher than acceptable sulfurs for rolling applications. The curves in Figure 5.10 support this statement.

Sulfur levels must be reduced, particularly for any expected tonnage for export.

Figure 5.10





REFERENCE: "New Development in Low Sulfur Steel - Needs for Production", 35th General Meeting, AISI, New York, New York (USA), May 26, 1977. Authors: John P. Orton, STELCO; Peter J. Koros, J&L; John J. Bosley, USS.

C. Transit Times

The total transit time is too long, particularly for the size ingot being cast.

Reducing transit time in steel producing should consist of an immediate 1-month trial of changed ingot pouring sequences and elimination of holding times after pouring. This is covered in Section 6, Rolling Mill. This practice change was initiated on September 18, 1982.

5.5 FURTHER RECOMMENDATIONS

5.5.1 Conversion to Furnace Lance Oxygen Practices

As an intermediate-term project, a 100-ton per day oxygen plant with the instrumentation, distribution, and furnace oxygen lances, should be designed and installed.

This is a significant "round-out" project and would optimize the ingot tonnage after desulfurization and benefits from larger heat sizes are attained. The recommendation is made considering factors as follows:

A. The actual capital equipment required, other than the oxygen plant itself, is estimated on a preliminary basis at $800,000 (see Appendix 7). The most desirable way to acquire oxygen facilities is by buying oxygen through a long-term leasing arrangement.

B. If the 100 tons per day plant is installed and operated by Karabuk, the capital cost would be approximately $6,400,000. Such facilities should be planned and built for approximately 50% of any future BOF oxygen requirements. They would be designed for a delivered volume of 100 tons per day at 220 PSI. This would require a line pressure regulating system and use of supersonic velocity furnace oxygen lances for the open hearth shop. Depending on the method of amortizing the oxygen plant costs, the cost per added ton ingot capacity will vary from $9 with leased oxygen facilities to $68 for capitalized oxygen plant and distribution system.

There are operating cost savings estimated at $2 per ingot ton in addition to the increased ingot tonnage possible.

C. Conversion to oxygen practice with 40% potential fuel savings, or $3,747,500 per year, in fuels would relieve the serious energy problem now existing at Karabuk. Careful evaluation of these savings in total plant profit would further enhance the change to oxygen and help offset the high capital conversion costs.

5.5.2 Increased Heat Size

In the transition from 657,000 annual tons to the 812,500 maximum plan supported by lance oxygen, a logical step would be to increase the heat size to the maximum the ladle cranes will carry. This is 164 tons per heat (2 ladles at 100 tons each - 2 with linings at 18 tons = (200 - 36) = 164 tons per heat. This step is proposed as Case 3 (see Appendix 8). The cost for this step would be that required to increase capacity of the steel ladles, which is not large, and this could easily be done at the Karabuk maintenance shops.

5.6 INCREASED INGOT CAPACITY OPERATING PLANS

Several cases have been developed to achieve a realistic forecast for steel production transition and use of additional hot metal tonnages from blast furnace improvements. These data are shown in Appendix 8.

All cases presuppose that all hot metal tonnage possible will be converted to ingots.

All the major raw materials are indicated in Appendix 8 to show the expected variations from step to step.

5.7 IMPACT OF MAXIMUM PRODUCTION OF 812,500 TONS ON PLANT SCRAP BALANCES

Appendix 9 displays he purchased scrap necessary to support each case. The total cold scrap to be handled is important and Appendix 9 has been developed to show how much total scrap will be processed in each case. Case 4, for 812,500 ingot tons, will require 47.9 tons per heat for 656 tons scrap each day. Also required each year is 80,700 tons of purchased scrap. This is probably more than is available within Turkey and will require long-term purchases from the USA or Europe. Scrap is available for purchase and the total price is not prohibitive. Presuming the 812,500 tons results in exported steel products, the balance of payments from importing scrap would be controllable.

5.8 TIMETABLES AND RESPONSIBILITIES

In conjunction with the steel producing department manager, one member of steel producing management has been assigned coordination and reporting responsibility for each improvement project.

Priorities and appropriate timing for each action on the projects were established with the department manager and some activity on 13 of 25 projects resulted by September 30. This report also places emphasis on additional benefits to he realized and should be used by the department manager to keep the projects moving.

Improved limestone sizing .... Adopted 1 June 1982
Responsibility: Erol Kigil

Reduced sulfur .... 1 September 1982

Trial heats with additional burnt lime.

Increase burnt lime production .... 1 January 1983

Increase burnt dolomite usage .... 1 January 1983

Scrap handling and preparation:

A. Alteration to building ...... Commence by 1 September 1982

B. Clean stockhouse building and rearrange scrap storage .... 31 December 1982

Responsibility: Safik Dogan

Provide working inventories inside stockhouse .... 31 December 1982

Responsibility: Sefik Dogan

Reduce air infiltration .... 31 August 1982

Responsibility: Seref Yucebag

Checker blowing program .... No Date Set

Additional development work is required.

Reduce fuel consumption .... 31 August 1982

Responsibility: Seref Yucebag

Assign a combustion engineer to steelmaking ...... No Date Set

Assign door life responsibility to a steelmaking engineer .... 1 September 1982

Reha Derici has been assigned. Major problems to be identified by date specified.

Modify furnace roof, Step 1 .... 1 October 1982

Responsibility: Asil Savran

Reduce furnace rebuild time .... 1 October 1982

Responsibility: Refractory Superintendent

Improve ingot surface .... No Date Set

This is contingent upon the completion of other projects.

Reduce transit time .... 1 August 1982

Responsibility: Refik Gandarli

Improve mold life .... No Date Set

A procedure is being developed by Semik Ergintan and Ali Goban.

5.9 METHOD OF STUDY, OBSERVATIONS, AND TECHNICAL DATA DISTRIBUTED

The previous UNIDO reports on the Karabuk steelmaking department were reviewed prior to the start of the mission. Upon arrival, each value was verified by actual observation and review of reports. Priorities were established for developing solutions for identified problems. Changing circumstances altered first impressions.

For example, from previous reports the UEC Consultant expected to find considerable difficulty in pouring practices. Observation over 20 heats actually poured demonstrated virtually no serious problems in pouring practice. At first, from observations on the charging floor, a conclusion was drawn that 1,600° C tapping temperatures were too hot and contributed to excessive bottom maintenance. Continued evaluation recognized that the bifurcated spout and splitting 150-ton heats into 2 ladles caused more temperature losses than conventional pouring. The number of small ladle skulls observed tended to verify that the tapping temperatures are reasonable for this shop.

All steelmaking facilities and practices were frequently monitored, including visits to the limestone and dolomite quarries. All operating and cost reports for 1981 and 1982 to date were reviewed. Observations at the stripper yarc and meetings with refractory, industrial engineering, and raw materials departments were used, making facts available upon which the various recommendations were based.

Technical Data Distributed

While the methods mentioned previously were being employed, much information, coaching methods and technical data were given to the proper persons, with the following documents left at the steel production department.

1. 1st Helper heat report.
2. Monthly USS comparative open hearth operating report.
3. Monthly operating usage report.
4. Daily fuel and oxygen reports.
5. Weekly furnace rebuild status reports.
6. Monthly fuel and oxygen operating trend charts.
7. Sample air infiltration traverse sheet.

8. Mold, stool inventory chart, year-to-date, 1981.

9. Results of steel chemistry tests run in the USA.

10. Results of checker brick test run in the USA.

11. Sample of dead-burned dolomite used at Geneva Works, USS.

12. Oxygen burning and scarfing equipment and techniques.

13. Specifications information -- raw materials and refractories.

14. Training and theory data:

    a. 1st, 2nd, and 3rd Helper training manuals.
    b. UEC energy saving questionnaire to evaluate practices.
    c. USS Youngstown Works' performance record on energy savings.

15. Prints of specific equipment:

    a. Corrugated, fluted mold designs in similar ingot sizes.
    b. USS Geneva Works 2-port fuel burner.
    c. USS Youngstown Works -- furnace oxygen layout, general only.

APPENDIX 1

INGOT TONNAGES AND HOT METAL SULFUR

Year	Ingot Tons Per Year	Charge to Tap (Hours)	Hot Metal Sulfur (Average)
1974	642,474	8.70	.047
1975	625,037	8.78	.053
1976	609,941	9.02	.065
1977	601,324	9.28	.059
1978	597,772	9.37	.070
1979	561,871	9.63	
1980	564,673	9.45	
1981	558,493	9.52	.077
1982*	547,960	9.89	.08
PERCENT CHANGE, 1982 vs. 1974	-10.5	+ 11.4	+ 74.4

* January-August projected.

FURNACE REBUILD DATA

Furnace Number	Rebuild Commence	Rebuild Complete	Total Days	Type	Number Heats
1981: B	24 JAN	13 FEB	20	Major	490
F	24 FEB	19 MAR	23	Minor	263
D	19 MAR	18 APR	30	Minor	257
C	18 APR	07 MAY	19	Major	515
E	03 MAY	27 MAY	24	Major	483
A	30 MAY	18 JUN	20	Minor	284
B	17 JUN	10 JUL	23	Minor	274
F	10 JUL	19 AUG	40	Major	476
D	19 AUG	07 SEP	19	Minor	265
C	08 SEP	28 SEP	20	Major	253
E	05 OCT	27 OCT	22	Minor	268
B	15 OCT	09 OCT	25	Major	471
A	31 OCT	16 DEC	47	Major	562
1982: D	16 DEC	10 JAN	25	Major	468
F	10 JAN	06 FEB	26	Minor	269
C	06 FEB	25 FEB	19	Minor	254
E	26 FEB	21 MAR	24	Major	485
B	21 MAR	13 APR	24	Minor	261
A	14 APR	14 MAY	30	Minor	238
D*	14 MAY	05 JUN	22	Minor	254
F*	29 MAY	24 JUN	27	Major	492
C	25 JUN	26 JUL	32	Major	495
E	26 JUL	16 AUG	21	Minor	269
B	16 AUG	10 SEP	25	Major	522
		AVERAGE:	25.3		

* Frequent observations were made on these 2 furnace rebuilds.

KARABUK HOT METAL DESULFURIZATION STATION
(Preliminary Estimate)

LOCATION .... Inside No. 1 Mixer Building
CAPACITY ...... 67% of 1,860 Tons/Day = 1,250 MT/Day

ESTIMATED CAPITAL EQUIPMENT COSTS:

	1,000 Dollars		
	Turkey	Exchange	Total
Process Equipment	500	1,000	1,500
Utilities, General Service	750	--	750
Lancemaking, Scales, Dekishing, etc.	650	100	750
Total	1,900	1,100	3,000

TOTAL ESTIMATED CAPITAL COST .... $ 3,000,000

Estimated calcium carbide consumption to reduce the average metal from .090 to .045 at 45% efficiency would be 3-4 kg/MT hot metal.

APPENDIX 4

REPRESENTATIVE HEATS

DATE	NUMBER HEATS	CHARGE/ TAP	TAP/ TAP	TAP/ START CHARGE	SULFUR First	SULFUR Ladle	AVERAGE BOXES, FEED Ore	AVERAGE BOXES, FEED Burnt Lime Limestone
3/05-3/31	30	9:36	12:20	2:46	.067	.045	.6	1.0
5/14-5/17	30	9:00	10:33	1:33	.052	.042	.8	.4
5/20	10	8:20	10:13	1:54	.055	.043		NO DATA
5/21-5/23	34	8:38	10:45	2:07	.057	.044	.7	.2
5/25-5/26	18	8:52	10:50	1:58	.055	.044		NO DATA
5/27-5/29	26	9:10	10:57	1:47	.061	.045	.6	.7
5/30-6/04	51	8:59	11:01	2:02	.058	.047	1.10	.4
6/05-6/09	51	8:34	9:45	1:15	.064	.067	.9	.8
6/10-6/13	46	9:14	10:38	1:14	.073	.050	.5	1.5
6/14-6/15	16	9:10	11:04	1:54	.045	.035	1.0	.5
6/16-6/17	21	8:52	11:12	2:20	.050	.039	.7	.1
6/18-6/19	24	8:58	10:30	1:32	.064	.049	.4	.8
6/20-6/22	33	9:15	10:56	1:41	.063	.048	.8	1.0
Average:	383	8:53	10:41	1:48	.058	.044	.8	.6
9/01-9/19	186	10:50	12:41	1:51			NO DATA	
Rail Heats:	7	9:12	10:31	1:19	.053	.033	.4	2.6

Number Boxes - Limestone/Burnt Lime	Empirical Value*: Expected Sulfur Reduction
0	.01
1	.015
2	.020
3	.025
4	.030

* Projected values based on actuals from 383 heats above.

RECOMMENDATIONS: SCRAP HANDLING AND PREPARATION

The managers of the steel producing division are aware of many of the problems and have concurred with part of the solutions mentioned below.

1. Immediately do whatever is necessary to correct the building vibration problem in Scrap Yard A building to allow for 2-crane operation.

   A. Clean out all old scrap and level area.

   B. Prepare a detailed layout and material flow sketch by types of material processed.

   C. Extend railroad tracks through building.

   D. Put major effort to burning steel scrap, and discontinue iron scrap burning until the crane operation is effected.

2. A steel producing operation this size should maintain a prepared scrap inventory (ready to be loaded for charging) of at least 10,000 tons.

   Approximately 1,000 tons of molds and stools or pig iron stock, and 1,000 tons of steel scrap, should be maintained inside the stockhouse. This stockpile will be replenished as soon as possible after use.

3. The stockhouse should be cleared of everything except raw materials.

   The maintenance materials should be moved outside and stored neatly. All rebuild debris should be cleaned up immediately and not allowed to accumulate in this area. All space inside is needed for prepared iron and scrap stockpiling.

4. A detailed written plan for the cutting beds should be developed, and all craftsmen, scrap burners, and everyone involved trained to use all space as the layout plan dictates.

5. The very short-term ability to process the necessary scrap rests with efficient cutting outside in Scrap Yard B until the Scrap Yard A buiding is completed. Adequate locomotive crane support must be assigned to service the outside burning crew. This should include one locomotive crane each turn the outside scrap crew is assigned. Of course, enough effective burners should be scheduled to utilize this crane properly.

6. There are several specific suggestions to improve equipment, as follows:

   A. Oxygen should be piped directly from the oxygen plant to cutting stations in Scrap Yard A.

   B. It is suggested that a bulk propane tank be set up outside the area and that propane outlets be tied in to oxygen stations. This would virtually eliminate the use of oxygen and acetylene bottles in this building. (This is a significant safety item.)

   C. The engineering department should design and build a powder flux iron skull burning installation. The major torch suppliers can be of great assistance here. Industrial engineering can also work out financial aspects of this torch, which is the only effective method to burn cast iron skulls.

   D. A review of the best cutting torches currently available should be made and improved torches purchased. Vendors and torch suppliers may assist in furnishing technical assistance.

7. A complete study for conditioning blooms for rail production should be made. Considerably more scarfing capacity is needed. The crews for this operation should not come from the scrap burning allocation, as this results in a critical part of steel producing capability being reduced.

   An industrial engineering methods and layout study should be completed immediately.

DEVELOPMENT OF ECONOMICS:
FLUSH OPEN HEARTH SLAG ON GROUND

1. PRESENT METHOD: COST OF SLAG POTS, MAINTENANCE, HANDLING.

	TOTAL TL
25 pots at 2,750,000 TL	68,500,000
Maintenance costs on pot cars	15,000,000
Dumping costs - pit side	30,000,000
- stockyard	50,400,000
Track maintenance (caused by dumping)	94,500,000
Cost to rerail slag pot cars	10,000,000
Steel producing labor on pots .... (20 men at 163.5 TL/hour x (48 x 50)	7,831,000
TOTAL COST PER YEAR	276,231,000

2. PROPOSED METHOD:

Labor:	
Tractor Operators - 7 x 174.7 TL/hour x (48 x 50)	2,935,000
Truck Drivers - 7 x 174.7 TL/hour x (48 x 50)	2,935,000
* Maintenance:	
Tractors - 2 (35,525,000 TL 5)	14,210,000
Haulage trucks - 2 (28,000,000 10)	5,600,000
Fuel cost	3,975,000
Tire replacement	3,150,000
TOTAL PROPOSED COST PER YEAR	32,805,000

* Maintenance equation: $\frac{\text{Total Cost}}{\text{Life}}$ = Average Maintenance Cost/Year

3. SAVINGS

	TOTAL TL
Present costs	276,231,000
Proposed costs	32,805,000
Savings	243,426,000

This is $ 1,391,000 per year savings.

4. CAPITAL COSTS:

2 977K tractors	=	203,000 x 2	=	$ 406,000
2 20T Euclid tractors	=	160,000 x 2	=	$ 320,000
				$ 726,000

$726,000 x 175 TL/$	127,050,000
Install front flush steel slag retaining chambers: $20,000 x 6 = $120,000 x 175 = ...	21,000,000
TOTAL CAPITAL	148,050,000
SAVINGS YIELD PER YEAR	243,426,000

APPENDIX 7

ESTIMATED CAPITAL FOR 100 NT/DAY OXYGEN PLANT,
OXYGEN DISTRIBUTION, MEASURING, FURNACE LANCES

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1. OXYGEN PLANT (located where BOF studies indicated) .. $ 5,600,000

   Daily output: 100 T O_2, 220 psi, 1,000 ft^3 per ton ingots produced.

   Long-term lease should be accomplished, if possible, with major air production expert contracted to build plant and operate.

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2. KARABUK FACILITIES:

6" distribution line from O_2 plant, 500 m outside, 250 m OH building	$ 100,000
12 oxygen flow meters	42,000
30 oxygen lances at $3,500 each	105,000
12 lance hoists and structures	100,000
3 lance cooling water pumps	60,000
Water supply lines, $12,000/furnace	70,000
Oxygen supply lines (header to furnace), $25,000 per furnace	150,000
Engineering	100,000
Contingency (10%)	73,000
TOTAL	$ 800,000

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3. TOTAL ESTIMATED CAPITAL REQUIREMENT:

   $ 5,600,000 + $ 800,000 = $ 6,400,000

STEEL PRODUCING

DEVELOPMENT OF INTERMEDIATE-RANGE OPERATING PLAN AND MATERIAL BALANCE

		BASE CASE 1981 ACTUAL	CASE 1 (1) FLUX SINTER - RECORD STEEL MELTING	CASE 2 (2) ORE CRUSHING	CASE 3 (3) INCREASE HEAT SIZE	CASE 4 (4) OXYGEN LANCES
1.	STEEL PRODUCTION DATA:					
	a. Ingot tons, annual	558,4[illegible]3	642,474	657,000	718,300	812,500
	b. Number heats	3,643	4,283	4,380	4,380	5,000
	c. Heat size	153.3	150	150	164	162.5
	d. Number furnaces	5.0 (-)	5.0	5.0	5.0	4.0
	e. Tap-Tap, hours:minutes	11:58	10:14	10:00	10:00	7:00
	f. Number heats/day	10.0	11.7	12.0	12.0	13.7
2.	YIELD	84.4	85.0	85 0	85.0	84.0
3.	TOTAL BLAST FURNACE PRODUCTION - TONS	551,566	679,000	757,000	757,000	834,000
4.	MATERIAL BALANCE - TOTAL	664,870	755,850	772,940	845,100	967,300
	Hot metal	429,613	536,000	604,000	604,000	679,000
	Pig iron	7,390	12,000	12,000	12,000	12,000
	Molds - stools	13,460	13,490	12,350	13,500	15,300
	Other iron	13,300	14,150	14,850	14,850	15,560
	Revert (mill scrap)	43,560	50,110	51,250	56,030	63,370
	Open hearth scrap	36,150	41,530	42,560	46,500	52,620
	Ore, metallic tons	54,170	62,320	63,730	68,700	48,750 (5)
	Ore, natural tons at 60% Fe	90,280	(6)	(6)	(6)	(6)
	Purchased scrap - 1981	45,700	26,200	-27,800	29,520	80,700
	- 1982	62,000				
	Raw limestone	35,911	41,760	42,700	46,700	42,250 (5)
	Burnt lime	6,700	3,850 (8)	3,940	4,310	2,440 (5)
	Kolemanite	5,250	5,780	5,900	4,330 (9)	3,250 (5)
	Burnt dolomite	31,655	36,620 (5, 7)	37,450	40,940	30,700 (5)

NOTES:

(1) Results from coke crushing-flux sinter in blast furnace modernization; used record steel melt year as blast furnace was close to it.
(2) Generated by ore crushing, blast furnace rebuild modernizations.
(3) No change in blast furnace from Step 2; larger heats in open hearth.
(4) Includes ore pellets and all other blast furnace modernization, roof oxygen lances in open hearth.
(5) Reduced with oxygen practice.
(6) Varies with Brazilian-Divrigi ore mix.
(7) Exceeds in-plant scrap stockpile.
(8) Based on 1982 experience.
(9) Reduce 33% by substituting roll scale.

SUMMARY OF SCRAP HANDLING REQUIREMENTS

	BASE CASE	CASE 1	CASE 2	CASE 3	CASE 4
Purchased Scrap *	54,000	26,200	--	29,520	80,700
Total Cold Scrap	167,900	157,540	105,210	172,400	239,550
Total Number Heats	3,643	4,283	4,380	4,380	5,000
NT Scrap Per Heat	46.1	36.8	24.0	39.4	47.9
Total NT Scrap Per Day	461	430	288	473	656

NOTES:

1. The 8-month rate of purchased scrap projected to an annual rate is 65,000 tons. To support CASE 4, 15,000 tons additional scrap would be required and would probably need to be imported.

2. All above plans can easily be supported through the improved scrap handling facilities, except CASE 4. This much total increase in scrap processed should be attainable with all report recommendations installed.

* From APPENDIX 8.

LISTING OF MAJOR STEEL PRODUCING AND AUXILIARY EQUIPMENT

1. FURNACES

   a. 6 150-MT Krupp furnaces, with no fans, powered stack daft.

2. CHARGING

   a. 3 37-MT, 360° travel EOT charging cranes.
   b. 1 7-MT, 360° travel EOT charging cranes.
   c. 6 charging stands, with total loaded charging box storage capacity of 112 (including ore, limestone, scrap).

3. SCRAP STOCKING

   a. 17 x 160 m^2 area.
   b. 3 EOT stockhouse cranes.
   c. 2 scales for weighing cold charge material.

4. SCRAP BURNING, LOADING YARD

   a. 18 x 150 m^2 area.
   b. 2 EOT cranes.

5. OUTSIDE BURNING

   a. Serviced by locomotive cranes; presently includes 50,000 tons unprepared scrap.

6. HOT METAL MIXERS

   a. 2 600-ton basic lined mixers (one each end of shop) in bay adjacent to pouring aisle, away from furnace aisle.
   b. 2 100-ton EOT mixer cranes.

7. POURING AISLE

a. 3 100-ton ladle cranes.
b. 2 100-ton ladle cars, electric drive gantry, pouring stands capable of pouring one heat after ladles are set on stands.
c. Capability to pour 2-1/2 heats simultaneously (after setting first heat into pouring stands).
d. Capable of storing 3 sets of molds (provided one string is 35 x 35 cm) inside pouring bay at one time.
e. 22 steel ladles and 11 split launders.

8. SLAG HANDLING EQUIPMENT

a. 18 slag pot cars (fill 2 pots during flush, 1-2 tappings).
b. 28-22 slag pots, with usage approximately 25 per year.

9. INGOT BUGGIES AND MOLD COMPLEMENT

a. 118 ingot buggies, 93 average in service.
b. 5 strings, 55 x 55 x 205 cm mold strings (10 buggies/string).
c. 2 strings above size cars with plates for crossover stripping.
d. 2 strings, 35 x 35 x 148 cm mold strings (7 buggies/string).
e. 1 string above size with plates for crossover stripping.

10. STRIPPING

a. 2 stripper buildings, each with a stripper crane.

11. EVALUATION OF EQUIPMENT

The above complement of equipment is adequate to support the increased production programs recommended. Additional ingot buggies would be required if larger heats were poured.

Size of steel ladles to be increased 8 tons each to meet Case 3 near end of blast furnace modernization.

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

ROLLING MILL DIVISION

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CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

6.0 - ROLLING MILL DIVISION

6.1 SUMMARY - SOAKING PITS

6.1.1 The major problems in the rolling mills are located in the soaking pits and are fuel related.

The use of fuel oil in the soaking pits must be eliminated to alleviate the extensive damage being done to the pits and the instrumentation by its continued use.

6.1.2 The following benefits will result if the use of fuel oil is discontinued in the soaking pits:

A. Soaking pit refractory life will increase 100%.

B. Scale and cinder generation will be reduced significantly, at least 67%.

C. Soaking pit utilization will also improve. Combined with the use of mixed gas the mechanical bottom cleaning equipment will raise the pit utilization up to at least 80%.

D. Pit dampers can be maintained.

E. The instrumentation can be rehabilitated and will function properly.

F. The BTU's per ton will decrease because with instrumentation and dampers the pits can be sealed properly to minimize loss of heat at the coping level.

6.1.3 Changes to be made by the rolling division:

A. The 34"-28" mill schedule should be changed to reduce the excessively high generation of cold steel (20.75%).

This change will also aid in the reduction of transit time. Reduced transit time improves quality, reduces fuel consumption and increases soaking pit production.

B. The pit repair and/or rebuilding program must be done according to soaking pit manufacturer specifications.

C. The ingot charging pattern should be changed to obtain uniform heating of the ingots, permit an additional two ingots per pit to be charged, reduce the side wall erosion and significantly reduce the bottom build-up of scale and cinder.

D. The ingot rolling pattern on the 34" mill should be altered to improve surface quality.

E. No one has sole responsibility for the operation of the soaking pits.

F. As a result of all the problems, the fuel rate is excessively high (1,500,000 + BTU's/ton).

6.1.4 Changes outside the rolling division are recommended:

A. Elimination of the 15 minute platform hold time on all semi-killed heats will lower transit time, improve quality, reduce fuel consumption and increase soaking pit production.

B. High sulphur content, flat-sided ingots cause heating and rolling surface problems.

6.1.5 The continued use of fuel oil has a very severe and serious effect upon the soaking pits. It must be discontinued if improvement is desired. It will take a period of one year to recover after the fuel oil is eliminated.

6.1.6 If these recommended changes are made, the fuel rate should drop to less than one million BTU's per ton. The soaking pits should be able to uniformly heat and the 34" mill to properly roll, 700,000 metric ingot tons of quality product in 1984.

6.2 SUMMARY - ROLLING MILLS

6.2.1 Continuous Mill

The key to the 12" mill problem is the vast potential of the continuous mill and how to realize it.

The continuous mill is programmed for 300,000 MT per year. By providing the continuous mill reheat furnace with adequate fuel, it is possible to eliminate 877 hours per year of heat related delay time (1981 actual).

If these delay hours are converted to operating hours, the continuous mill will produce 344,000 MT per year, the combined tonnage of both the continuous and 12" mill.

The continuous mill reheat furnace fuel problem can be solved by converting it to burn fuel oil.

This will enable the continuous mill to produce an annual volume equal to the normal continuous mill program of 300,000 MT per year plus the 44,000 MT per year from the 12" mill.

This proposal will require a capital expenditure to convert the continuous mill reheat furnace to burn fuel oil. A steam line must be installed from the boiler house to the continuous mill furnace to atomize the fuel oil. Without steam atomization, fuel oil should not be used. The conversion of the continuous mill reheat furnace to fuel oil will provide an additional source of mixed gas for the soaking pits. When the pit rehabilitation is completed and the BTU consumption of the soaking pits is under one million BTU's per ton; this added quantity of mixed gas might even be sufficient to satisfy the needs of the soaking pits.

The cost of converting the continuous mill reheat furnace to fuel oil should be balanced by the savings resulting from shutting down the 12" mill.

The continuous mill is the newest mill and should be the facility on which to expend capital for modernization.

The furnace conversion must be an integral part of a total program to upgrade the continuous mill facilities and make the unit more productive.

It is recommended that the rolling division proceed with a request to convert the continuous mill reheat furnace to fuel oil.

Consideration should be given to increasing the billet size to 85 mm x 85 mm x 9 m or larger. This will increase production by at least 18-3/4%.

Four factors should be considered:

A. Furnace heating capacity.

B. Drafting (roll design).

C. Power requirements for heavier drafts.

D. Required speed increase.

The answers can be furnished by a competent rod mill manufacturer.

The delivery speed of the mill is 5,000 feet per minute. Modern rod mills are approaching 20,000 feet per minute. The extent to which the continuous mill can be modernized and its productivity increased, is very great.

6.2.2 12" Mill

The 12" mill is an old hand mill highly inefficient because of original design and the use of excess spell hands. Its hourly production of 16mm and 18mm rounds is only 4.4 metric tons per hour. Both of these sizes can and should be rolled on the continuous mill.

The first consideration in making the decision on whether the 12" mill should be shut down is:

Can the 12" mill product (size, shape and annual production) be assumed by another mill without a loss of total saleable product?

This is covered in the continuous mill analysis. Since the answer is yes on all counts, the decision should be to shut the 12" mill down as soon as certain heat related delays have been eliminated from the continuous mill. This is necessary to make the tonnage transfer possible. Without the availability of sufficient fuel, the continuous mill cannot produce the required tonnage.

If finished product total tonnage by section is not critical, the shut down could be made immediately and the result would be a loss of 44,000 metric ton per year of 16 mm and 18 mm rounds but an increase of approximately 48,000 metric ton per year of billets. Shutting the 12" mill down will result in an annual estimated savings of $1.5 million.

6.2.3 16" Mill

The 16" mill is an old hand mill highly inefficient for the same reasons as the 12" mill; original design and excessive use of spell hands. The mill rolls angles, I-beams, channels, rails and rail parts. The size range is too large for the continuous mill to produce.

There is no mill which can absorb this tonnage. That means one of two decisions must be reached:

A. The tonnage and sections are important enough that Karabuk cannot afford to drop them and substitute bloom or billet tonnage off the 28" two high mill.

B. The cost of producing this product off the 16" mill is so high Karabuk cannot afford to continue operating the mill.

The mill is so old and inefficient it does not warrant sizable capital expenditures to rehabilitate it. If the answer is to shut it down, this can be done.

If the answer is that the products are essential to sales and it must continue to operate, the following steps should be taken:

A. Every effort should be made to mechanize the operation to the maximum extent. Billet turners, lifting motorized tables, and any other tool or equipment which will eliminate manual labor should be investigated. Labor saving tools such as magnetic release self-unloading chains, rotating tilting "C" hooks, scrap boxes which can be handled by the craneman without ground assistance and pendant operated cranes, are all available and replace labor.

B. Modern mills should be visited for ideas.

C. Look critically at the spell requirements.

D. Perhaps the speed of the mill could be increased.

The items must be simple and inexpensive as large capital sums should not be spent on a mill as old and costly to operate as the 16" mill.

The objective should be a fifty percent (50%) reduction in the labor requirements to operate the mill.

E. The recommendation is that the 16" mill should continue to operate as long as it is possible to maintain without major rehabilitation. The rolling mills should spend their money to modernize the continuous mill and rehabilitate the soaking pits.

6.2.4 28" Three High Mill

The status of this mill is identical to that of the 16" mill.

6.3 CONCLUSION

6.3.1 A recap of the major rolling mill projects recommended with the estimated annual savings will emphasize the importance of adopting the changes as quickly as possible.

Project	Estimated Annual Savings
Elimination of 15 Minute Platform Hold Time on All Semi-Killed Heats	$ 294,224
Change the 34"-28" Mill Schedule	566,594
Reducing Transit Time	406,003
Mechanical Bottom Cleaning	538,193
Fuel Oil on Continuous Mill Furnace and Shut Down 12" Mill	1,500,000
TOTAL	$ 3,305,014

In addition to the dollar value, the potential production increase in the soaking pits is 27.5%.

6.3.2 The current soaking pit conditions will require time and effort to correct. Even if the fuel oil were removed from the soaking pits today, it would require a year to recover and bring the pits back to normal efficiency. There is no short-cut and no magic formula. The recommendations in this report establish the guidelines for a program which, if followed, will correct the problems existing in the soaking pits.

6.4 PRESENT CONDITIONS

The rolling mill division was inspected from the soaking pits to the continuous rod and bar mill. The most serious problems exist in the soaking pits. In view of this, they received the most attention and most of the recommendations are related to improving their conditions. Without well-maintained, properly operating soaking pits, the blooming mill cannot function efficiently and the open hearth cannot produce at capacity since not all the ingots can be heated. Before considering the purchase of additional soaking pits, every effort should be made to insure that the present pits are producing at maximum capacity.

The soaking pit conditions, as they existed at Karabuk in April, 1982, that cause the problem are:

A. The use of fuel oil on the soaking pits is the primary problem.

B. Abnormally long transit time (2'-58" finish pour to finish charge) extends soaking pit heating time and adversely affects the surface quality of the ingots.

C. Incorrect ingot charging pattern prevents the bottoms of the ingots from being heated properly and causes the tops to wash which builds cinder and scale very rapidly.

D. Extremely high sulfur content in the ingots, when coupled with all the other problems, results in very poor surface quality on the rolled products.

E. Ingots are rolled incorrectly on the blooming mill, thereby contributing to the ruptures or tears which occur on every ingot rolled.

F. Flat-sided molds, used to teem the ingots, do not produce as good a surface as fluted or corrugated side molds.

G. Continued use of fuel oil will deteriorate the soaking pits further and the plant cannot survive further pit deterioration without serious results.

H. Because there was a shortage of mixed gas for the reheating furnaces on all the mills in the rolling division, the soaking pits and the 28" three-high mill reheating furnaces were equipped to burn fuel oil as well as mixed gas. Since adequate steam was not available to atomize the fuel oil, ambient temperature air was used. However, No. 6 (Bunker C) fuel oil is not properly atomized without steam. Without this proper atomization, better results were obtained by firing two fuels (mixed gas and fuel oil) at the same time. Sufficient combustion air was available to fire both fuels simultaneously, and the mixed gas aided in the fuel oil atomization. This practice increased the firing rate of the pit and enabled the heaters to heat the ingots in less time. Soon it was standard practice to fire all the pits using two fuels. This practice, while it may be faster than using mixed gas only, is resulting in pit deterioration and unevenly heated ingots.

I. The unburned oil is sprayed on the refractories in the top front half of the soaking pits. The oil soaks into the porous refractory, burns, and melts the refractories. This condition is causing the pits to be taken out of service every two to three weeks for coping repair.

J. The use of two fuels has resulted in excessive waste gas products, so much that the exit over the bridge wall could not handle the increased volume. This caused the pit pressure to build up to the point where it was impossible to maintain the seal between the cover and the pit at the coping level. The result was the seal plates on the cover were burned off.

K. Because of the manner in which the ingots were charged into the pits, the ingot tops were over heated and melted, while the bottoms were relatively cold. This could be established by observing the ingots rolled on the 34" bloomer. The ingot tops were smaller and the bottom portions were definitely cold as they were darker than the tops. Tearing or rupturing normally occured on the colder surface of the ingot since it was not hot enough to be plastic and would rupture during the rolling operation.

L. By melting the top portion of the ingots consistently, the cinder and scale build-up on the soaking pit bottom is very rapid. The pits must be taken out of service for 7-1/2 days for bottom cleaning after only 49 operating days. This down-time for bottom cleaning is excessive and is due entirely to the use of fuel oil. Normally the bottom should only have to be cleaned after at least 120 operating days.

6.5 RECOMMENDATIONS (NO CAPITAL EXPENDITURES REQUIRED)

To correct the existing conditions at the soaking pits, it is recommended that the following changes be made effective immediately:

6.5.1 Assign an engineer to be solely responsible for the soaking pits (Completed May 15, 1982)

The importance of this recommendation cannot be stressed too strongly. Every recommendation -- its trial, evaluation and adoption -- and the success of the entire program is in his hands. The value of this man to this program is extremely important and to insure he has the time to do all the tasks required, all his other responsibilities should be relieved. At this time, this is the most important assignment in the rolling division.

6.5.2 Eliminate the 15-minute platform hold times on all semikilled heats

Eliminating the 15-minute platform hold times on all semikilled heats, will shorten transit time by 15 minutes which converts to a 20 minute reduction in pit time for each pit load (three pit loads per heat). This recommendation will not only save time and money (fuel) but will also improve the quality of the product.

The fuel savings are estimated at US $294,224, plus a potential increase in pit productivity of 2.9%.

6.5.3 Pour the heats on Furnace C, D, and F in reverse order, so the first ingot poured is always the first ingot stripped

By pouring the heats on Furnaces C, D and F in the reverse order, the stripper will receive every heat with identical pouring practices. The first ingot poured in every case will be on the lead or front end of the heat as it enters the stripper. Since stripping is started on the end nearest the soaking pits, the first ingot poured, which is the coldest ingot, will always be stripped first and the danger of molten metal will be reduced.

6.5.4 Change the 34"-28" mill downturn from a 24-hour downturn to three 8-hour downturns

By changing the 34"-28" mill downturn from a 24-hour downturn to three 8-hour downturns, each 8-hour downturn will be separated by four or more operating turns. This will reduce the generation of cold steel from 20% to 15%.

In the event of a repair requiring more than eight hours to complete, provisions can be made to schedule a 24-hour downturn every fourth week. (See Appendices 1 and 2 for present and proposed 34"-28" mill schedule.)

This change will generate significant cost and operating improvements as follow:

A. Reduction in cold steel generated which will reduce the BTU's per ton requirements of the soaking pits by an amount equal to $566,594 per year.

B. Increase productivity of the soaking pits by approximately 10.5%.

C. Improved quality because of better transit time.

D. Free molds for open hearth use.

E. Increase refractory life due to fewer severe changes in pit temperatures.

F. Require less fuel by maintaining heat in the pits during downturns rather than the present practice of allowing all the pits to go cold during the 24-hour downtime.

6.5.5 Change the way the ingots are charged in the pits

Currently the ingots are charged criss-cross in the pits, with the bottom half of each ingot touching the adjacent ingots (see Appendix 3). This method of charging is incorrect for the following reasons:

A. The flame cannot heat the bottom half of the ingot as it is blocked out by the position of the charged ingot.

B. The tops of all the ingots are overheated, causing a rapid build-up of scale on the pit bottom.

C. The hearth coverage of 29% is extremely low, when ideally it should be between 35% and 42%.

D. The erosion of the pit walls is excessive because of the current charging pattern.

E. In an effort to compensate for this excessive wear, the pits are being rebuilt with a thicker division wall. This reduces the width of the pit and changes its heating characteristics.

F. The manner in which the ingots are charged makes it difficult for the pit craneman to charge or to draw ingots from the pits without damaging the coping.

In view of all the negative results of the current ingot charging practice, it is recommended that the accepted world standard practice for charging ingots in a soaking pit be followed (see Appendix 4).

This will increase the hearth coverage to 34% by charging fourteen (14) ingots per pit instead of twelve (12). Eventually, the pit charge could be increased to sixteen (16) ingots per pit.

The pits should be rebuilt according to manufacturer's specifications as the abnormal wall erosion will be corrected by the proper charging pattern.

Once the cranemen are familiar with the new charging pattern it will be easier and quicker than the current pattern.

6.5.6 Change pit repair and/or rebuild practice

In an effort to compensate for the excessive side wall erosion experience due to the manner in which the ingots are charged, the masonry department is not repairing or rebuilding the soaking pits according to soaking pit manufacturer's specifications.

One or two additional courses of brick are added to the width of the pit side walls. This course of action is incorrect for two reasons:

A. It alters the design of the soaking pit, changing the heating characteristics of the pit.

B. It reduces the width of the pit and makes proper charging of ingots very difficult, if not impossible.

The solution to the problem is to charge the ingots as recommended in 6.5.5. This will significantly reduce the severe side wall erosion making the masonry revisions unnecessary. It will also allow a space between each ingot charged for uniform heating.

6.5.7 Reduce the transit time of two hours, 58 minutes, by at least 30 minutes

The long transit time is the result of many factors:

A. The platform hold time of 15 minutes on all semi-killed heats is unnecessary.

B. The locomotive service to move stripped heats into the soaking pit building is inadequate.

C. The torn-up condition of the track in the soaking pits makes it necessary to bridge long distances to charge the ingots.

D. No attention is paid to the transit time -- even the abnormally long times.

E. The current 34"-28" mill schedule is not conducive to good transit time.

Cooperative effort by all three divisions involved (open hearth, transportation, and rolling divisions) is necessary for improvement.

A new transit time report has been developed and installed by the rolling division.

This report will pinpoint the segment of the total transit time which is exceeding the objective. As each portion of the heat is recorded, the actual time should be compared to the objective and the reason for any excessive time over objective should be recorded immediately. Normally the reason for delay is known at the time of the delay. Recalling the conditions and reasons for delay 24 hours after the fact is extremely difficult and highly inaccurate because it is done by people other than those involved.

With this report and a serious effort by everyone involved, the transit time will improve. Improvement in transit time will be accompanied by a corresponding reduction in the soaking pit hours required to heat the steel.

The benefits from this project are annual reduction in fuel costs of $406,003 and an annual soaking pit production increase of 5.7%.

6.5.8 Revise the 34" mill ingot rolling pattern. Incorporate a manipulation after the first two bullhead passes.

Current rolling practice at the 34" mill is shown (see Appendix 5).

The current rolling practice compensates for the unevenly heated ingots delivered to the mill for rolling and was adopted because the ingot went diamond-shape when the manipulation was made after two passes.

In any ingot rolling operation, it is critical to work-harden all four surfaces of the ingot as soon as possible. This is particularly true of flat-sided, poorly heated, high sulfur content, improperly rolled ingots, which results in product with a torn and ruptured surface.

The 34" blooming mill is drafting lightly and taking additional passes due to the condition of the ingots. When properly heated ingots (hotter and uniformly heated) are available to roll, the drafting can be increased, the number of passes reduced, and the production of the 34" mill can be increased from 16.5 ingots per mill hour to 23 ingots per mill hour. This is based upon rolling 30 ingots per operating hour and using the same 23.14% delay time as experienced by the 34" mill in 1981.

The proposed rolling practice shown in Appendix 5 does not anticipate the improvements in heating of ingots but recognizes the same operating conditions existing today.

The improved rolling rate anticipated on the 34" mill with the advent of properly heated ingots will reflect in the proposed rolling practice the same as it would on the current practice.

6.6 RECOMMENDATIONS (MINOR CAPITAL EXPENDITURES REQUIRED)

In addition to the previous eight projects, all of which can be installed without capital expenditure, there are two additional projects which will require minor capital expenditure. These projects are:

6.6.1 Purchase a mechanical bottom cleaning machine to remove scale and cinder from the soaking pit bottom

Normal dry bottom operation of a soaking pit generates a scale build-up on the pit bottom until it reaches a point where there is danger of it flowing over the pit bridgewall and entering the flues. Before this happens, the pit is removed from service and the pit bottom is cooled by running water on the cinder. Men then enter the pit and remove the cinder build-up using jack-hammers. This build-up is extremely rapid in the Karabuk soaking pits. The pits are taken out of service after 49 operating days (see Appendices 6 and 7). They remain out of service for the 7-1/2 day period required to clean the pit using men with jackhammers. An average of four men per turn are required. As a result, the pit is out of service too long, the man-hour requirements are very high, and the work is hot and heavy. No one wants to do it and it is difficult to secure the people needed to perform the work.

A mechanical bottom cleaning machine can be purchased which will clean the pit and have it back in operation heating steel in 32 hours. Only one man is required to operate the unit, but a spell-man is furnished to insure 100% operating time. The unit is operated remotely and can clean out the pit bottom in eight to 16 hours. Allowing eight hours to cool off and eight hours to reheat the pit, the outage time is 32 hours maximum. This compares to 7-1/2 days on the current practice.

The result is increased pit utilization with a potential production improvement of 8.5%. The labor savings are 37,488 man-hours per year. In view of the excellent benefits and pressing need for additional pit productivity, it is recommended that this equipment be purchased immediately.

6.6.2 The second project requiring a capital expenditure is two-way communication for the steel run locomotive.

A very important function necessary to maintain a minimum transit time on all heats is adequate locomotive service to move stripped heats from the stripper into the soaking pits. Under the present practice, the only time a locomotive is available is when another heat is being delivered to the stripper. This is not adequate service. The heat should be moved as soon as it is stripped. It should not have to wait until the locomotive is available based upon delivery time of the next heat.

To correct this condition, it is recommended that the steel run locomotive be equipped with a two-way communication system. The engineer can then be contacted by the transportation dispatcher, who will dispatch the locomotive to the area requesting the service. With only ten to 12 heats per day to transport to the stripper, the locomotive should be able to furnish all the service required, provided that a method of communicating with the engineer at any time is available. The two-way communication system will meet this need.

The Industrial Engineering group should study this operation around the clock to determine the work load on the locomotive and to justify the expenditure necessary to install the system. Once the basic system is installed, it can be extended to other units very inexpensively. Good locomotive service is essential to attain good transit time.

6.7 COST REDUCTION PROJECTS-LABOR PORTION ONLY (SUMMARY)

	Saving
6.7.1 - Remote Radio Controlled Soaking Pit Covers	7 Men
6.7.2 - Remote Radio Controlled Locomotives	54 Men
6.7.3 - Eliminate Metallic Chips on the Ingot Stools	7.5 Men
6.7.4 - Purchase a Mechanical Bottom Cleaning Machine - Soaking Pits	15 Men
6.7.5 - Relocate Controls on 34" Rolling Pulpit	6 Men
6.7.6 - Pendant Controlled Overhead Cranes	30 Men
Total Savings	121.5 Men

6.7 COST REDUCTION PROJECTS - LABOR ONLY

The following are cost reduction projects involving labor reductions which can be implemented by the purchase and installation of proven labor saving equipment. These employees would be available for transfer to other departments in the plant which would be required to justify the increase in working force. All should be evaluated by the plant to establish their feasibility. Catalogue information, blue prints, sketches and/or vendor bids, have been furnished on each item listed in this section. All have been discussed in detail with the Director - Rolling Mills and all the literature presented to him.

6.7.1 Remote Radio Controlled Soaking Pit Covers

6.7.1.1 Present Conditions:

The soaking pit covers are opened and closed by three (3) men per turn operating manual switches on the cover level.

A. Recommendations for improvement:

Purchase and install 100% solid state circuitry to enable each pit craneman to open and/or close the cover of any soaking pit from any location on the crane runway. (Retain the present manual system for standby service in case of emergency.)

B. Benefits - Labor Reduction

Current requirements:

	3	men per turn
x	3	mill turns
	9	men total

Proposed requirements:

Zero
Savings (Annual) 9 men

6.7.2 Remote Radio Controlled (Diesel) Locomotives

6.7.2.1 Present Conditions:

Plant (Diesel) locomotives are all manned by a three (3) man crew. All available diesel locomotives are scheduled around the clock.

6.7.2.2 Recommendation for Improvement:

Purchase and install radio remote control system which will provide control of the horn, bell and sanders, as well as control of the direction, throttle and brakes. With this unit, one man can operate the diesel locomotive without any loss of efficiency.

6.7.2.3 Benefits - Labor Reduction

Current requirements:

3 men per locomotive
14 diesel locomotives
3 turns per day - operating level
67% = equipment utilization (assumed)

3 men per locomotive x 14 locomotives x 3 turns per day x .67 utilization = 84 men

Proposed requirement:

1 man per locomotive
all other conditions (same)

1 man per locomotive x 14 locomotives x 3 turns per day x .67 utilization = 28 men

Annual savings 84 men - 28 men = 54 men

6.7.3 Eliminate Metallic Chips on Ingot Stools

6.7.3.1 Present Conditions:

A crew of four to five men per turn, shovel metallic chips onto the empty stools before the molds are placed on the empty stools.

6.7.3.2 Recommendation for improvement:

Eliminate the use of metallic chips. This will improve the internal quality of the ingot and will not seriously increase the stripping operation. If something must be done, plates can be added or the stools could be coated with a special coating designed specifically to reduce stool stickers.

It is recommended to eliminate anything added to the stools. Instead compressed air lances should be used to blow the stools clean.

6.7.3.3 Benefits: Labor Reduction - Quality Improvement

Current requirements:

4.5 men per turn
x 3 turns per day

13.5 men

Proposed Method:

2 men per turn (maximum)
x 3 turns per day

6 men

Annual savings 13.5 men - 6 men = 7.5 men

6.7.4 Mechanical Equipment to Clean Cinder and Scale from Soaking Pit Bottom

6.7.4.1 Present Conditions:

The scale and cinder build-up on the soaking pit bottom is removed manually by four (4) men per turn using pneumatic jack-hammers. It requires 22.5 turns to complete the job. It is necessary to perform this task fifty-nine (59) times per year on all twelve (12) pits (1981 actual).

6.7.4.2 Recommendation for improvement:

Purchase a remotely controlled mechanical pit digger which will clean the pit bottom in eight to sixteen hours. The operation will require two (2) men to erect, operate, dismantle, transport and maintain the machine.

6.7.4.3 Benefits: Labor Reduction - Increased pit utilization and resultant production increase.

Current requirements:

4 men per turn
22.5 turns per occurrence
59 occurrences per year

32 man hours per turn x 22.5 turns per year x 59 occurrences per year = 42,480 MH per year

48 MH/week x 52 weeks per year = 2,496 MH/man/year

Recommended method:

2 men x 48 hours x 52 weeks/year = 4,992 man-hours/year
Savings: 42,480 - 4,992 = 37,488 man-hours/year

$$\frac{37{,}488}{2{,}496 \text{ MH/man/year}} = 15 \text{ men}$$

6.7.5 Relocate Controls in 34" Mill Rolling Pulpit

6.7.5.1 Present Conditions:

Rolling is accomplished by a four (4) man crew on the 34" mill rolling pulpit.

6.7.5.2 Recommendation for Improvement:

Consolidation of controls will reduce the 34" mill rolling crew to two (2) men (one [1] roller and one [1] manipulator). Two man crew is standard in every rolling mill pulpit in the United States.

6.7.5.3 Benefits: Labor Reduction

Current requirements

4 men per turn
3 turns
12 men

Recommended Improvement:

2 men per turn
3 turns
6 men

Annual Savings: 12 men - 6 men = 6 men

6.7.6 Pendant Controlled Overhead Cranes

6.7.6.1 Present Conditions

Every electric overhead traveling (EOT) crane in the plant is operated by a craneman who rides the crane in a cab located just below the crane bridge girders.

6.7.6.2 Recommended Improvement:

Equip each shop crane with a pendant control, so that the crane followers (on the ground) can hook up and unhook the load, and in addition, operate the crane from the ground without the presence of the craneman in the crane cab.

6.7.6.3 Benefits: Labor Reduction

Current requirements:

1 craneman per crane
3 turns per day
10 shops in the plant
30

Recommendation for Improvement:

0 - cranemen on pendant controlled cranes

Annual savings: 30 men - 0 men = 30 men

6.8 ADDITIONAL POTENTIAL COST REDUCTION ITEMS

All of the following items have been discussed with the Director, Rolling Mills. Engineering prints, sketches, quotes, catalogues, brochures and detailed explanations of each item and its potential value to Karabuk Iron and Steel has been reviewed with the Director, Rolling Mills.

No attempt has been made to calculate the savings on each of the items listed as it would involve extensive study to properly evaluate them. This can be done more capably by the Plant Industrial Engineering forces.

6.8.1 Gunning Equipment and Material for Use in the Soaking Pits

6.8.1.1 Present Conditions:

The side walls of the soaking pits are severely eroded in a very short period of time. This is due to three factors:

A. The manner in which the ingots are charged (see Appendix 3).

B. The use of improperly atomized fuel oil as a fuel.

C. The type of refractory (fire clay brick) used in the pit walls.

6.8.1.2 Recommendation for Improvement:

Purchase and use gunning equipment with special gunning refractory. Special material is available for shooting on hot pits, other material is available which is better suited for shooting on cold pits. The object is to build-up the side walls where they are eroded, until they are back close to specification dimensions.

This practice, followed by proper charging of the ingots, will increase the life of the side walls by 100% to 200% over their present life.

If it is possible to rebuild the pits using higher alumina brick, this would also contribute to reduced side wall erosion.

All of these recommended changes will increase soaking pit availability and production.

6.8.2 Self-Dumping Buckets

6.8.2.1 Present Conditions:

All the boxes used for scale, scrap, and debris are hooked up by chains or cables, requiring the services of hookers or groundmen to hook up the lifting chains or cables and to unhook them for dumping. They must also be hooked and unhooked as they are returned to their original place.

6.8.2.2 Recommendation for Improvement:

Self-dumping boxes, which the crane can pick-up, transport, empty, and then transport back to the original area and release without the benefit or assistance of any hookers or groundmen will eliminate the need for the ground assistance.

Determination of the areas where this item will reduce labor requirement should be the function of the Plant Industrial Engineering Department.

6.8.3 Tilting "C" Hook

6.8.3.1 Present Conditions:

The hot steel is removed from the mill by the overhead crane and a ground crew who do all the hooking up, positioning the lift, and unhooking. Chains and a "C" hook on a spreader are both used.

6.8.3.2 Recommendation for Improvement:

A tilting "C" hook attached to a spreader so that the "C" hook can be rotated will eliminate the need for hookers or groundmen to assist the craneman in any way. He will be able to load the steel off the mill hot (1500/1600°F) and pile it in the yard without the assistance of ground personnel. The craneman can remove steel from the mill and dump it in railroad cars without assistance.

Justification for its purchase or manufacture should be furnished by the Industrial Engineering Department.

6.8.4 Improve Blade Life - Hot Saws

6.8.4.1 Current Practice:

The saw blades use very little low pressure water for coolant because there is no water shield and the increased use of water results in cooling the product to be sawed. The teeth of the sharpened blades are neither heat treated nor swedged. As a result the blade life is very poor and often delays the mill for frequent saw blade changes.

6.8.4.2 Recommendation for Improvement:

A modern saw blade sharpening, leveling, swedging and heat treating operation was reviewed with the Director, Rolling Division.

Two proposals for cooling the saw blade during the sawing operation and two methods of shielding the water to keep it from reaching the product being sawed were discussed.

Justification for the equipment should be made by the Industrial Engineering Department.

Following are chemistry and hardness of the blades used in USS:

Element	Content
Carbon	.30/.36
Manganese	.90
Phosphorus	.015
Sulphur	.029
Silicon	.20

Hardness - 60 Shore - Teeth
35 Shore Balance

6.8.5 Magnetic Releases for Self-Unloading Chains

6.8.5.1 Current Practice:

All lifts are manually hooked and unhooked by groundmen working with the crane.

6.8.5.2 Recommendation for Improvement:

Cranes can be equipped with a magnetic release which allows the craneman to release the chains when the weight of the load has been relieved. This will permit the use of fewer people working with each shipping cranes.

6.8.6 <u>Coping Damage</u>

6.8.6.1 Current Practice:

The cranemen use the copings (refractory) to straighten up the ingots prior to charging. Also after drawing, the ingot is dragged over the coping to change its position in the crane tongs.

6.8.6.2 Recommendation for Improvement:

No crane should be allowed to touch the pit copings for any reason at any time. Any contact between the ingot and the coping results in coping damage. Coping damage results in unsealed pits and wasted fuel. Instructions should be given to all cranemen, "Never touch the pit copings."

6.8.7 <u>Soaking Pit Accessories</u>

6.8.7.1 Current Practice:

The soaking pit cleanout door is extremely difficult to open and close. It is not securely latched for the safety of personnel working in the pit cellar.

6.8.7.2 Recommendation for Improvements:

Sketches and prints of counterweighted clean-out doors were reviewed. Also a safety latch which will latch securely was shown. A simple, inexpensive opening and closing was featured. The bottom casting and the casting support cleanout door were also discussed. For safety, this design should be adopted.

6.8.8 <u>Welding Blooming Mill Rolls</u>

6.8.8.1 Current Practice:

When the rolls reach scrap diameter they are converted to another size roll, sold as is, or scrapped.

6.8.8.2 Recommendation for Improvement:

Rolls are expensive and for quality reasons most of them are imported. It is suggested that a set of smaller mill rolls, when they reach scrap diameter, be sent to Iskenderum to be repaired by welding. The roll should be built up to the original roll diameter and then turned to the proper configuration. Put this welded set of rolls in the mill and keep accurate records of the total tonnage it produces. Compare this tonnage to the tons produced on a new roll. Then develop a cost per ton to determine which is the most economical; new or welded rolls.

If welded cost less per ton, and it should, make several more trials. Then purchase roll welding equipment and reweld rolls at Karabuk.

6.8.9 Inaugurate an Ingot Weighing Program

6.8.9.1 Current Practice:

The weight of the present ingot is not known. Steel producing is convinced it is heavy and the rolling division thinks it is light. Actually no one knows.

6.8.9.2 Recommendation for Improvement:

An ingot weighing program should be started. Normally, this is the function of the Metallurgical Department, since they should be neutral. They are also responsible for the yield levels in the plant.

The weighing program consists of the following:

Each week four (4) randomly selected ingots from one heat will be removed from the drag, placed on an empty, preweighed truck, and taken to the same scale and the total load weighed. Since the tare weight of the empty truck is known it is very easy to establish the total weight of the four (4) ingots and ultimately an average ingot weight.

Maintain these records until approximately fifty (50) ingots have been weighed. If there is a significant difference between the theoretical weight of 3.9 MT and the actual ingot weight, note the difference carefully. Continue the weighing of another fifty (50) ingots. If the results are the same, perhaps some consideration should be given to altering the ingot weight (lower or higher) depending upon the 100 ingot study results. An accurate ingot weight is necessary for valid yield results in both the Open Hearth and the Rolling Division.

6.8.10 Recycle Soaking Pit Cinder

6.8.10.1 Current Practice:

The scale and cinder removed from the soaking pit bottom is not recovered. No attempt is made to keep refractories and other debris out of a pit scheduled down for bottom cleaning.

6.8.10.2 Recommendation for Improvement:

Good operating practice dictates that no refractories or debris be thrown into a pit scheduled down for bottom cleaning. The metallic content (60/65%) mandates recycling this material. With the current bottom cleaning practice (manual labor) the material is small in size and should be used in the blast furnace or the sintering plant. Screening may be necessary before use.

When mechanical equipment is available for bottom cleaning the material removed will be much larger in size. Again no refractories or debris should be allowed in the pit.

The savings available from this operation is over $400,000 U.S. per year.

6.8.11 Schedule Mills to Optimize the Use of Mixed Gas

6.8.11.1 Current

There is not a well-defined schedule of operating and down-turns on each mill. The down-turns are not staggered to optimize the use of mixed gas. It may not be critical since there is never enough mixed gas available for the Rolling Division regardless of how the mills are scheduled down.

6.8.11.2 Recommendation for Improvement

Install a staggered schedule similar to the following example.

Assumption: Mixed Gas is the only fuel for the Rolling Divisions (excluding emergency use).

See material flow Chart IV. A. 6.10.5.

Mill	Operating Turns Per Week	Scheduled Down-Turns Per Week	Day, Turns Down
34" Mill 28" 2-High Billet Profile	20	1	Thursday, 0800-1600
28" 3-High	20	1	Monday, 0800-1600
16"-21" Mills	20	1	Tuesday, 0800-1600
Continuous Mills	20	1	Wednesday, 0800-1600

34"-28" 2-high is a combination mill and will take the same down-turn.

By scheduling each mill down on a different day the distribution and availability of mixed gas will be optimized for the mixed gas consumers, namely, the rolling division.

The down-turn can be changed between mills from week to week providing no two mills are scheduled down the same day. The down-turns are scheduled daylight turn Monday through Thursday because more maintenance assistance will be available during those turns.

6.8.12 Install a double crossover and extend the length of both tracks to No. 1 pit.

6.8.12.1 Current Practice

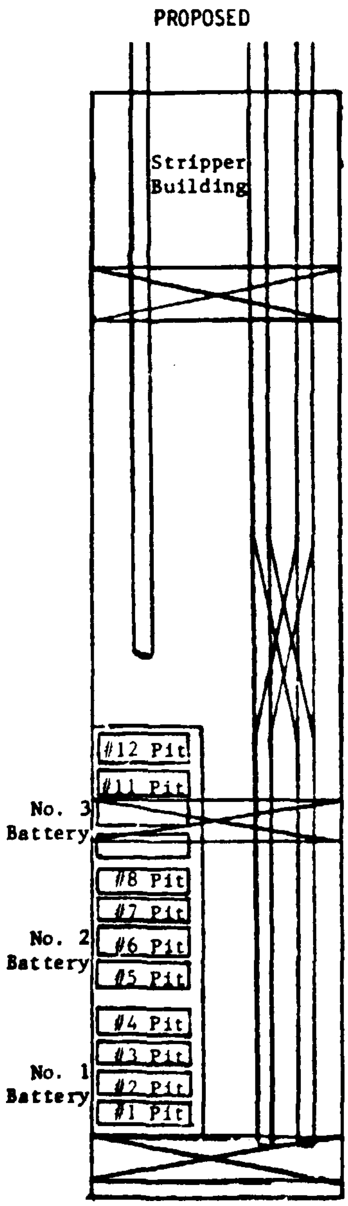
The track nearest the building column line extends to No. 5 pit. The adjacent track can be used to No. 7 pit. Each track is a single spur which dead ends in the soaking pit area. No way exists to get from one track to the other except 500 feet outside the building where both lead from a single track.

6.8.12.2 Recommendation for Improvement

Extend both tracks North until the soaking pit crane can charge No. 1 pit from either track without bridging. Install a double crossover between the two tracks. Locate the crossover just south of No. 12 pit. See sketch (next page). This will afford maximum flexibility to the handling of heats and removing empty drags of buggies from the pits. This flexibility will be necessary when trying to charge and draw 58,500 MT ingots per month.

6.8.12.3 Recommendation

Add a crossover and extend tracks in stripper and soaking pit building.



Stripper and Soaking Pit Building

6.8.13 Current Practice

In the event of a broken roll, spindle or coupling boss the extent of the damage will be directly related to the roller's ability to sense trouble and react immediately to shut the mill down. Regardless of how quickly he reacts, the mill will be subjected to potentially serious damage.

6.8.13.2 Recommendation for Improvement

It is recommended that spindle safety limit switches be installed on both ends (motor room end and mill end) of the top and bottom spindles on all mills. The design and function of these switches has been discussed with the Director, Rolling Mills. Detailed prints have been furnished. This switch will effectively stop any mill in less than 1/2 revolution by automatically activating the mill emergency stop as soon as any irregularity is noted. The cost is minimal and they can be fabricated and installed by plant personnel.

6.8.14 Use of Air Tools

6.8.14.1 Current Practice

Hand tools are employed exclusively by the maintenance mechanical and electrical departments as well as the operating roll change crews.

6.8.14.2 Recommendation for Improvement

It is recommended that air powered tools be utilized for maintenance and roll change crews. The heavy sledging to loosen and tighten nuts will be done quicker, better, and with less effort. This is truly one way to work smarter, not harder.

6.8.15 Pre-Fab Railroad Track Sections

6.8.15.1 Current Practice

When a section of rail must be replaced it is torn out, the area is leveled off and work begins, laying ties, laying rails, fastening rails to ties and making sure the track is level and the gauge correct.

6.8.15.2 Recommendation for Improvement

Pre-assemble the ties and a section of rails. When the old section is torn out and leveled, drop the pre-assembled section into place and final leveling and gauging is ready to start. This will reduce a 32-hour job to 4 hours. On operations which are critical this reduction in delay time is important.

6.8.16 Study the feasibility of furnishing a spare locomotive to eliminate delay time fueling and watering.

6.8.16.1 Current Practice

Each locomotive must spend nearly one hour per turn out of service so it can be fueled and watered. This time is lost to the Operating Department if they need service during that time.

6.8.16.2 Recommendation for Improvement

Study the feasibility of a spare locomotive which would relieve 5 or 6 different locomotives during the 8-hour turn so they could go to be fueled and watered. This would provide the Operating Department with continuous service during the entire turn. The Industrial Engineering Department have sufficient information to make an intelligent recommendation without additional study.

6.8.17 Bloom and/or Billet Turning

6.8.17.1 Current Practice

Many blooms or billets are turned manually. This is hot and heavy work requiring spell hands.

6.8.17.2 Recommendation for Improvement

A bloom and/or billet turner has been discussed with the Director Rolling. Due to potential for labor reduction, this project should be given a high priority for solution.

6.8.18 Pit Sealing

6.8.18.1 Current Practice

The simultaneous burning of two fuels, with the resultant volume of waste gases too great for the flue and complete lack of any instrumentation, has resulted in pit pressures so high it is impossible to maintain a seal on the pits. No effort is made to seal the pits and any effort would generally be wasted because of the existing conditions. The seal plates on most of the pits are in the process of burning most of the time.

6.8.18.2 Recommendation for Improvement

- Discontinue the Use of Fuel Oil.

- Replace the Dampers.

- Use Two Thermocouples per Pit.

- Rebuild the Pits to Specifications.

- Heat by Instruments.

At this point, the pits can and should be sealed. Effort must be maintained to insure that the pits remain sealed. It is recommended that this be a specific assignment to one individual on the soaking pit crew.

6.8.19 Proper Operation 34" Mill Entry and Delivery Table Rolls

6.8.19.1 Current Practice

The Entry and Delivery Table Rolls on the 34" mill are activated by two switches. One switch is for the entry rolls, another switch for the delivery rolls. Each switch controls both the forward and reverse motion of each set of rolls. One man operates both switches individually. The problem is that the pattern of operation varies widely. The delivery rolls are often stopped while the bloom is being rolled in the mill. Other times the rolls are reversed to stop the bloom near the rolls. The bloom lands on dead table rolls, rolls rotating in the reverse direction to the bloom or rolls turning in the proper direction. All three conditions have been witnessed often. Two out of three are wrong and will result in high maintenance costs.

6.8.19.2 Recommendation for Improvement

Place the entry and delivery rolls on one circuit and one controller when one roll goes forward all rolls go forward and vice versa. This will eliminate this problem. For further improvement, transfer this control to the roller and eliminate the table roll operator completely. (See Labor Saving Section Project 6.7.5 for Details).

6.8.20 Bloom and Billet Identification

6.8.20.1 Current Practice

The Identification Heat Number is painted on several blooms or billets in each lift of steel. Many pieces of steel fall off the table or out of the lift. Once it falls and becomes separated from the original lift, the identity is lost.

6.8.20.2 Recommendation for Improvement

Install pneumatic stamping hammers on each mill outlet. End stamp every bloom or billet with the heat no. of the steel. Eliminate lost identity through 100% positive identification of every bloom and/or billet.

6.9 PROJECTED LEVELS OF PRODUCTION - STEEL PRODUCING DIVISION

6.9.1 Soaking Pit Conditions

UNIT LOADING	BASE CASE 1981 ACTUAL	CASE I *	CASE II *	CASE III *	CASE IV *
Open Hearth - M Tons Ingots	558,493	642,474	659,000	718,300	812,500
34"-28" 2-High - M Tons Ingots Heated	526,860	592,474	602,000	658,300	752,500
28" 3-High - M Tons Ingots Heated	47,204	50,000	55,000	60,000	70,000
Soaking Pits: Ingots per Pit	12	13	14	14	16
M Tons per Pit	46.8	50.7	54.6	54.6	62.4
Transit Time - Hot Steel	2'58"	2'45"	2'30"	2'15'	2'00"
Pit Hours per Pit Load (Hot Steel) to:					
Heat (Transit Time x 1.5)		4.15	3.75	3.50	3.00
Soak (Constant)		.75	.75	.75	.75
Charge and Draw Pit (Constant)		1.00	1.00	1.00	1.00
Total		5.90	5.50	5.25	4.75
Pit Hours per Pit Load (Cold Steel) to:					
Heat (Constant)		10.00	10.00	10.00	10.00
Soak (Constant)		1.00	1.00	1.00	1.00
Charge and Draw (Constant)		1.00	1.00	1.00	1.00
Total		12.00	12.00	12.00	12.00
Mill Schedule (2 Weeks per Year Scheduled Outage):					
34"-28" Mills:					
Operating Turns per Week	19.5	18	18	19	20
Down-turns per Week	1 - 24 Hours/2 Weeks	3 - 8 Hours	3 - 8 Hours	2 - 8 Hours	1 - 8 Hours
Annual Outage (MTCE)		14 Days	14 Days	14 Days	14 Days
Product Mix: Pct Hot Steel Charged	79.25	82.5	85	87.5	90
Pct Cold Steel Charged	20.75	17.5	15	12.5	10
Total	100.00	100.0	100	100.0	100
Type of Fuel Used: Mixed Gas (Only)		MG Only	MG Only	MG Only	MG Only
Fuel Oil and Mixed Gas	FO + MG				
Firing Rate of Soaking Pit	25 MIL BTU/Hour	20 MIL BTU/Hour	20 MIL BTU/Hour	20 MIL BTU/Hour	20 MIL BTU/Hour
Pit Hours per M Ton Ingots: Hot Steel		.116	.101	.092	.076
Cold Steel		.237	.220	.220	.192
Soaking Pits (Heating): M Tons Hot Steel Ingots	422,805	488,791	511,700	576,012	677,250
M Tons Cold Steel Ingots	104,055	103,683	90,300	82,288	75,250
Soaking Pit Hours to Heat Steel: Hot Steel		56,700	51,682	52,993	51,471
Cold Steel		24,573	19,866	18,103	14,448
Total		81,273	71,548	71,096	65,919
Pit Hours Available (12 Pits x 24 Hours/Day x 351 Days/Year):					
100% Utilization	101,088	101,088	101,088	101,088	101,088
Utilization Expected (Percent)	64.4	71.5	71.5	80.0	80.0
Pit Hours Available to Heat Steel	71,407	72,278	72,278	80,870	80,870
Pits Can Heat Steel		No	Yes	Yes	Yes
Reason:		Transit time too long. Pit hours/ton too high. Cold steel too high. Pit charge too small.			

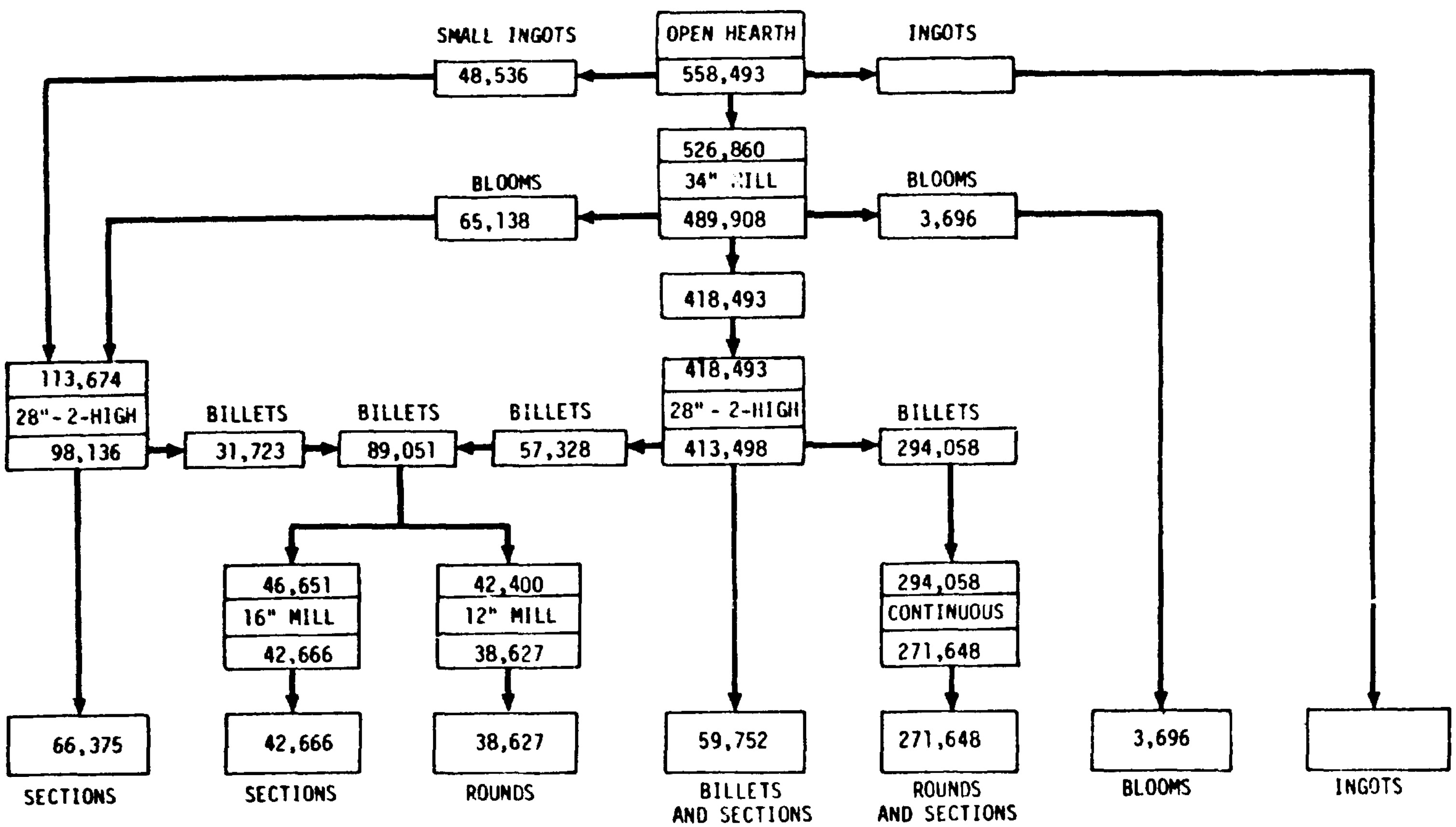
* The open hearth conditions which establish the annual ingot tonnage for each case are detailed in Section 5, STEEL PRODUCTION.

6.9.2 Rolling Mill Conditions

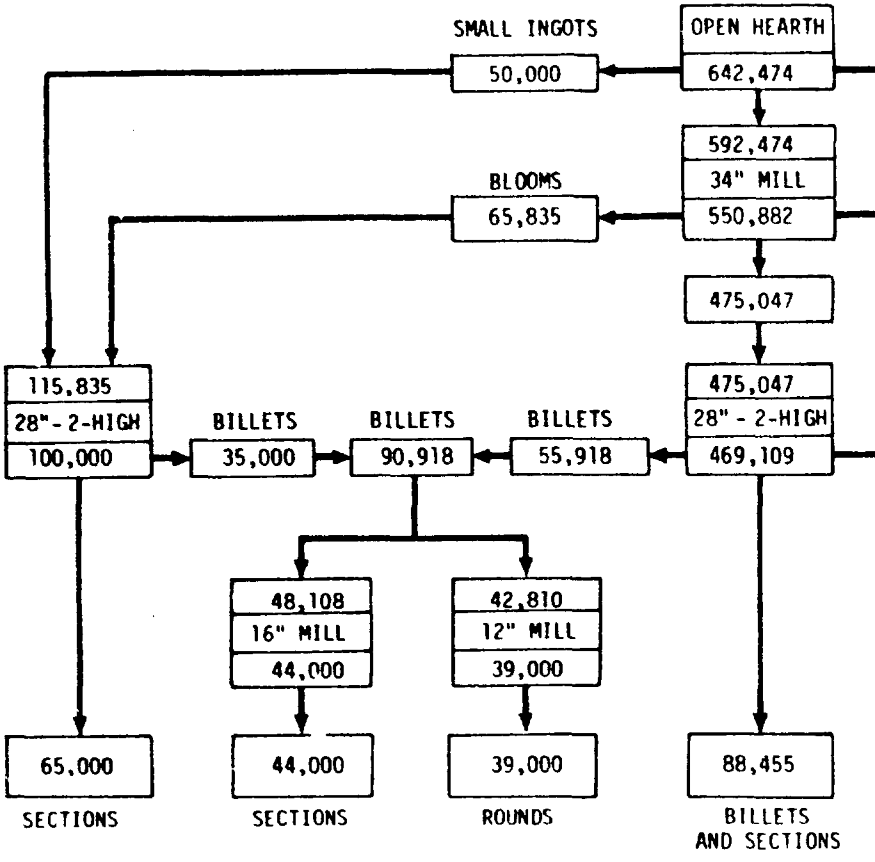
UNIT LOAD	BASE CASE 1981 ACTUAL	CASE I	CASE II	CASE III	CASE IV	MAXIMUM PRODUCTION, 34" MILL
34" Mill -						
M Tons Ingots Rolled	526,860	592,474	602,000	658,300	752,500	702,000
M Tons Semi-finished Product	489,908	550,882	559,740	608,928	699,749	645,840
Percent Yield	92.98	92.98	92.98	92.5	92.0	Case IV-A and IV-B product flow, Charts 6.10.5 and 6.10.6, show sale of 40,500 MT annually in ingot form because of 34" mill bottleneck at 702,000 MT per year of ingots.
M Tons Product per Hour (Operation and Delivery)	59.80	83.40	83.40	82.24	80.73	
Mill Delay (Percent)	23.14	23.14	23.14	24.00	25.00	
Ingots per Mill Hour	16.5	23	23	22.8	22.5	
Mill Operating (Turns per Week):						
Operating Turns	19.5 - 8 Hrs.	18 - 8 Hrs.	18 - 8 Hrs.	19 - 8 Hrs.	20 - 8 Hrs.	
Down-turns	1 - 24 Hrs./ 2 Weeks	3 - 8 Hrs.	3 - 8 Hrs.	2 - 8 Hrs.	1 - 8 Hrs.	
Annual Outage (Scheduled Maintenance)	14 Days	14 Days	14 Days	14 Days	14 Days	
Mill Hours per Year Mill Required	8,190.75	6,605	6,712	7,404	8,667	
		vs.	vs.	vs.	vs.	
Available Mill Hours per Year		7,200	7,200	7,600	8,000	
Mill Can Roll Product		Yes	Yes	Yes	No	
Reason					34" Mill Bottleneck	

6.10 ROLLING DIVISION MATERIAL FLOW

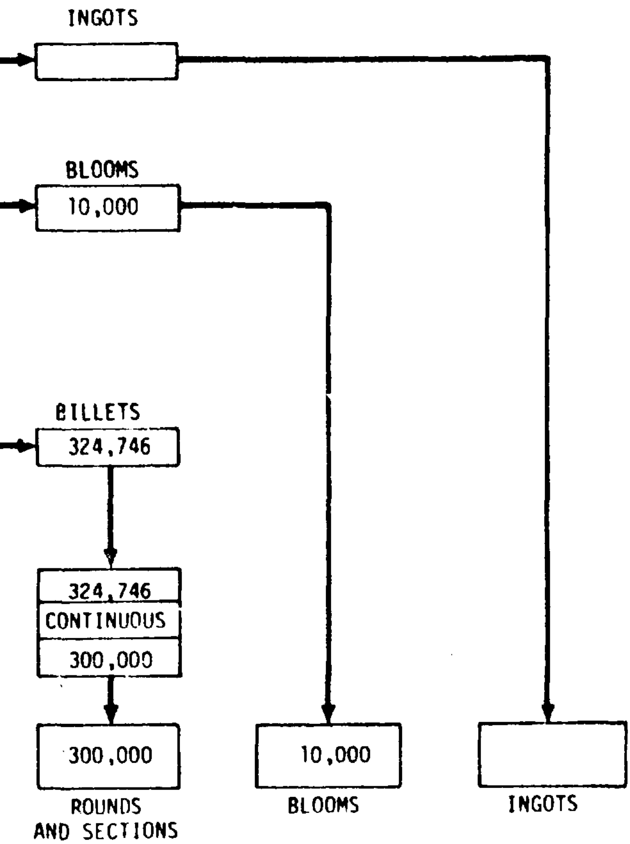
6.10.1 Base Case - 1981 Actual



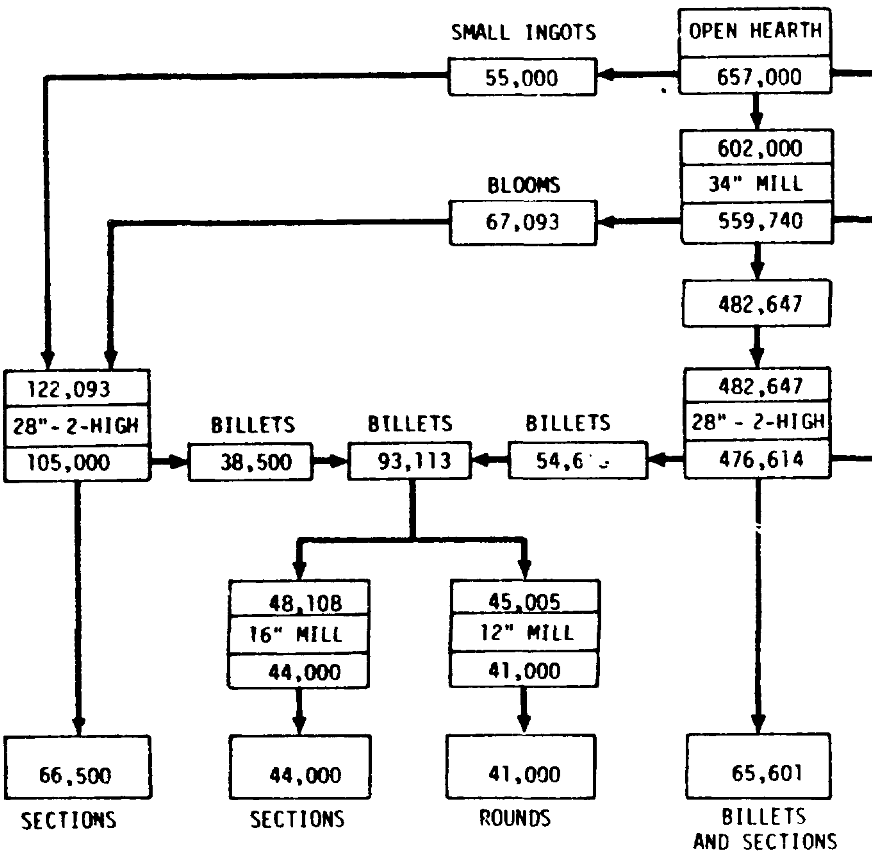
6.10.2 Case I

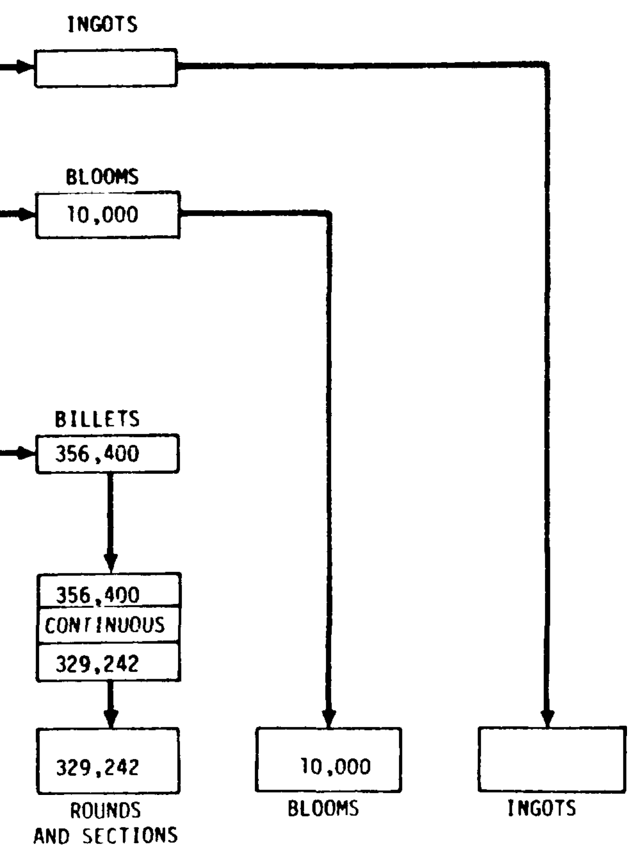


SMALL INGOTS
OPEN HEARTH
50,000
642,474
592,474
34" MILL
BLOOMS
65,835
550,882
475,047
115,835
28"-2-HIGH
100,000
BILLETS
35,000
BILLETS
90,918
BILLETS
55,918
475,047
28" - 2-HIGH
469,109
48,108
16" MILL
44,000
42,810
12" MILL
39,000
65,000
SECTIONS
44,000
SECTIONS
39,000
ROUNDS
88,455
BILLETS
AND SECTIONS

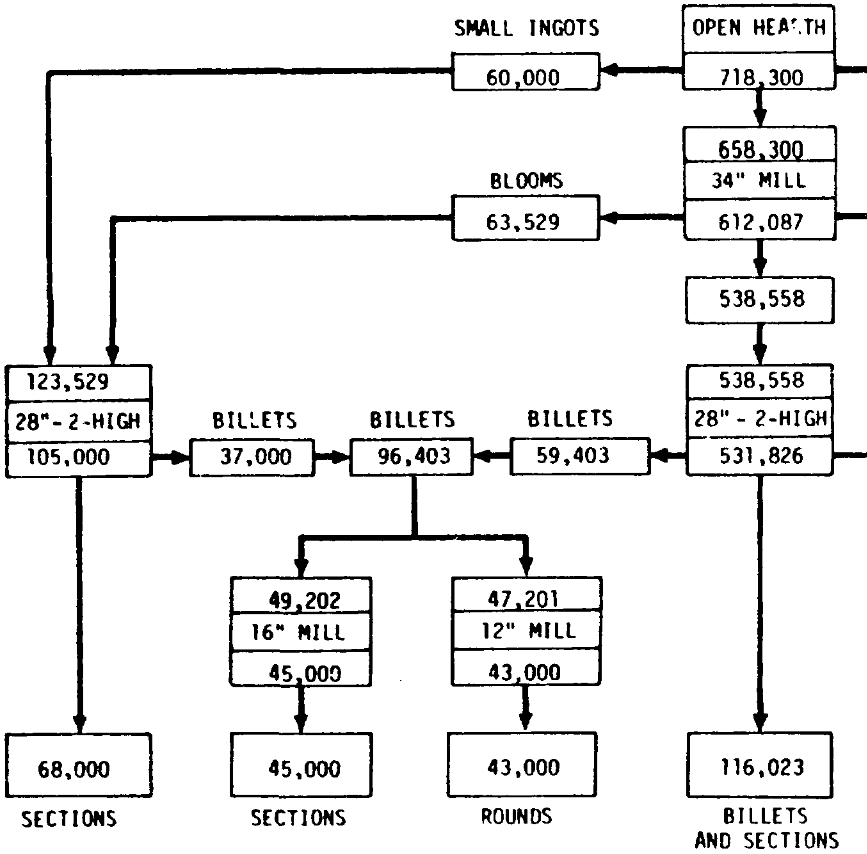

INGOTS
BLOOMS
10,000
BILLETS
324,746
324,746
CONTINUOUS
300,000
300,000
ROUNDS AND SECTIONS
10,000
BLOOMS
INGOTS

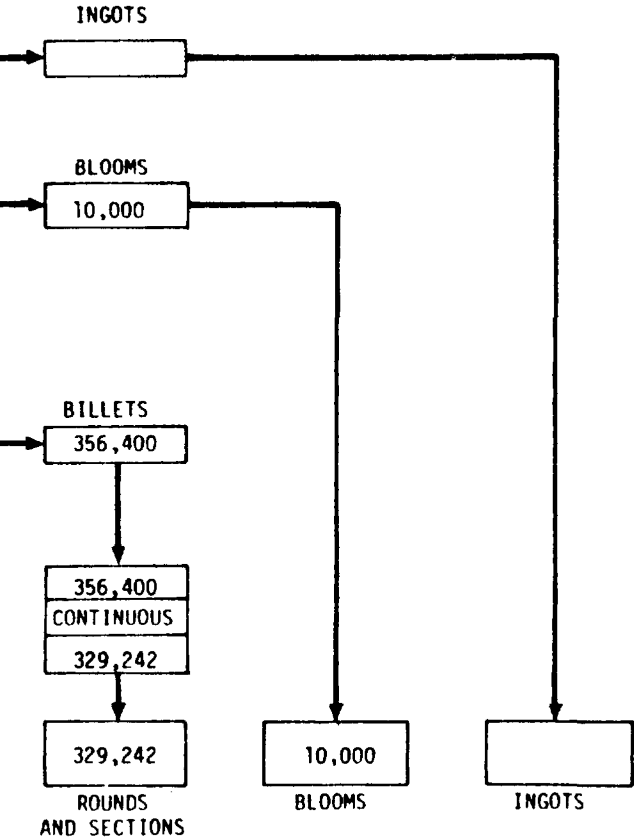
6.10.3 Case II


SMALL INGOTS
OPEN HEARTH
55,000
657,000
602,000
34" MILL
BLOOMS
67,093
559,740
482,647
482,647
28" - 2-HIGH
476,614
122,093
28"-2-HIGH
105,000
BILLETS
38,500
BILLETS
93,113
BILLETS
54,6
48,108
16" MILL
44,000
45,005
12" MILL
41,000
66,500
SECTIONS
44,000
SECTIONS
41,000
ROUNDS
65,601
BILLETS
AND SECTIONS

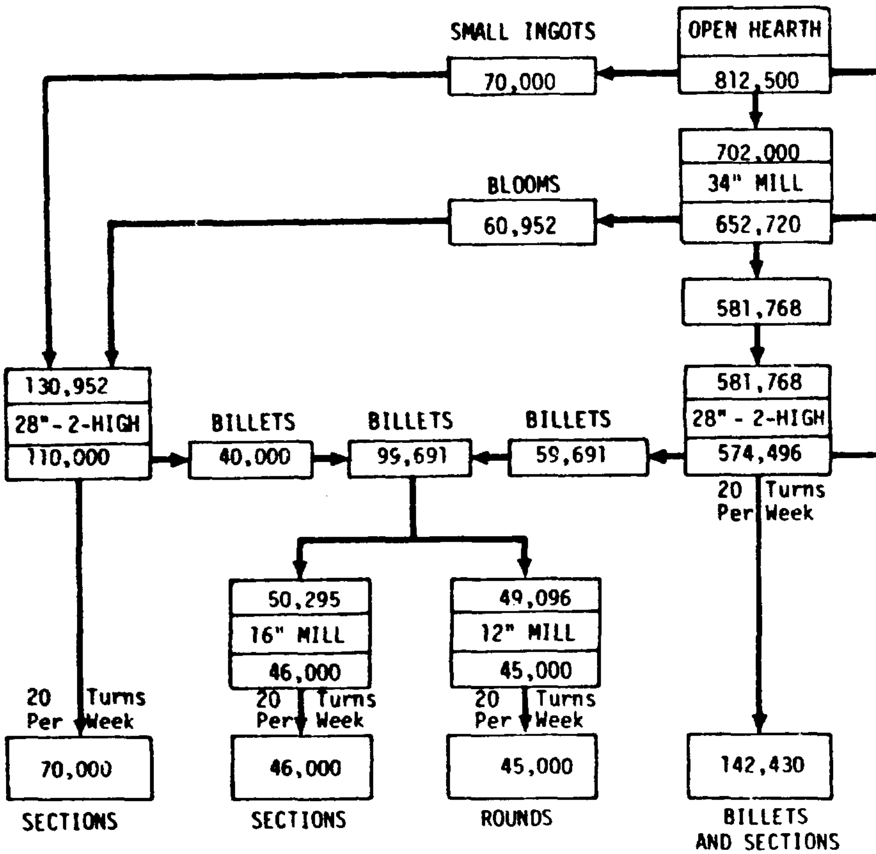

INGOTS
BLOOMS
10,000
BILLETS
356,400
356,400
CONTINUOUS
329,242
329,242
ROUNDS AND SECTIONS
10,000
BLOOMS
INGOTS

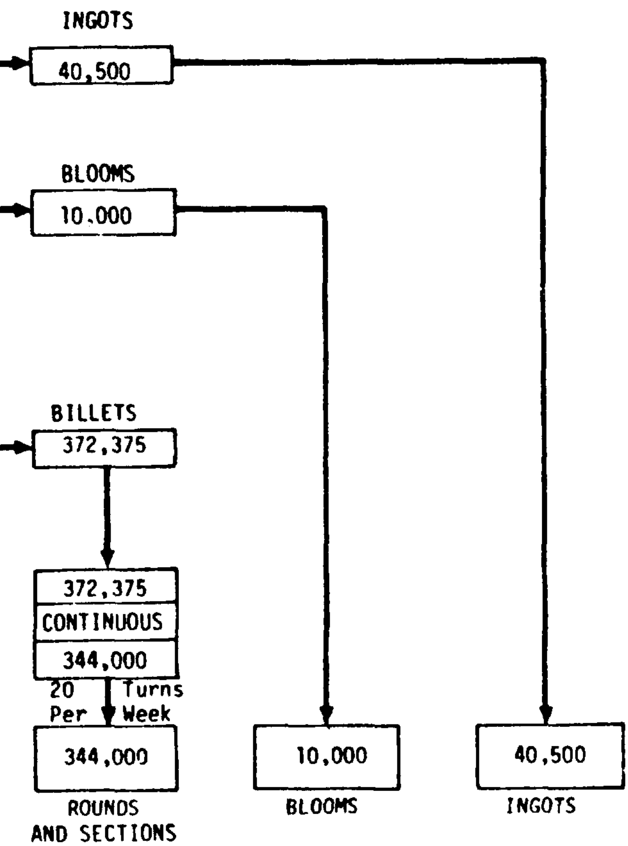
6.10.4 Case III



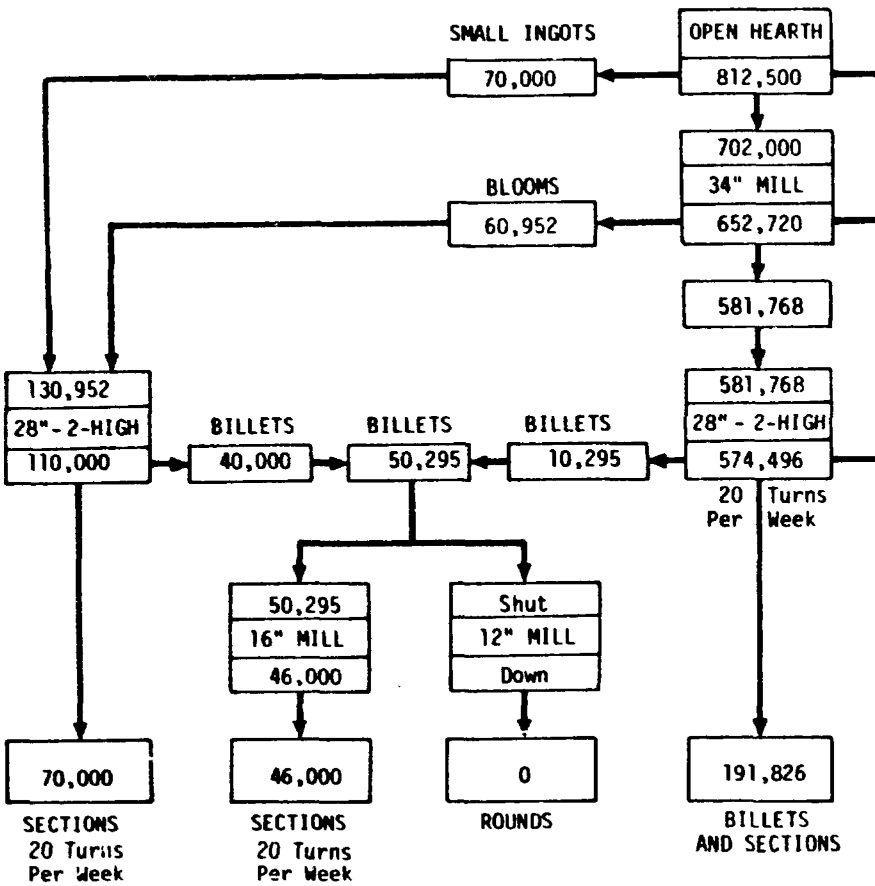

INGOTS
BLOOMS
10,000
BILLETS
356,400
356,400
CONTINUOUS
329,242
329,242
ROUNDS AND SECTIONS
10,000
BLOOMS
INGOTS

6.10.5 Case IV.A - 12" Mill Operating

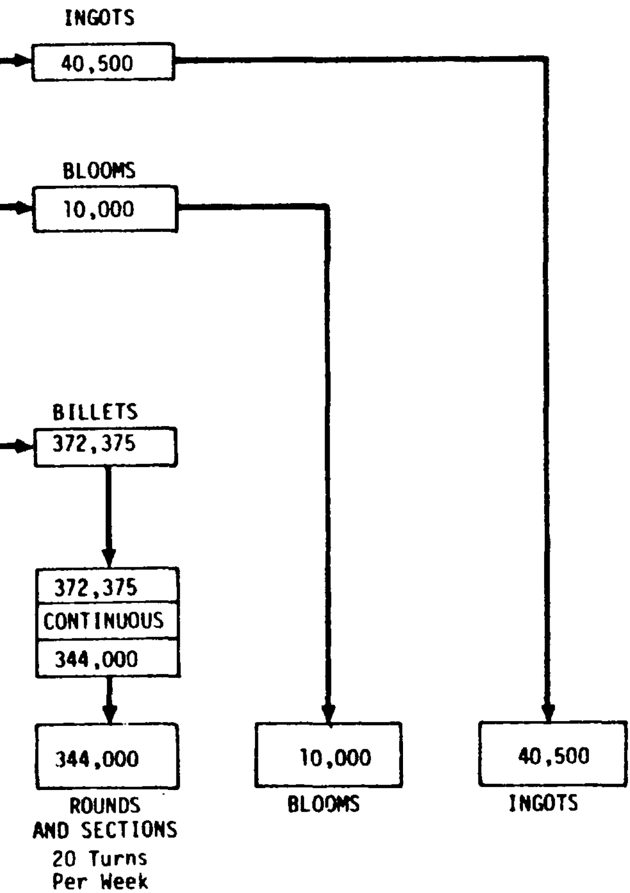



INGOTS
40,500
BLOOMS
10,000
BILLETS
372,375
372,375
CONTINUOUS
344,000
20 Turns
Per Week
344,000
ROUNDS
AND SECTIONS
10,000
BLOOMS
40,500
INGOTS

6.10.6 Case IV.B - 12" Shut Down



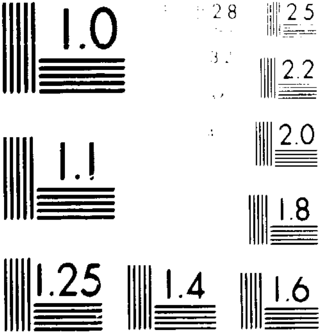
NOTE: 12" Mill shut down;
45,000 MT rounds lost,
49,3[illegible]6 MT billets gained.


INGOTS
40,500
BLOOMS
10,000
BILLETS
372,375
372,375
CONTINUOUS
344,000
344,000
ROUNDS
AND SECTIONS
20 Turns
Per Week
10,000
BLOOMS
40,500
INGOTS

6.11.1 All Rolling Mills

	34" MILL	28" 2-HIGH MILL Billets	28" 2-HIGH MILL Profiles	28" 3-HIGH MILL	16" MILL	12" MILL	CONTINUOUS MILL
M Tons Charges	526,860	226,885.9	191,606.8	113,674.2	46,650.8	42,400.5	294,057.7
M Tons Product	489,908	224,412	189,085.7	98,136.3	42,665.7	38,626.6	271,648.1
Percent Yield	92.98	98.91	98.65	86.33	91.46	91.10	92.38
Operating Hours Per Year	6,163:10	6,050:00	5,864:00	5,162:50	6,084:50	5,881:35	5,057:55
Delay Hours Per Year	2,027:35	2,132:15	2,324:00	2,467:10	1,659:05	1,862:25	3,086:05
Total	8,190:45	8,182:15	8,188:00	7,630:00	7,743:55	7,744:00	8,144:00
Scheduled Down-turns Per Year:							
Weekly	569:15	569:15	572:00	1,130:00	1,016:00	1,016:00	280:00
Annual	--	--	--	--	--	--	336:00
Total	569:15	569:15	572:00	1,130:00	1,016:00	1,016:00	616:00
Grand Total Hours Per Year	8,760:00	8,751:30	8,760:00	8,760:00	8,760:00	8,760:00	8,760:00
Percent Delay (Excluding Scheduled Down-time)	23.14	24.37	26.53	28.16	22.48	21.26	35.23
Ingots Per Operating Hour	21.9						
Ingots Per [Operating + Delay Hour]	16.8						
M Tons Per Ingot	3.9						
M Tons Per Operating Hour	85.5	37.1	32.2	19.0	7.0	6.6	53.7
M Tons Per [Operating + Delay Hour]	65.5	25.6	21.6	11.2	4.9	4.4	34.8
Man-Hours Per Year	271,605	196,985	218,328	420,305.5	686,070	In 16" Mill Total	531,752

83.08.11



1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

6.11.2 Continuous Mill - Operating Plan

Product Size	Program M T/Yr. Product	Tons/ Operating Hour Mfg. Spec.	Operating Hours/Yr.	Program 12" Mill Tonnage	Continuous Operating Hours/Yr.
Rounds					
8 mm	50,000	39	1,282.1		
10 mm	10,000	45	222.2		
12 mm	65,000	45	1,444.4		
14 mm	60,000	59	1,017.0		
16 mm	20,000	61	327.9	25,000	409.8
18 mm	20,000	67	298.5	19,000	283.6
20 mm	5,000	70	71.4		
22 mm	10,000	70	142.9		
24 mm	2,000	70	28.6		
26 mm	5,000	70	71.4		
28 mm	2,000	70	28.6		
30 mm		70			
32 mm	5,000	70	71.4		
Angles					
40 x 40 x 5	20,000	55	363.6		
50 x 50 x 5 50 x 50 x 6	15,000	56	267.9		
60 x 60 x 6	10,000	60	166.7		
	300,000		5,804.6	44,000	693.4

*24.04% = Delay time with heat-related delays excluded.

5804.6 = Annual operating hours to roll 300,000 MT.
693.4 = Annual operating hours to roll 12" Mill tonnage - 44,000 MT.
6498.0 = Annual operating hours to roll 344,000 MT.
1562.0 = 6498 operating hours x 24.04% = 1562 delay hours per year.
8060.0 = Operating + delay hours to roll 344,000 MT.
400.0 = Weekly scheduled downtime, 1 8-hour turn/week x 50 weeks/year.
300.0 = One 12-1/2 day annual maintenance outage
8760.0 = Total hours available in one year.

The continuous mill can roll the 12" Mill (44,000 MT per year) tonnage plus 300,000 MT per year Program.

**See Continuous Mill annual delay exhibit, Section 6.11.2.1, for development of 24.04% delay.*

6.11.2.1 Continuous Mill Delays - 1981

ANNUAL DELAYS	
HOURS:MINUTES	REASON
965:20	Operating reasons
25:50	Mechanical
43:20	Electrical
34:20	No power
--	No water
85:00	No billets
485:30	Daily maintenance
221:10	Change mill (section)
18:55	Change resistors
434:05	No heat
443:35	No gas
2757:05	TOTAL DELAY
5057:55	Mill operating hours
336:00	Annual maintenance
280:00	Weekly scheduled maintenance
329:00	Meal time allowance
8760:00	TOTAL CLOCK HOURS PER YEAR

2757:05

2757:05 + 5057:55 = 35.28% DELAY

Converting no heat and no gas delay time to operating hours:

2757:05 - (434:05 + 443:35) = 1879:25 New annual delay hours

5057:55 + (434:05 + 443:35) = 5935:35 New annual operation hours

Total = 7815 Operating and delay

$\frac{\text{1879:25 hours/year}}{\text{7815 hours/year}}$ = 24.04% New delay percent without fuel delays

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6.12 APPENDICES

6.12.1 34" Mill Schedule - Current

TYPICAL SCHEDULE
34" BLOOMING MILL

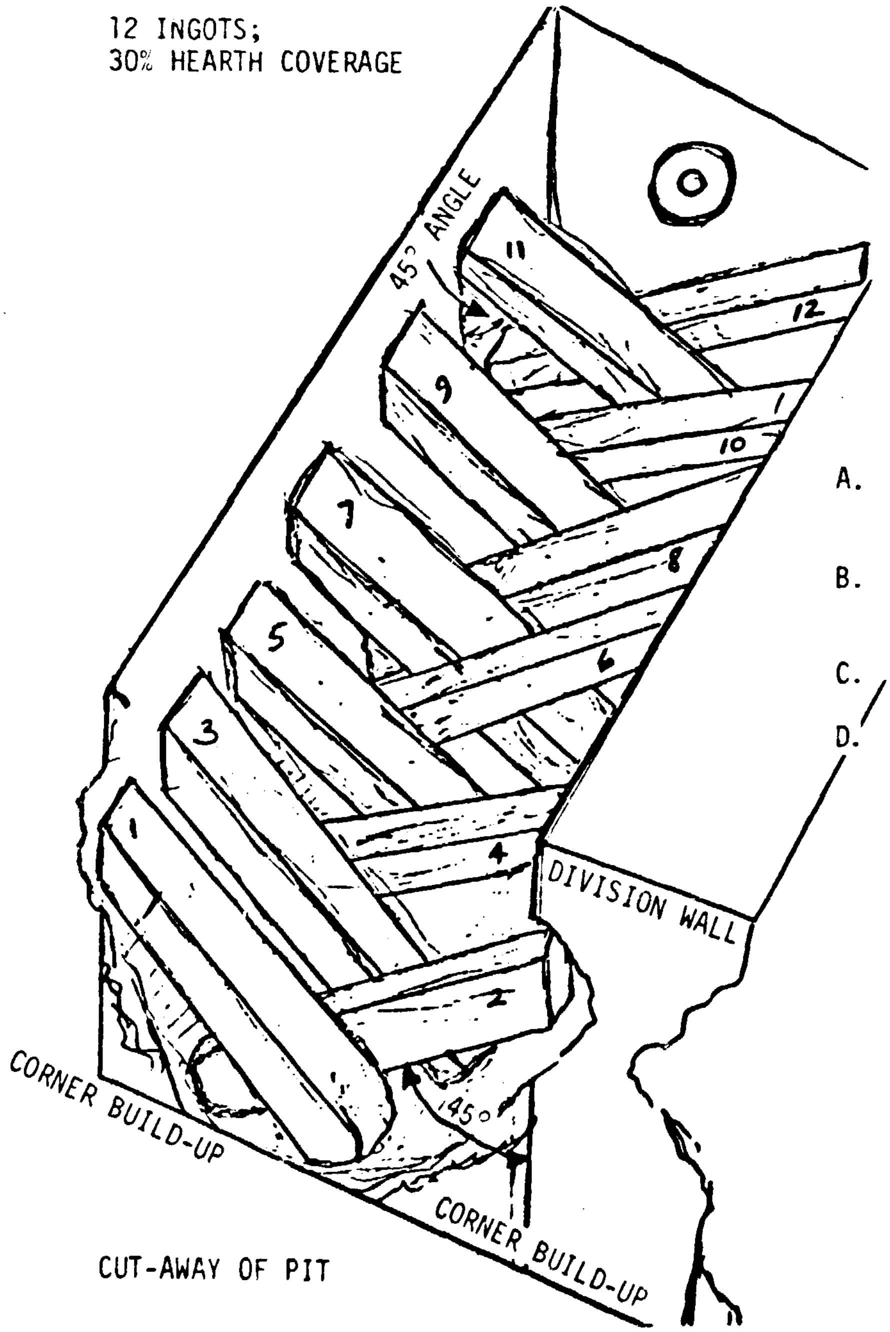
SCHEDULED DOWNTURNS BY MILL CREWS A, B, C												
	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24	00-08 08-16 16-24
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1								C A B				
2					B C A							
3	C A B									C A B		
4				A B C			B C A					
5									B C A			C A B
6						A B C						
7		B C A	C A B								B C A	
8								A B C				
9					C A B							
10	A B C									A B C		
11				B C A			C A B					
12									C A B			A B C
13						B C A						
14		C A B	A B C								C A B	
15								B C A				
16					A B C							
17	B C A									B C A		
18				C A B			A B C					
19									A B C			B C A
20						C A B						
21		A B C	B C A								A B C	
22								C A B				
23					B C A							
24	C A B									C A B		
25				A B C			B C A					
26									B C A			C A B
27						A B C						
28		B C A	C A B								B C A	
29								A B C				
30					C A B							
31	A B C									A B C		

6.12.2 <u>Proposed 34" Blooming Mill Schedule (Typical), Mill Crews A, B, and C</u>

WEEK	TURN	MON	TUE	WED	THU	FRI	SAT	SUN
1	0:00 8:00	A	A	A	A	A	DOWN	A
	8:00 16:00	B	B	B	DOWN	B	B	B
	16:00 24:00	C	DOWN	C	C	C	C	C
2	0:00 8:00	B	B	B	B	B	DOWN	B
	8:00 16:00	C	C	C	DOWN	C	C	C
	16:00 24:00	A	DOWN	A	A	A	A	A
3	0:00 8:00	C	C	C	C	C	DOWN	C
	8:00 16:00	A	A	A	DOWN	A	A	A
	16:00 24:00	B	DOWN	B	B	B	B	B
4	0:00 8:00	A	A	A	A	DOWN	A	A
	8:00 16:00	B	B	B	B	DOWN	B	B
	16:00 24:00	C	C	C	C	DOWN	C	C
5	0:00 8:00	B	B	B	B	B	DOWN	B
	8:00 16:00	C	C	C	DOWN	C	C	C
	16:00 24:00	A	DOWN	A	A	A	A	A
6	0:00 8:00	C	C	C	C	C	DOWN	C
	8:00 16:00	A	A	A	DOWN	A	A	A
	16:00 24:00	B	DOWN	B	B	B	B	B
7	0:00 8:00	A	A	A	A	A	DOWN	A
	8:00 16:00	B	B	B	DOWN	B	B	B
	16:00 24:00	C	DOWN	C	C	C	C	C
8	0:00 8:00	B	B	B	B	DOWN	B	B
	8:00 16:00	C	C	C	C	DOWN	C	C
	16:00 24:00	A	A	A	A	DOWN	A	A
9	0:00 8:00	C	C	C	C	C	DOWN	C
	8:00 16:00	A	A	A	DOWN	A	A	A
	16:00 24:00	B	DOWN	B	B	B	B	B

6.12.3 Soaking Pit Current Charging Practice

12 INGOTS;
30% HEARTH COVERAGE



CUT-AWAY OF PIT

A. Ingots are charged at almost 45° angle.

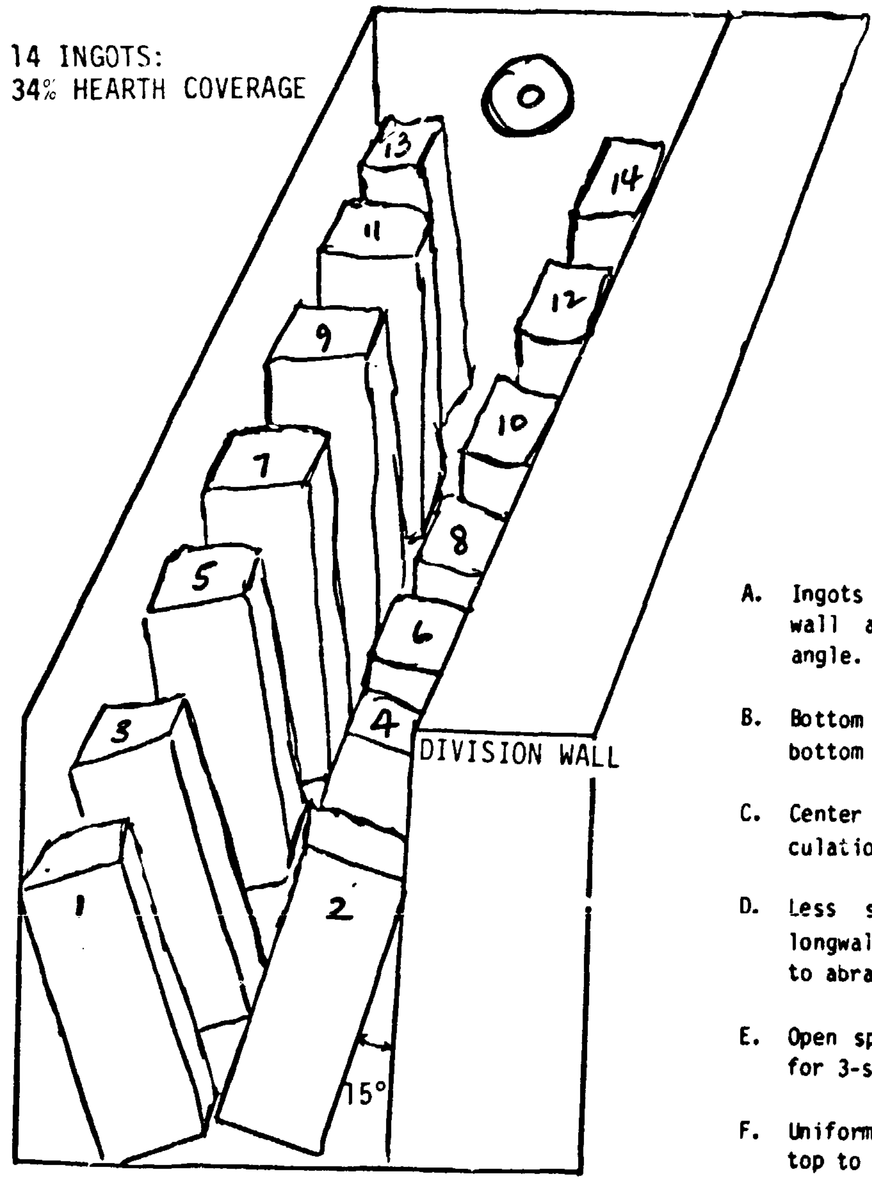
B. Wall erosion is maximum.

C. Many washed ingots.

D. Bottom of pit metal-to-metal from front to back, making for cold ingot bottoms.

APPENDIX 4

6.12.4 Soaking Pit Recommended Charging Practice



A. Ingots stand up against wall at a much smaller angle.

B. Bottom of ingots touch at bottom of pit.

C. Center open for good circulation to bottom of pit.

D. Less severe erosion of longwall refractories due to abrasion.

E. Open space between ingots for 3-sided heating.

F. Uniform heating of ingots top to bottom.

6.12.5 34" Mill Rolling Pattern:
550 x 550 mm Ingot to 180 x 170 mm Bloom

CURRENT PRACTICE			PROPOSED PRACTICE		
Pass	Type Pass	Size	Pass	Type Pass	Size
1	Bullhead	490 x 552	1	Bullhead	490 x 552
2	Bullhead	455 x 558	2	Bullhead	440 x 560
3	Bullhead	420 x 564	Turn		
4	Bullhead	385 x 570	3	Bullhead	490 x 455
5	Bullhead	355 x 577	4	Bullhead	450 x 465
6	Bullhead	325 x 584	5	Bullhead	400 x 480
7	Bullhead	295 x 592	6	Bullhead	360 x 495
8	Bullhead	265 x 600	7	Bullhead	330 x 505
Turn			8	Bullhead	300 x 516
9	306 mm Pass	492 x 285	Turn		
10	306 mm Pass	442 x 300	9	350 mm Pass	470 x 310
11	306 mm Pass	382 x 315	10	350 mm Pass	420 x 315
12	306 mm Pass	322 x 330	11	350 mm Pass	370 x 322
Turn			12	350 mm Pass	320 x 340
13	Bullhead	240 x 350	Turn		
14	Bullhead	200 x 362	13	350 mm Pass	270 x 340
Turn			14	350 mm Pass	200 x 360
15	230 mm Pass	292 x 220	Turn		
16	230 mm Pass	222 x 235	15	240 mm Pass	280 x 215
Turn			16	240 mm Pass	200 x 240
17	Bullhead	180 x 245	Turn		
18	Bullhead	150 x 262	17	270 mm Pass	180 x 220
Turn			18	270 mm Pass	150 x 240
19	174 mm Pass	180 x 170	Turn		
			19	174 mm Pass	180 x 170

6.12.6 1981 Record of Soaking Pit Bottom Cleaning

( ) = Occurrences

NUMBER OF DAYS PIT OUT OF SERVICE DUE TO BOTTOM CLEANING

PIT NO.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL OCCURRENCES	TOTAL DAYS
1	(1) 7			(1) 6		(1) 8		(1) 4			(1) 6		(5)	31
2	(1) 6		(1) 11		(1) 9		26	(1) 11		(1) 13			(5)	76
3	(1) 8		(1) 2		(1) 7		(1) 18		(1) 12			(1) 5	(6)	52
4			(1) 9			(1) 12			(1) 8			(1) 3	(4)	32
5	(1) 7	(1) 4		(1) 5				(1) 11			(1) 15		(5)	42
6		(1) 5		(1) 5	(1) 4			(1) 6		(1) 9		(1) 3	(6)	32
7		(1) 7				(1) 4		(1) 11		(1) 4		(1) 1	(5)	27
8					(1) 4			7	(1) 11		(1) 5		(3)	27
9			(1) 5				(1) 8		7	(1) 4	(1) 5		(4)	29
10	3	(1) 5	(1) 5			(1) 6		(1) 7	7	(1) 7		(1) 5	(6)	45
11		2	(1) 4	(1) 3		8	(1) 2	(1) 8			3	(1) 3	(5)	33
12		(1) 5		(1) 2			(1) 4				(1) 3	(1) 1	(5)	15

Occurrences per year = 59

$$\frac{441 \text{ Days Lost}}{59 \text{ Occurrences}} = 7.5 \text{ Days Per Occurrence}$$

6.12.7 1981 Soaking Pit Utilization

ROLLING DIVISION RECORDS

Month	Number of Pits	Pits Operating
January	12	7.2
February	12	8.1
March	12	8.0
April	12	7.8
May	12	7.8
June	12	8.6
July	12	7.0
August	12	7.6
September	12	8.0
October	12	7.4
November	12	7.6
December	12	7.0
Total		92.1

92.1 ÷ 12 = 7.7 Operating Pits

7.7 ÷ 12 = 64% Pit Utilization

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

7.0 POWER AND FUEL

- CONTENTS -

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

7.0 POWER AND FUEL

7.1 SUMMARY OF POWER AND FUEL REPORT

7.1.1 Soaking Pits and Rolling Mills

The major problem in the rolling mills is the firing of fuel oil in the soaking pits. Oil firing should be used only for emergencies. Gaseous fuel must be used to reestablish automatic control of pit temperature, fuel/air ratio, and furnace pressure. Refractory damage will be reduced and product quality will improve. Increased firing rates using gaseous fuel will be required to improve soaking pit production.

The rolling division's primary problem is gaseous fuel availability. If this problem is not solved, the rolling mills will not only fail to improve, their productivity will get worse. The gaseous fuel balance must be controllable to completely satisfy the rolling division's need. The following changes can be made.

7.1.2 Power House

In the near term the powerhouse must reduce its use of gaseous fuel and burn 89.5 tons more coal per day to replace the oil at the soaking pits with mixed gas. The mixed gas needed is 10,000 Nm^3 per hour. A partial reduction can be made immediately by increasing the steam production on 1-4 boilers, and by limiting steam production on Boilers 5 and 6. Superheater tube failures in 5 and 6 Boilers must be eliminated by replacing the present tubes with more heat resistant tubes and by reducing the number in each boiler by 10 to 20%.

The calculated saving should be $1,800,000 per year by replacing oil at the soaking pits with coal at the boilerhouse.

These savings include reduced maintenance and production costs at the soaking pits.

The power circuits in the plant should be tied to the outside source of power to take advantage of less expensive power and own generation should be increased when there is a shortage of outside power. Reducing own generated power will reduce the use of gaseous fuel in the boilers. Savings of 15% of the present power costs are possible.

7.1.3 Natural Draft Cooling Tower

A plan is submitted to ultimately determine whether the plant can use the natural draft cooling tower as originally designed. If not, it should be used for the plant water system only, to provide production units with clean cooling water. The condensers in the powerhouse would be piped to use "once through" water as they currently are and remain separated from the cooling tower system.

7.1.4 Open Hearth

Burner changes should be made to increase the amount of tar burned and to reduce gaseous fuel use. Compressed air for tar atomization should be replaced with steam. Burners can then be built to burn 100% liquid fuel (no gas), thereby releasing more gaseous fuel to the rolling mills.

7.1.5 Fuel Distribution

A fuel and power distribution center should be established to direct the use of utilities for maximum economy. The reduction of gas bleeding should be given high priority. From this center, "in plant" power generation would be controlled. An energy director should be appointed to direct the plant energy systems to save $4,000,000 per year.

7.1.6 Coke Plant

In the past three years the calorific value of the coke oven gas has dropped 20% or the equivalent of 6,000 Nm^3 per hour of coke oven gas. This change in calorific value was the result of the reduction in pressure in the collector mains at the coke batteries. With this reduction came an increase in density which reduced the corrected volume by 14%; therefore, the total energy reduction is greater than 25%. The pressure reduction was made to reduce the smoke problem on the battery tops. Door seals, etc., should be repaired so that the normal collector main pressures can be reestablished. With lower pressures, air is infiltrated into the ovens and burns part of the fuel. The fuel that is burnt is lost to the plant. These reductions are still taking place; for example, Batteries 1 and 2 had their collector main pressure reduced six months ago from 4.0 to 3.5 mm water pressure. A reduction in door leakage must be accomplished by repairing seals, not by reducing pressure.

7.1.7 Plant Fuel Group

A plant fuel group should be established to cover the entire plant in order to solve problems with furnaces, stoves and boilers. The instrument group would be used as a source of qualified candidates. Specialists would train them with a leader selected to spend three months in a foreign steel plant for additional training. Specialists from this group would be assigned to the fuel consuming departments such as blast furnaces, open hearth, and rolling mills.

7.2 ROLLING MILL PROBLEMS

7.2.1 Soaking Pit Heating Practice - Fuel Oil and Tar

Many of the steel quality problems in the blooming mill (34") can be traced to the heating practices in the soaking pits. Most of these problems surfaced after fuel oil firing was installed. The operators found that there was sufficient combustion air available to burn not only all the mixed gas but maximum oil as well. The soaking pit firing rates were increased from 4.0 million Kcal per hour to 6.4 million Kcal per hour. Since the soaking pits were, and still are, a major bottleneck in steel production, the increased productivity due to the increased firing rates was welcomed. For one reason or another, the disadvantages were ignored. These disadvantages are as follows.

- Pit temperature differentials become very large, causing severe refractory damage where the oil droplets strike the walls and covers.
- Flame temperatures are very high when firing oil, increasing scale formation, as indicated by a test on No. 12 pit using gas only. The scale clean-out cycle was 100 days longer than pits using fuel oil.

- The fuel/air ratio cannot be controlled, because the control system was not designed to function when firing two fuels. Very high fuel rates result.

- Automatic temperature control was negated because the thermocouples were destroyed by the unatomized oil droplets striking them.

- The temperature measuring device in the wall opposite the burner was removed because of the rapid deterioration of the refractory wall. The temperature measurement in the burner wall gives many examples of widely varying draw temperatures: for example, from 1,200 to 1,480° C. Temperatures above 1,365° C will cause washing of the steel surface because scale melts above 1,365° C. These very high temperatures should cause further alarm because the wall opposite the burner will be hotter.

- The velocity of the combustion gases in the pits with maximum air flow at all times causes additional scale loss.

$$\text{Rate of Scale Formation} = (V)^{0.6-0.7}$$

where V is the velocity of the combustion gases.

7.2.2 Recommendations

A. Eliminate the use of fuel oil except for emergencies.

B. Provide additional mixed gas to replace the oil by burning more coal in the boilers.

C. Increase the mixed gas firing rate by installing a 6" pipe through the burner wall in the horizontal plane at the burner height directed toward the flame at a 30° angle from the burner centerline. This pipe, with a shut-off valve, will be connected to the mixed gas supply line downstream of the control valve. The firing rate will increase from 3.3 to 5.0 million Kcal per hour. The pipe should extend into the pit not more than 5" and be sealed into the wall. During the 21-day outage, at least one battery should be equipped with these pipes.

D. After fuel oil is no longer used consistently, reestablish the temperature measurement in the wall opposite the burner. The thermocouple should be located at the level of the tops of the ingots.

E. Reactivate the automatic temperature control when oil is no longer used consistently.

F. Limit the maximum air flow by adjusting the control valve linkage to burn all the available mixed gas with 10% excess air.

G. Reactivate the fuel/air ratio control valve linkage to maintain 10% excess air at all firing rates.

H. Reinstall dampers, for the following reasons:

(1) To control the pit pressure.

(2) To prevent flames entering a non-operating pit where people are working. The present practice is dangerous.

(3) To prevent drafting cold air from a non-operating pit into the collector flue, reducing the preheated air temperature.

7.2.3 General Comments on Pit Pressure

Pit pressure or furnace pressure control in soaking pits is extremely important in reducing infiltrated air into the pit bottom which lowers the temperature of the ingot bottoms. Bottoms are the coldest part of the ingot normally, and air infiltration makes them even colder. Rolling quality is dependent on uniformly heated steel; therefore, furnace pressure control is extremely important for quality rolling of steel. All dampers should be reinstalled during the 21-day outage later in the year.

7.2.4 Benefits of replacing oil on the soaking pits with gas:

COST SUMMARY

Benefits	Annual Savings
Hotter, more uniformly heated ingots, surface quality improvement	Significant but indeterminant
Production improvement, soaking pits, 34"-28" Mills	$ 424,587
Refractory usage reduction; also, installation labor	$ 349,358
Reduced fuel oil purchases, soaking pits	$ 3,570,000
Increased tonnage production:	
28" 3-high mill	5,680 MT/Year
Continuous mill	7,291 MT/Year
34"-28" 2-high mills	122,477 MT/Year
Reduced pit bottom cleaning due to a 50% lower scale generation	$ 62,330
	$ 4,406,275
Additional mixed gas purchased by soaking pits:	
7000 Nm^3 per hour, coke oven	$ 3,080,717
3500 Nm^3 per hour, blast furnace gas	405,325
	$ 3,486,042
Additional work and maintnance costs in boiler house	Indeterminate
SAVINGS $4,406,275 - $3,486,042	$ 920,233

In the event it is impossible to substitute coal for coke oven gas in the boilerhouses due to unavailability of coal, both domestic and imported, it is recommended that fuel oil be used in the boilerhouse and that mixed gas be made available for use in the soaking pits. This suggestion would generate all the dollar savings listed above, and it would eliminate many of the operating problems which the use of fuel oil on the soaking pits has caused. These are discussed in detail in other sections of this report.

Any thought of competing on the export market is unrealistic as long as the combination of mixed gas and fuel oil is used for heating on the soaking pits.

7.2.4.2 Calculation of Savings

A. Production improvement, 34"-28" mills and soaking pits.

Hotter, more uniformly heated ingots will enable the 34" mill to increase productivity by 25%. Many costs vary with the tonnage, but the soaking pit and the 34"-28" mill labor costs are relatively constant per year because of the manner in which they are scheduled. Therefore, an increase in production would not result in additional soaking pit or mill labor costs. Labor costs, as furnished by the Director-Rolling Division, are:

200 TL/MT product = 34" mill
190 TL/MT product = 28" 2-high billet mill
450 TL/MT product = 28" 2-high profile mill

Average labor cost:

$$200\ \text{TL} + \frac{(190\ \text{TL} + 450\ \text{TL})}{2} = 520\ \text{TL/MT product}$$

489,908 MT = Annual production, 34" mill
25% = Anticipated increase, 34" mill production
122,477 MT = Anticipated MT increase, 34" mill

489,908 MT/year x 520 TL/MT labor costs = 254,752,160 TL per year, labor

489,908 MT/year + 122,477 MT = 612,385 MT/year annual tonnage

$$\frac{254{,}752{,}160\ \text{TL/year}}{612{,}385\ \text{MT/year}} = 416\ \text{TL/MT revised labor cost}$$

520 TL/MT - 416 TL/MT = 104 TL/MT labor savings

104 TL/MT x 612,385 MT/Year = 63,688,040 TL/year savings

$$\frac{63{,}688{,}040 \text{ TL/year}}{150 \text{ TL/\$100}} = \$424{,}587 \text{ annual savings}$$

B. <u>Refractory Usage</u>

This savings is based upon an estimated 50% reduction in the consumption and installation of clay fire brick in the soaking pits if the use of fuel oil is discontinued.
<u>1981 Report</u>:

1,912 MT fire clay bricks	=	soaking pits and 28" reheat furnace
184 MT fire clay	=	soaking pits and 28" reheat furnace
83,310 man-hours	=	masonry labor

Masonry split the usage as follows:

1,910 MT bricks	=	soaking pits
184 MT clay	=	soaking pits
2 MT bricks	=	28" reheat furnace

This split the man-hours:

85 man-hours	=	28" reheat furnace
81,225 man-hours	=	soaking pits

<u>Labor</u>:

48 man-hours/week x 52 weeks/year = 2,496 man-hours/year/man

$$\frac{81{,}225 \text{ man-hours/year}}{2{,}496 \text{ man-hours/man/year}} = 32.5 \text{ men/year}$$

50% reduction	=	16 men
Annual earnings per man	=	$7,333

16 men x $7,333/year = $117,328 labor savings

<u>Brick</u>

1,910 MT bricks x $233.33/MT	=	$ 445,660/year
50% reduction (.50 x $445,660)	=	$222.830/year savings

Clay

184 MT/year x $100/MT = $ 18,400/year
50% reduction (.50 x $18,400) = $ 9,200/year savings

Total Savings:

Labor	=	$ 117,328
Brick	=	222,830
Clay	=	9,200
		$ 349,358 per year

C. Reduced fuel oil purchases, soaking pits

By eliminating the use of fuel oil on the soaking pits, the entire cost of purchased fuel oil can be saved. This is a total of $3.57 million per year.

D. Increased production

No attempt is made to dollarize the value of the additional tonnage which the uninterrupted source of mixed gas will enable the pits and the mills to provide. It is important to note that the potential increase is essential if the blast furnaces and the open hearths accomplish their objectives. Without the ability to heat and roll additional tonnage, the rolling division soaking pits quickly become the plant bottleneck.

The increase in mixed gas availability comes not only from the boilerhouse change, but also from the many soaking pit related projects which will reduce the fuel rate in the soaking pits by an estimated 300,000 BTU's per ton.

(1) 28" 3-High Mill

Delay time	=	438 hours/year	=	delay, no heat
		443 hours/year	=	delay, no gas
		881 hours/year	=	total heating delays

The possible reduction of this heating delay, based upon mixed gas availability, is estimated conservatively at 50%.

881 x .50 = 440.5 delay time eliminated
12.9 MT/hour = production rate, 28" 3-high mill

440.5 hours x 12.9 MT/hour = 5,685 MT/year increased production

(2) Continuous Rod and Bar Mill

434 hours/year = Delay, no heat
33.6 MT/hour = Production rate
50% = Estimated improvement, heating delay

434 x .50 = 217 hours delay eliminated

217 hours x 33.6 MT/hour = 7,291 MT/year Increased production

(3) 34" Mill and Soaking Pits

489,908 MT = annual production

The calculation of the anticipated increased production for the 34" mill is based on factors other than the reduction in heating delay time. The total estimated production increase annually, with an adequate supply of mixed gas for the soaking pits, comes not only from the reduced heating delay time but also from the effect of hot, uniformly heated ingots on the rolling rate. Heavier drafting and fewer passes will also contribute to the production increase which has been conservatively estimated at 25% above the current (1981) rolling rate. This translates to tonnage of:

Current rolling rate	=	489,908 MT/year
Estimated increase	=	25%
Estimated annual tonnage increase	=	122,477 MT/Year

E. Reduced [illegible]it bottom cl[illegible]ing due to a 50% lower scale generat[illegible]

By [illegible]d gas for fuel oil, scale generation will [illegible] estimated 50%.

(1) Statistics:

7.5 days	= period of time pit is down
32 man-hours	= per turn when pit is down
59 occurrences/year	= total pit outages.

(2) Man-hour requirements:

7.5 days/outage x 3 turns/day x 32 man-hours/turn = 720 man-hours per occurrence

720 man-hours/occurrence x 59 occurrences/year = 42,480 man-hours/year to clean out scale

50% improvement = .50 x 42,480 man-hours/year
= 21,240 man-hours saved

$$\frac{\text{21,240 man-hours/year}}{\text{48 man-hours/week x 52 weeks/year}} = \text{8.5 men per year}$$

8.5 men/year x $7,333/man/year = $62,330/year savings

7.3 PROBLEMS WITH MIXED GAS

The calorific value of the mixed gas consistently changes because of insufficient supplies of coke oven gas.

7.3.1 Recommendations

A. Establish a Fuel and Power Distribution Center to direct the use of coke oven gas.

B. Correct the door leakage problems in the coke plant.

C. Temperature control, fuel/air ratio control, and furnace pressure control:

- Ingots are heated by eye. After the ingots are charged, the heater fires maximum fuel (both gas and oil) until he believes the ingots are ready to roll. Fuel and air are shut off manually and the ingots are rolled in about an hour or less.

- The soaking pit metering and controls are old, 20 to 40 years, and should be replaced with modern microprocessors. This new equipment handles all the normal metering and control and allows for optimization of the fuel/air ratio. Optimization of the fuel/ air ratio seeks the steepest slope of the temperature rise curve after charging and the minimum fuel input to hold the temperature set-point after it is reached. This system uses the latest technology and is very effective in reducing energy consumption in soaking pits.

7.4 FUEL BURNING PROBLEMS

At the present time, instrument service is provided by the gas distribution group with very little knowledge of the theory of furnace operation. Some of the theory was presented to the rolling mill and gas distribution department managers after the need was recognized.

7.4.1 Recommendation

An energy course should be provided to instruct instrument technicians, heaters, foremen, engineers, managers, everyone associated with the soaking pits and reheating furnaces in the basics of furnace operation. This course should provide classroom and hands-on training. It should take 6 weeks to complete. UEC has a formalized course available for such a program.

7.5 RECUPERATION

Each soaking pit battery of 4 pits has a recuperator. The recuperator is ceramic and seems to be in good condition. However, the dampers which separate each pit from the common collector flue have been removed. Without the dampers, the collector flue drafts cold air from non-operating pits, diluting the hot gases from operating pits and reducing the recuperation potential. With the reinstallation of all the dampers during the 21-day outage, the recuperators, which appear tight, should do well.

7.6 COPING LEAKAGE EFFECT ON FUEL EFFICIENCY

Soaking pit copings are in extremely poor condition. Section 6 of this report deals with the reasons for the conditions and makes recommendations for improvement. A major cause of the very poor energy efficiency of the pits is the large quantity of hot waste gases leaving at the coping. The gas leaves at temperatures of 2,600° F or higher. With the flame temperature of 3,000° F, only 400° are useful; therefore, the efficiency of this waste gas is not more than 14%. In addition, it gives up its sensible heat in the combustion chamber above the ingots and upsets the temperature uniformity in the soaking pits. Coping leakage is a constant problem and must be corrected as it occurs because of its serious effect on operations.

7.7 POWERHOUSE

7.7.1 Coal Firing

Coal was to be the primary fuel in the boilerhouse, but to a large degree it has been replaced with blast furnace gas and coke gas. Originally, as now, the plant fuel balance required these gaseous fuels to be used in steel reheating furnaces.

Powerhouse management decided not to burn coal on the two new boilers because of higher maintenance costs. They have expressed concern over reducing gas consumption and increasing coal use because the manufacturer cautioned them about burner problems when using small quantities of gaseous fuels. Every boiler operator has burner problems; problems which are generally resolved by bleeding small quantities of air into the gas tube of the burner when not using gas. In any case, boilers should not take a higher priority than steel reheating furnaces. Except for long-term burner deterioration, the boilers can function without coke gas. This statement was proven in the past when the boilerhouse operated for 24 hours without coke gas during a planned gas line outage.

The powerhouse management gives the following additional reasons why it is impossible to reduce the use of coke gas on the boilers:

Permission has been given to use 5,000 Nm^3 per hour of coke gas and the reported use of 7,500 to 10,000 Nm^3 per hour is caused by meter errors and is not over 5,000 Nm^3 per hour. The meters on Boilers 5 and 6 are believed to be the major problem.

This statement is partially correct because all coke gas meters were found to read 14% high because of the density change in the past few years. The density has risen from .345 to .47 due to the reduction in the collector main pressures in the coke plant.

In addition, boiler efficiency tests (see Appendix 8) indicate the possibility of an additional error of 23% due to naphthene deposits in the venturi tube which measures the gas flow to Nos. 5 and 6 Boilers. However, the real problem is superheater tube failures. When coal is fired over a sustained period or when blast furnace gas is fired at rates above 15,000 Nm^3 per hour superheater tubes begin to fail.

When firing coal, the water wall tubes become covered with ash and slag reducing the rate of heat transfer to the tube and causing the gases leaving the boiler furnace and to be hotter. These hotter gases raise the temperature of the superheater tubes and they fail. The failure of the superheater tubes with high firing rates of blast furnace gas is caused by higher gas temperatures surrounding them. The exact causes are not known but higher mass gas flows due to the lean gas is one of the many variables that contribute to higher temperature gas in the superheater tube space.

In 1956, the boilerhouse generated 0.498 million tons of steam and burned 39,000 tons of coal. In 1980, the boilerhouse generated 1.035 million tons of steam and burned only 25,550 tons of coal. The use of coke oven gas increased from 34,000,000 m^3 in 1956 to 66,000,000 m^3 in 1980. This is further indication that the boilerhouse can increase coal consumption and reduce gas use (see Appendix 1 for data on present and proposed fuel consumption).

A comparison of coal and gas costs follows:

Annual Cost of Gas

Coke Oven Gas = 7000 Nm^3/hour x 8,760 hours/year x $ .05024/Nm^3 = $3,080,717/year

Blast Furnace Gas = 3500 Nm^3/hour x 8,760 hours/year x $ .01322/Nm^3 = $405,325/year

Annual Cost of Coal

To Replace Coke Oven Gas:

7,000 Nm^3 gas reduction in boilerhouse
3,500 kcal/Nm^3 = calorific value of gas

7,000 Nm^3/hour x 24 hours/day x 365 days/year x
3,500 kcal/Nm^3 = 214,620 million kcal/year
6,770 kcal/kg = calorific value of coal

$$\frac{214{,}620 \text{ Million kcal/Year}}{6{,}770 \text{ calories/kg}} = 31{,}703 \text{ tons coal/year}$$

$71.00 = cost of MT coal (1981)
31,703 MT/year x $71.00/MT = $2,250,913

To Replace Blast Furnace Gas:

3,500 Nm^3/hour = gas reduction in boilerhouse
1,000 kcal/Nm^3 = calorific value, BF gas

3,500 Nm^3/hour x 24 hours/day x 365 days/year x
1,000 kcal/Nm^3 = 30,660 million kcal/year

$$\frac{30{,}660 \text{ million kcal/year}}{6{,}770 \text{ calories/kg}} = 4{,}529 \text{ tons coal per year}$$

4,529 MT/year x $71/MT = $321,559/year

TOTAL ANNUAL COAL REPLACEMENT COST:

For Coke Oven Gas	=	$2,250,913
For Blast Furnace Gas	=	321,559
TOTAL		$2,572,482

SUMMARY:

Annual Cost of Gas	$3,486,042
Annual Cost of Coal as Replacement	2,572,482
SAVINGS	$ 913,560

The above savings will be partially offset by increased maintenance costs caused by coal firing.

7.7.2 Oil Firing

Consideration has been given to using heavy fuel oil in the boilers, but boilerhouse management believes that the manufacturer prohibits it. It is a probably a case of how much oil can be burned, not whether or not it can be burned. Perhaps the boiler could generate 50% of maximum rating but not 100%.

Recommendations

A. The boilerhouse should immediately reduce the use of coke oven gas consistent with restrictions caused by superheater problems.

B. The boiler manufacturer should be contacted and specific recommendations obtained regarding the maximum permissable use of No. 6 fuel oil. It should also be determined whether additional burners can be installed to increase this amount.

7.7.3 Superheater Tube Failures

There have been superheater tube failures in the new boilers. The causes of the failures are overheating of the tube wall because the steam flow in each of the superheater tubes is too low as indicated by the pressure drop measurement across the superheaters. In the USA practice, the pressure drop across the superheaters at full load would be 3 kg per $cm^2 \pm .5$ kg per cm^2 (Boilers 1-4 are designed for 3 kg per cm^2 pressure drop). The pressure drop over No. 6 Boiler superheater is .2 kg per cm^2 while generating 26 tons of steam per hour. At maximum generation, 32 tons of steam per hour, the pressure drop is calculated to be .3 kg per cm^2.

7.7.3.1 Recommendation

The following procedure has been used with success in solving similar problems in the past. Reduce the number of superheater tubes three at a time by plugging their header connections. Note the superheat temperature (it should fall slightly). Note the pressure drop over the superheater (it should rise to .25 kg per cm^2 at 26 tons of steam generated). If the removal of three tubes produces the predicted slight changes, remove three more tubes. Proceed to allow the temperature in the superheater area to rise by 50° C at a time to see if failures occur and, if they do, at what temperature. Then fire the boilers at the highest temperature that produces no failures.

Before proceeding with the above recommendations the boiler manufacturer must be consulted and his concurrence and further suggestions obtained.

7.7.3.2 The superheater tubes do not have sufficient quantities of alloying elements for this application. Our recommendation is to contact boiler tube manufacturers for tubes which have higher alloy content. Buy tubes for use in generating steam at 500° C. The present tubes have 1.4% molybdenum and no chromium. They need to be replaced with tubes with more molybdenum and some chromium and perhaps other alloys.

7.7.3.3 General Recommendation

Until the superheater problem is solved, the steam generation on Boiler Nos. 5 and 6 should be minimized by keeping Boilers 1-4 in operation the maximum time possible at maximum ratings, and by burning a minimum of coke gas and a maximum of coal. Boilers 5 and 6, when operating, should be generating only the balance of the steam needed to maintain steam pressure. 1500 Nm^3 per hour of coke gas can thereby be made available to the rolling mill reheating furnaces.

7.7.4 Boiler Efficiency

A test was made to determine the boiler efficiency by (1) the waste gas loss and an assumed 3% radiation and unaccounted for loss, and (2) the steam output versus fuel input by meter. The efficiency by the first means was 82.3%. In order to refine this very high efficiency we took into consideration the moisture in the blast furnace gas which has been found by others to be as high as 10% by weight of the gas. We assumed 5% by weight of the gas and calculated the loss. A second large heat loss is the ash pit which is a water box at the bottom of the furnace. From heat transfer curves, we calculated the heat loss to be 60,000 BTU per square foot per hour.

With these two losses taken into the efficiency calculation, the efficiency was 74.2%.

The second method of calculation produced an efficiency of 61.4%. Obviously there were some problems with the meter readings. All the meters were checked for calibration and found correct. However, the density of the coke oven gas was much different than the design density (actual 0.470 vs. design 0.349) and the meter readings must be reduced by 14%. Correcting the coke gas meter by 14% increased the efficiency to 66%. 74.2% efficiency versus 66% is still unsatisfactory. Another source of error can be the deposits of naphthene in the venturi tube which measures the coke gas flow. Therefore, the next step is to clear any deposits in the metering run.

7.7.4.1 Recommendations

Remove the naphthenes in the metering runs by either heat or physical means and keep the metering run free of additional deposits by heat tracing and insulation. The heated portion of the line should be four meters upstream from the venturi, the venturi itself, and three meters downstream.

7.7.5 Power Generation - Provide for Outside Purchase

No attempt is made to reduce power costs by buying outside generated power. The plant power system is set up in two parts: (1) the powerhouse, coke plant, and the blast furnaces, and (2) the balance of the plant. The powerhouse supplies the powerhouse, the coke plant, and the blast furnaces, and the outside source of power supplies the balance of the plant. The two systems about divide the load. The cost of power from the outside source is roughly one-half the cost of own-generated power.

7.7.5.1 Recommendation

Tie the two circuits together with oil circuit breakers with relaying to protect the powerhouse, coke plant and blast furnaces. The relaying should protect against low voltage and high currents, and provide power limits on the powerhouse generators. The oil circuit breakers should be designed to open in perhaps six cycles, or 1/10th second.

In-plant generators are compatable with the outside generated power and can be paralleled with it. Therefore, to control plant generation when the systems are tied together, the switchboard tender increases or decreases his speed control setting on the turbine governor to generate more or less power. With good communications with the Turkish Power Company, a mutually beneficial operating plan can be established; for example, the plant would generate at present loads during the hours of 8:00 a.m. to 9:00 p.m. but at light loads from 9:00 p.m. to 8:00 a.m. Plant generation on the week-ends would be very low. With such a plan the plant should be able to reduce its monthly power generation by 50%. By reducing power generation, less fuel will be needed to make steam. Coke oven gas use will be reduced and made available to the coke plant, the sinter plant, and the rolling mills. Potential savings of 15% of the total cost of power can be made by implementation of this recommendation.

7.7.5.2 General Comment

The proposed new power station should consider the country's power projections as part of the engineering study to determine boiler and power generating capacity. For example, it might be wise to be able to generate 50 megawatts or more of power in-plant to cover all plant loads, along with a percentage of the town's needs.

7.7.6 Fuel and Power Dispatching - Establish Distribution Center

Over the years, most steel plants have set up distribution centers to conserve fuel and power. The dispatcher has the authority to order changes to correct any imbalance. Generally the dispatcher increases or decreases power generation to burn the excess by-product fuel. Adjustments can be made to avoid bleeding by reducing coal consumption, by burning more gas, or by contacting other consumers to use more gas. Karabuk should set up such a system in the powerhouse.

All main units should have their power and fuel usage transmitted to the distribution center. The dispatcher should monitor the whole system on a timely basis to achieve maximum economy. A director should set the parameters under which the dispatchers operate; for example, he lists in order of priority, users of fuel and power, the costs of each fuel, etc.

At the present time, there is significant bleeding of blast furnace gas because the gas tender at the mixing station lacks authority to direct the boilerhouse operators to change fuels. This condition stems from poor cooperation between departments. Initial steps to be taken in establishing a distribution center are:

A. Improve the blast furnace gas bleeder flow meter so an accurate flow record is available.

B. Install a horn and light in the boilerhouse to indicate that blast furnace gas is being bled.

C. Install a bleeder flow meter in the boilerhouse so the boiler operators are aware of the quantity of gas being bled.

D. Reduce bleeding to a minimum by requiring each turn foreman of the boilerhouse to explain any bleeding above some minimum amount, for example, 2%.

7.7.6.1 General Comment

Lack of energy management at Karabuk is costing the plant large sums of money and contributing to poor quality products. Major examples follow:

A. With proper energy management, the 25% or more reduction in the coke gas calorific value in the past three years would not have occurred. The cost of this loss would have been made known and the maintenance of door seals would have been improved rather than collector main pressures reduced. The present cost of this loss is over $3.0 million per year and perhaps twice this amount.

B. With proper energy management, the use of large quantities of coke oven gas in the boilers would not have been allowed to go on for years without a solution. This cost of loss is in the soaking pits and is $1.8 million per year. Every phase of soaking pit operation is adversely affected by using fuel oil instead of gaseous fuels. If the soaking pits are to improve, gaseous fuels must be available, otherwise productivity will get progressively worse.

C. With proper energy management, the large quantities of blast furnace and coke oven gas which was bled would have been effectively used. The cost of this loss is large but unknown.

D. With proper energy management, the cost of electrical energy to the plant would be 15% lower by purchasing less costly power. In-plant generation could have been reduced by 50%, saving much needed coal and coke oven gas.

E. With proper energy management, the rolling mills would not have had 1,700 hours of lost production time due to heat delays.

7.7.6.2 Recommendations

There must be a distribution center for all energy systems. The operator on turns must be able to adjust the energy use within broad limits. Consuming departments must change types and quantities of fuel being used when so directed.

The head of the plant energy systems must be knowledgeable and decisive. He must be motivated to allocate energy based on the greatest benefit to the plant as a whole. He will set

priorities and must have the authority to enforce them.

Lack of proper energy management is costing approximately $4.8 million per year. Of all recommendations concerning energy, the most important is the concept of proper management. The energy systems problems must be solved head-on and not bypassed by easier and more costly methods.

7.8 NATURAL DRAFT COOLING TOWER

The natural draft cooling tower was in service only a very short time since it was built in 1962. The powerhouse manager, who is the individual responsible for the facility; explained that the tower lowered the water temperature only 4° C (30° C to 26° C). After a few months, the water system was returned to the "once-through" system because the turbine condenser vacuums became too low. The manager stated that the condensers are not to be operated above 30° C. This is incorrect; many units of this type operate at 50° C with no difficulty except for lower thermal efficiency.

7.8.1 Recommendations

There is no fundamental problem with the cooling tower and it should be returned to service in the following manner to prove conclusively that it is adequate for the job.

A. First, a thorough inspection must be made of the sprays, packing, pumps, tower sump, and clarifier equipment.

B. Second, place in service the clarifiers with the help of a water-treating company. The clarifier should operate for approximately six months to be certain it can clean the river water both in flood, as well as dry, conditions.

C. Third, start the cooling tower in parallel with the "once-through" system. The river water ("once-through") flow into the system should be slowly reduced and more water taken through the cooling tower until all the water is in the tower system.

If the outlet water temperature cannot be reduced to 30° C for the powerhouse condensers, the plant should consider supplying these units directly from the river. The blast furnaces, coke plants, open hearth, etc., would be on recirculated water.

Prior to the start-up of the cooling tower, a consultant from a builder of natural draft towers (not from the tower supplier) should be called in for specific directions for start-up. The consultant should assist in the inspection to establish conditions needed for satisfactory operation.

7.9 OPEN HEARTH SHOP

7.9.1 Regenerators

The condition of dampers, air-reversal valves, and the flue is unknown to the operators. On "F" furnace, one damper valve was found not closing the opening in the damper seat because it could not pass the bottom of the opening due to debris. The seat was broken and the damper did not ride on the seat as designed for approximately one-half the travel.

Since the pressure differentials are at a maximum over a closed damper, any leakage will be large. The leakage will be combustion air to the stack, by-passing the furnace.

The flues under one checker have been exposed to very high temperatures caused by secondary combustion. Infiltrated air into the checker chamber supplied the air for the secondary combustion.

7.9.1.1 Recommendations

An inspection program must be set up whereby dampers, air valves, and general flue conditions are made known to the operators and steps taken to correct the problem(s). There should be an inspection as soon as the furnace flues can be entered after the furnace is removed from service, and again before a furnace is put into operation.

Damper and air valve travel must be adjusted with cooperation of fuels people and maintenance men to be certain these units open and close correctly before a furnace is returned to operation.

Both damper seats must be replaced in "F" furnace as soon as possible because they are in very poor condition. It is probable that many seats in the shop are in need of replacement. With 65% of the combustion air from air infiltration in the checkers, slag pockets and uptakes on Furnace "A", it is not possible to burn the fuel equivalent to the air delivered to the flues by the fan.

7.9.2 Fuels Organization

At the present time, there is no fuels organization to assist the operators. The present service is instrument-oriented.

7.9.2.1 Recommendations

A fuel group must be set up to monitor fuel practices, consisting of the following:

A. Firing rate development for each furnace.

B. An air filtration monitoring program to reduce it.

C. A flue inspection program to uncover problems and have them corrected.

D. Have an on-going program to improve reversal time, check damper and air valve operation, reduce damper leakage, adjust combustion air flow, and work on furnace pressure problems.

E. Adjust and monitor the burners.

F. Observe and correct instrument problems.

G. Make routine oxygen and combustible analyses.

The group should be directed by a person trained in an open hearth shop with such an organization. The person should spend at least three months in training. He should return to Karabuk and set up the program using the same type of reports, inspection lists, etc. He should arrange classroom training sessions to communicate the basic knowledge.

The group should consist of eight men to cover all turns, plus two men on day-turn, seven days a week. To start, they should attend classes about 50% of their time, with the balance of the time spent working on the open hearth floor learning the practical problems of open hearth operation. When a furnace is removed from service, the leader would make inspections with his men, pointing out the problems and problem areas.

An energy course providing classroom and hands-on training should be instituted for the fuel group, furnace operators, melters, engineers, and department managers. The theory would be transmitted in a practical way so every one can profit from it.

7.9.3 Burners

The present burners burn nearly equal quantities of tar and coke gas with good results. However, there are many instances wherein it would be very beneficial for the Karabuk plant to have the open hearth furnaces burn more tar or all tar (no gas). These burners use high pressure and temperature air to atomize the tar. When the flow of tar exceeds 1,300 kg per hour (12 million Kcal per hour), the flow of atomizing air is interrupted intermittently by large quantities of tar passing through the burner. There are two possible restrictions which can cause this problem:

A. The tip orifice (the very end of the tar burner); or

B. The long tar air emulsion tube.

7.9.3.1 Recommendations

A. The tip orifice should be enlarged from 2.6 cm to 3.2 cm.

B. The tar/air emulsion pipe area should be enlarged by 50% by increasing inside diameter from 2.0 cm to 2.45 cm.

The burner with the above changes should burn 1,950 kg per hour of tar (18,000,000 Kcal per hour). With this capacity to burn more tar, the use of coke gas can be reduced as desired.

Experience indicates that maximum gas should be used until the hot metal is added, then it should be reduced to a minimum. With the rolling mill needing additional mixed gas, the open hearth, in the future, may be able to supply it with the fuel dispatcher's directions.

As more experience is gained with the burner, the open hearth furnaces may be able to operate without coke gas if necessary.

7.9.4 Furnace Reversal

Furnaces should reverse from fuel off to proper burning from the opposite side of the furnace in 11 to 13 seconds. This cycle at Karabuk takes 25 seconds. The main reason for the long cycle is the damper and air valve operation. It takes 7.1 seconds for these devices to move from open to closed. Until the damper is fully closed, no combustion air will move toward the furnace because the stack draft is much greater than the furnace draft. When the damper is closed, the combustion air begins to move toward the furnace, sweeping the products of combustion back up the downtakes and past the burner. Once the air is in the furnace, proper burning can again take place.

In a nine-hour heat with eight-minute reversals, the fuel is off 28 minutes. Reversal cycles should average five minutes for maximum refractory life and maximum preheated air temperature. However, with the very long fuel-off period at Karabuk, shortening the reversal time would be counter-productive.

7.9.4.1 Recommendation

Damper speed must be increased to attain full damper travel in two or three seconds. Damper seats must be changed when the damper does not seal. Fuel off to proper burning from the opposite side of the furnace will be reduced from 25 to 20 seconds. Effective burning time on a heat will increase by five minutes in a nine-hour heat.

7.9.5 Temperature Measurement of Roofs in the Furnace and Checkers

There are two radiation temperature measuring devices sighted on each furnace roof. These units sight through holes in the furnace front wall to "see" the roof at Door Nos. 1 and 5. Compressed air is used to pump ambient air through the holes to protect the units. This air is detrimental because it adds cold air to the combustion process. This measurement was abandoned in the United States when silica roofs were replaced with basic brick.

Each checker chamber roof temperature is measured by radiation devices. These units sight through holes cut into the checker walls to "see" the roof. Compressed air is used to force ambient air through the holes to protect the units.

The air used for protecting these units reduces the air preheat to the furnace when air is being heated and reduces the gas temperature entering the checker openings when waste gases are heating the checkers.

7.9.5.1 Recommendations

A. Remove the furnace roof radiation units and close the holes in the walls.

B. If the operator feels he needs the checker chamber units, convert them to closed end tube measurement. The closed end tube can be sealed into the wall to prevent air leakage into the furnace.

General practice in the United States is to use thermocouples in the flues; however, the use of flue or checker temperature measurement is not consistent from shop to shop.

7.9.6 Air Compressors Are Used to Atomize Tar

At the present time, there are eleven compressors supplying air to atomize tar, and ten are required to supply the needs. Maintenance costs are high and there are many emergencies where there is insufficient quantities of compressed air to operate all furnaces. In the future, more air will be required as more liquid fuel will be used.

7.9.6.1 Recommendations

Install a steam atomization system to replace the present system. With steam, the system including burners will be capable of reducing the gas usage in the open hearth to a minimum. For example, in U.S. practice, very little gas is used in the winter months because of high residential gas use.

7.10 FUEL AVAILABILITY - ROLLING MILLS

7.10.1 Soaking Pit Fuel Problems

The soaking pits have been averaging 2.2 pits burning mixed gas and the balance of the pits burning oil or tar. Atomization of the liquid fuels has been very poor, causing many problems. To replace the oil or tar in the soaking pits will require 10,000 Nm^3 per hour of mixed gas. Since the boilerhouse is using more than these quantities of coke and blast furnace gas and can burn coal, the boilerhouse should burn the coal and make the gaseous fuel available to the soaking pits.

To replace this quantity of gas will require the boilerhouse to increase its coal use by 3.73 tons per hour, or 89.5 tons per day.

7.10.2 Recommendation

A small portion of the 10,000 Nm^3 per hour can be made available from the boilerhouse immediately with proper direction. The balance must wait until the superheater problem in Boilers 5 and 6 is solved.

7.10.3 Problem - Fuel Availability for Reheating Furnaces

During the year 1981, the rolling mill reheating furnaces sustained 1,713.2 hours of heat delays. These delays could have been minimized if mixed gas had been available. The coke plant can supply this need provided the door leakage problem is corrected and the collector main pressure is increased to prevent air infiltration into the ovens causing part of the gas to be burned.

7.10.4 Recommendation

Correct the door seals on the ovens at the coke plant and raise the collector main pressure to 7 mm of water pressure.

7.11 GAS PRODUCTION PROBLEMS AT THE COKE PLANT

7.11.1 Low Calorific Value of the Gas

The calorific value of the coke oven gas is averaging 3,800 Kcal per Nm^3 versus a normal value of 4,800 Kcal per Nm^3. With the coke plant generating 30,000 Nm^3 per hour, this represents 6,000 Nm^3 per hour of lost gaseous fuel. This loss of calorific value is due to carrying very low positive pressure (2.5 to 4.0 mm of water pressure) in the battery collector mains. The normal collector main pressure is 7 mm of water pressure but, due to excessive leakage around the doors, etc., the pressure was reduced. With the zero pressure line two-thirds of the way up to the battery doors, infiltrated air pours through the door leaks, partially burning the gas generated in the ovens and thereby reducing the calorific value of the gas. Along with the calorific value reduction, the gas density increased from .345 to 470, requiring the metered volumes of the gas to be corrected by a factor of .86. The total reduction in calorific value dropped 3%. (See graph, Appendix 12.)

7.11.1.1 Recommendations

A. Establish a maintenance program to repair door seals and door frame sealing strips.

B. Increase the collector main pressure to 7 mm of water pressure to eliminate air infiltration into the ovens.

7.11.2 Lack of Coal to Operate Batteries at Full Production

Five of the 7 coke batteries are on 22-hour cycles. If 10% more coal were available, the batteries could consume it and produce 3,500 Nm^3 per hour of additional gas for the plant.

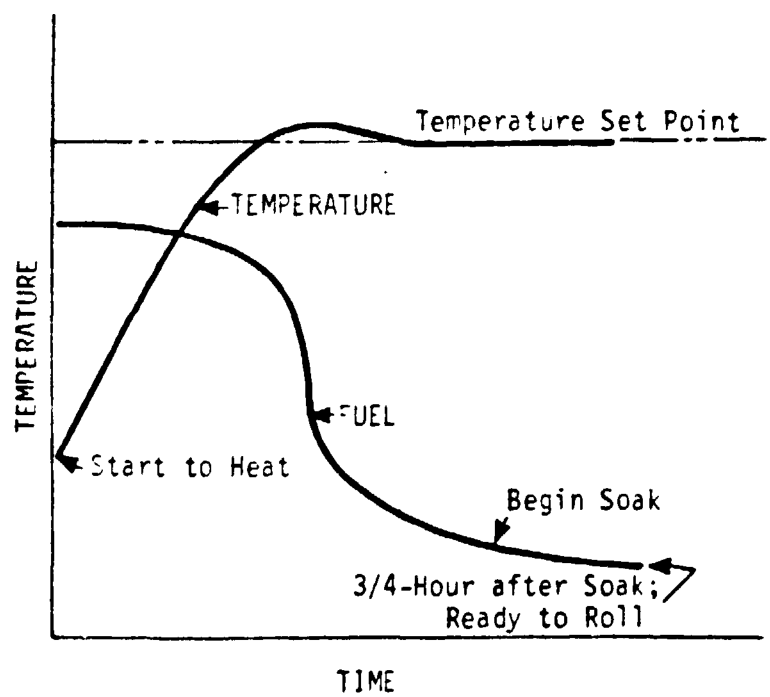
7.11.2.1 Recommendations

A. Increase the coal supplies to the coke plant by 10% to increase gas production.

7.11.3 General Comment

If the recommendations in Paragraphs 7.11.1.1 and 7.11.2.1 could be implemented, rolling mill problems would be greatly eased. The soaking pits would be given hope for the future, and production delays on the mills would be minimized.

TEMPERATURE AND FUEL CURVES FOR HEATING INGOTS



The above curve is a typical heating curve for a soaking pit. Automatic control will provide this type of curve. The ingots will roll much better, for they will be as hot and as uniform as the soaking pits can make them.

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APPENDIX 2

FUEL CONSUMPTION OF UNITS OF IRON AND STEEL WORKS,
KARABUK, TURKEY

April, 1982

FACILITY	COKE OVEN GAS Nm^3	BLAST FCE GAS Nm^3	COAL MT	COKE MT	FUEL OIL Tons
Power Plant	7,339	59,060	2,800	--	--
Rolling Mills	8,835	6,650	Soaking Pit ..... Ingot Furnace ...		765 300
Coke Plant	1,440	66,128	--	--	--
Steel Shop	14,928	440	--	--	--
Foundry	1,297	--	550	--	--
Pipemaking	300	279	184	--	--
Machine Shop	497	--	--	--	--
Sulfuric Acid Plant	--	--	--	50	--
Sinter Plant	--	--	3,498	--	--
Blast Furnace	145	43,435	--	87,604	--
Others	243	5,822	--		--

FUEL CONSUMPTION
TURKISH IRON AND STEEL COMPANY, KARABUK WORKS

PROPOSED 30-DAY MONTH

FACILITY	COKE OVEN GAS Nm3	BLAST FCE GAS Nm3	COAL MT	COKE MT	FUEL OIL Tons
Power Plant	339	55,060	5,464	--	--
Rolling Mills	16,835	10,150	Soaking Pit ..... Ingot Furnace ...		0 300
Coke Plant	1,440	66,128	--	--	--
Steel Shop	13,928	440	--	3,664.7	--
Foundry	1,297	--	550	--	--
Pipemaking	300	279	184	--	--
Machine Shop	497	--	--	--	--
Sulfuric Acid Plant	--	--	--	50	--
Sinter Plant	--	--	3,498	--	--
Blast Furnace	145	43,435	--	87,604	--
Others	243	5,822	--	--	--

COAL CONSUMPTION IN THE POWER PLANT, HIGH CONSUMPTION MONTHS

Year - Month	Tons Per Month	Tons Per Day
1979 - January	4,700	151.6
February	3,300	117.9
April	3,250	108.3
May	3,000	96.7
June	3,250	108.3
December	4,550	146.8
1980 - January	3,500	112.9
August	3,750	121.0
1981 - October	3,500	112.9
November	3,000	100.0
December	3,500	112.9

POWER PLANT DATA

Work Done	1956	1980
Power Generated	62.8 MM KWH	66.0 MM KHW
Steam Produced	498.5 MM Tons	1,035 MM Ton
Air to Blast Furnace	628.4 MM m^3	1,631 MM m^3
Coal Consumption	39,800 Tons	25,550 Tons
Coke Gas Consumption	34.02 MM m^3	66.2 MM m^3
Blast Furnace Gas Consumption	122.4 MM m^3	386.9 MM m^3

OPEN HEARTH COMBUSTION TEST

1. PURPOSE OF TEST: To determine the following:

   1.1 The maximum firing rates at the various stages of the heat; and

   1.2 The quantity of air infiltration in the downtakes, slag pockets, and checkers.

2. DISCUSSION:

   Plant laboratory people used 2 orsat units to measure carbon dioxide, oxygen, and carbon monoxide in the downtakes at floor level and above the checkers. The measurements in the downtakes at floor level represent the combustion results in the furnace. The difference between the two oxygen readings represents the air infiltration in the downtakes, slag pockets, and checker chambers.

3. CONCLUSION:

   The firing rates in the furnace "A" should be as follows:

   3.1 Start charge to bank doors 21 to 22 mm Kcal per hour.

   3.2 Bank doors to the working of the heat 20 mm Kcal per hour.

   3.3 Begin working the heat until the heat is tapped 18 mm Kcal per hour.

4. RECOMMENDATIONS:

   4.1 A chart should be placed on the "A" furnace panel stating the firing rates that should be used at the different periods of the heat.

4.2 A sealing program to reduce air infiltration must be started. The infiltration as a pecent of the combustion air was 65%. The goal should be 10%. The insides of the downtakes, slag pockets, and the checker chambers should be sprayed with gun mix to seal them. The spraying should be done at the end of rebuilds and a touch-up spraying as soon as the furnace is heated up.

TEST DATA, "A" FURNACE, KARABUK OPEN HEARTH

Firing Side	Position	Stage of Heat	Total Fuel, MM K-Cal Per Hour	Air Flow Cubic m	CO Pct	O Pct	CO Pct
RM	Downtake	Start Chg	24	24,000	18.0	.2	1.6
RM	Checkers	Start Chg	20	24,000	8.8	10.2	0.8
RM	Downtake	After HM	20	24,000	14.0	2.8	1.0
RM	Checkers	After HM	20	24,000	8.0	10.0	0.0
BF	Downtake	Begin Flush	20.5	24,000	13.2	3.2	0.6
BF	Checkers	Begin Flush	20.5	24,000	8.0	10.0	0.0
RM	Downtake	Flushing	20	24,500	14.0	4.2	0.6
BF	Checkers	Flushing	19.5	24,000	9.2	10.8	0.0
RM	Downtake	Lime Boil	20	24,500	17.4	0.0	0.2
RM	Checker	Lime Boil	20	24,500	1010	910	0.0
BF	Downtake	Lime Boil	20.5	24,000	16.0	1.0	0.0
RM	Downtake	Lime Boil	20.5	24,000	14.8	1.4	0.0
RM	Checker	Lime Boil	20	24,000	9.0	910	0.0
BF	Dowtake	Working Ht	20	24,000	15.6	0.2	0.6
BF	Checker	Working Ht	20	24,000	9.0	9.0	0.0
RM	Downtake	Working Ht	20	24,000	16.0	0.4	0.8
RM	Checker	Working Ht	20	24,000	10.0	8.0	0.0
BF	Downtake	Working Ht	19	24,000	15.8	0.2	0.4

BOILER HOUSE TEST

1. PURPOSE OF TEST

1.1 Determine the boiler efficiency by the calculation of the waste gas loss; and

1.2 Determine the boiler efficiency by the calculation of the heat in the steam divided by the fuel input.

2. DISCUSSION

The temperature and analysis of the waste gases were taken at the outlent of No. 5 boiler. The heat in the waste gases was calculated from this data.

The lower heating value minus the assumed heat loss to radiation, etc., of 3% minus the heat loss to water liquid in blast furnace gas divided by the higher heating value equals the boiler efficiency, by calculation of the waste gas loss. The boiler efficiency by meters is equal to the heat in the steam divided by the heat in the fuel.

3. SUMMARY

The boiler efficiency by heat loss calculation is 74.1% ; by meters, it is 66%. It must be assumed at this point that the coke gas metering is in error due to the deposits of naphthenes in the venturi measuring device. The magnitude of the error is 23%, provided the assumptions that the heat loss to the ash pit and to liquid water in the blast furnace gas are correct.

To be positive of these results, the venturi must be cleaned of naphthene deposits and with steam tracing and insulation of the coke gas line from the min feed ine to the end of the venturi, kept free of these deposits.

4.0 DATA ON BOILER NO. 5

The fuel fired = 15,000 Nm^3 per hour at 105 BTU per hour, and
2,924 Nm^3 per hour at 454 BTU per hour.

The orsat analysis was 13.2% CO_2 and 6.8% O_2.

The waste gas temperature was 165° C, or 330° F.

The steam production was 26 tons per hour.

Using 170% theoretical air flow, the waste gas analysis was:

$.409\ CO_2 + .138\ H_2O + .211\ O_2 + 2.41\ N_2$.

Waste gas loss:

CO_2 - 2.8 BTU; H_2O - .8 BTU; O_2 - 1.08 BTU;
N_2 - 12.05 BTU; total - 16.73 BTU.

Radiation loss:

3%, or 5.3 BTU.

Assume: 5% water (liquid) in the blast furnace gas, or 4 BTU.

Assume: heat loss to the ash pit is 10.13 BTU.

The boiler efficiency = $\frac{164.4 - 16.73 - 10.13 - 5.3 - 4.0}{173.1}$

Waste gas + losses = 74%

Blast furnace gas input = 55.6 MM BTU per hour.

Coke oven gas input = 46.9 MM BTU per hour.

Total fuel input = 102.5 MM BTU per hour.

Heat in the steam = 67.84 MM BTU per hour.

$$\text{Boiler efficiency by m} = \frac{67.84 \text{ MM BTU per Hour}}{102 \text{ MM BTU per hour}}$$

$$= 74.1\%$$

SOAKING PIT EQUIPMENT

NUMBER OF PITS: 12

TYPE OF PITS: One-way top-fired

MAUFACTURER: Stein & Atkinson, London, England

RECUPERATORS: One common ceramic unit for 4 pits; built by Surface Combustion Corporation

STATE OF EQUIPMENT:

1. Refractories are in poor condition.
2. Steel work is in good condition.
3. Instrumentation is serviceable. Potentiometers on Batteries 1 and 2 should be replaced.
4. Cover carriages are in good condition.

STATE OF THE ART: These pits with gaseous fuels can meet with corrections above average practice.

APPENDIX 10

POWER HOUSE EQUIPMENT

UNITS	CAPACITY	AGE YEARS	MANUFACTURER	STATE OF EQUIPMENT	STATE OF THE ART
3 Turbo-blowers	51,000 m^3 per hour; 1.7 ATM	40	Kent, England	Excellent	Average
2 Turbo-blowers	110,000 m^3 per hour;	20	AEG, Germany	Excellent	Average
2 Turbo-generators	12.5 KVA 80% PF	40	G.E., Frazer Chambers	Excellent	Average for for steel plants
4 Boilers	22 tons, 30 Maximum	45	C.E. England	Good; Controls old but in use	Fair for steel works
2 Boilers	32 tons, 40 Maximum	22	Borsig Germany	Excellent	Good for steel works
Auxiliaries		20-45	Various	Good	Good
Water-treating plant		Lime soda zeolite		Good	Good

Power house steam cy is 1940-1950 state-of-the-art.

The proposed new cycle will be near best practice.

New boilers should automatically change fuels to minimize the use of gaseous fuel so as not to bleed them.

RECIRCULATING COOLING WATER SYSTEM WITH NATURAL DRAFT

1. One hyperbolic cooling tower, new in 1962, by Salzgitter (Germany.

2. Two clarifiers, 1,600 m^3 per hour of river water.

3. Three sets of pumps:

   a. One set for pumping water to the tower sprays;
   b. One set for pumping water to the power house;
   c. One set for pumping water to the plant system.

4. One pond to provide storage for the recirculation system.

   The first attempts at operation were in 1962. Parts operated for several months but, because of many problems, the system was returned to a once-through system. In 1975, plant operators tried the system again for a few hours and then shut it down.

   The pond is in use as a settling basin. All pumps are in service except the tower pumps.

   Clarifiers would need repairs to start up.

   Tower conditions are unknown.

OPEN HEARTH FURNACES

Original four furnaces were built by Krupp (Germany) in 1940 as 65-ton furnaces.

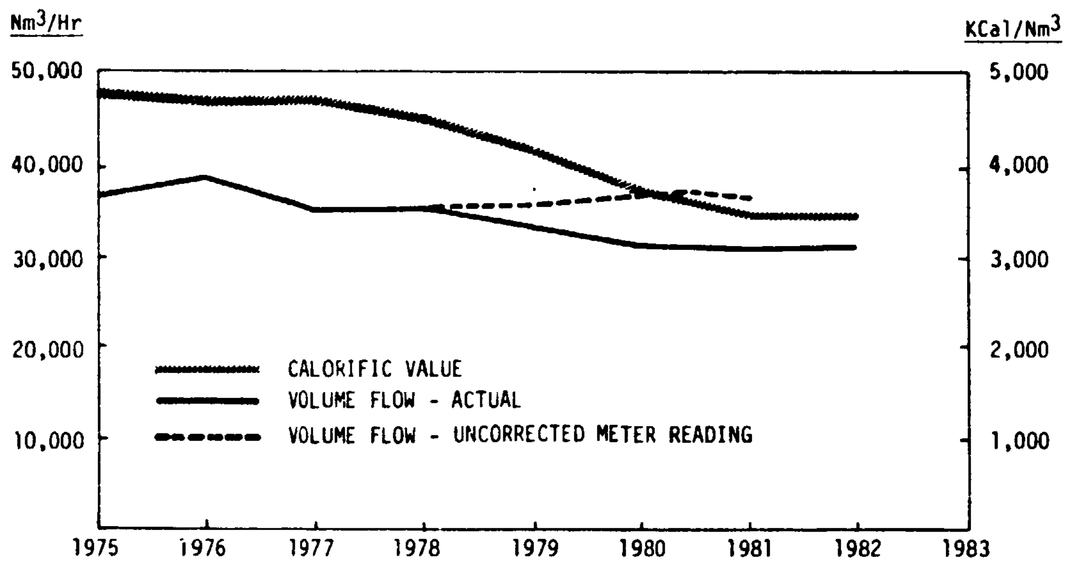
Size increased to 150 tons in 1958-60.

Two additional furnaces were built, 1958 to 1963, by Krupp (Germany).

Leeds & Northrup Speed-o-Max G units for temperature measurement of the steel bath. One serial number is 8360248 B.

APPENDIX 13

COKE OVEN GAS FLOW AND HEATING VALUE
ACTUAL EXPERIENCE



Average gas flow per hour (1975-78)................. 36,000 m^3 per hour
Average Kcal per m^3 (1975-78) 4,600
Average gas flow per hour (1981-82) .... 31,000 m^3 per hour
Average Kcal per m^3 (1981-82) .... 3,500 Kcal per hour

(36,000 m^3 per hour)(4,800 Kcal per m^3) .... 165.6 MM Kcal

Total energy from coke gas (1981-82) per hour:

(31,000 m^3 per hour)(3,500 Kcal per m^3) .... 108.5 MM Kcal per hour

165.6 - 108.5 .... 57.1 MM Kcal per hour

---

If fuel cost is $3.52 per MM BTU, the cost of loss is $798 per hour.

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8.0 - ACCOUNTING AND COST

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ACCOUNTING AND COST

8.1 SYNOPSIS

8.1.1 Accounting paper flow and reporting practices were reviewed. Circumstances contributing to significant delays were identified and recommendations were made to eliminate the delays.

8.1.2 Computer hardware ordered for 1983 delivery was reviewed to determine whether adequate capability and capacity are available for the new computer applications to be installed in 1983. Outside assistance is recommended to help in planning new applications to assure maximum benefits to the plant.

8.1.3 It is concluded that Karabuk should continue to use an actual cost system for the present.

8.1.4 Cost analysis service is minimal and it is recommended that it be substantially improved.

8.2 ACCOUNTING PAPER FLOW AND REPORTING PRACTICES

The flow of accounting information was reviewed with special emphasis on month end closing data since the distribution of monthly costs to the producing units (see Appendix 8.6.1) and the submission of financial statements to General Directorate (see Appendix 8.6.2) are made from 3 to 4-1/2 months after the month being reported.

At the time of the review, there was a general lack of concern in the Accounting Department over the lateness of the cost data and financial statements. With some exceptions, there was a tendency to wait for cost data to be submitted without checking to determine the reason for its lateness. Following the review this condition has significantly improved.

Major delays in month-end reporting result from late receipt of invoices for purchases of raw materials, absence of scale weights for rolling mill production, lack of meters for electricity consumption in the rolling mills, shortage of personnel, the unavailability of back-up clerical help during illness and vacations and the nonexistence of schedules or directives designating due dates for the submission of various production and cost data. Delays in getting completed reports typed and cumbersome work procedures (in some instances) are also contributing factors to the late completion of cost tables and financial statements.

8.2.1 Recommendations to Eliminate Delays in Reporting Practices

A. Use estimated costs for raw materials whenever actual costs are not known at the time needed for monthly closing. This is now being done. However, UEC was informed by a member of the State Auditing Group that State regulations prohibit the use of estimated costs for December accounting. If this regulation is not changed it will mean the continuation of three to four month delays in year-end closing with a subsequent backlog effect on succeeding months.

Generally accepted accounting principles in developed countries permit the use of estimated values at year end, and it is recommended that the Turkish Government adopt this practice for State enterprises.

B. Use theoretical weights for rolling mill production whenever actual weights are not available at time needed for monthly closing. The rolling mill manager has made special arrangements to have the Transportation Department deliver production to General Directorate stockpiles promptly at the end of the month so that actual scale weights are immediately available.

C. Install meters at rolling mills to measure usage of electricity or use theoretical rolling mill production to eliminate delays in preparation of plant electricity consumption report. Prompt action was taken by the Electrical Maintenance Department to install individual meters not only at the rolling mills but also at other desirable locations. The plant electrical energy consumption report for the month of August was received in the Accounting Department on September 8.

D. Study work procedure involved in preparation of report of benzine and motor oil consumption by plant vehicles to determine whether the report can be compiled on the computer. The plant completed the study in July and plans to include this activity in new computer applications to be installed in 1983.

E. Publish a monthly closing schedule which will indicate realistic due dates so that all persons involved will know when production reports and cost data is expected. Karabuk accounting has indicated it will publish such a schedule but intend to defer developing it until after studying detailed paper flow related to mechanization of stock control and cost accounting functions.

UEC does not agree with this decision and suggests that time spent in preparing a closing schedule under present reporting conditions will serve to emphasize cost awareness throughout the plant and will identify additional situations which have the potential of delaying the flow of accounting data.

8.3 COMPUTER HARDWARE AND APPLICATIONS

The present computer (IBM System 3, Model 10) is used for payrolls, to consolidate information for financial statements, and to prepare sales information and furnish sales statistics. Service is performed for both Karabuk and for General Directorate. General Directorate applications were transferred to IBM 5280 (auxiliary hardware consists of IBM 5281, IBM 5256 and IBM 5285) acquired in June 1982.

IBM System 3 will be replaced by IBM 4331 at the beginning of 1983. This represents a significant increase in computer capability and is easily upgradeable if desired.

Two major new computer applications planned for 1983 are the mechanization of storeroom accounting (including perpetual inventory records to replace 40,000 stock record cards) and the consolidation of cost information and printing of monthly cost tables presently being done by Cost Accounting.

The manager of the computer center is probably the only person in the plant who fully comprehends the problems associated with the development and installation of new computer programs and the change-over to new equipment. While some of his staff are experienced, he needs more trained employees to meet the scheduled installation dates in 1983 (Appendix 8.6.3).

Since there is a State moratorium on hiring new employees, Karabuk is planning to train some of the personnel to be displaced by the new applications to operate the terminals which will be placed at strategic locations in the plant. Although two additional programmers would be helpful, the present staff of four programmers will have to absorb the work load. In-plant training programs are planned to educate personnel in the operation of the terminals. On-the-job type training will be given at Eregli, a sister steel plant, which also has an IBM 4331.

8.3.1 Recommendations

A. It is recommended that outside assistance be secured to help in planning the new applications to ensure the maximum benefit to the plant. The payroll application should be examined to determine whether the manual effort required to accumulate actual hours worked by blue collar workers can be economically performed on the computer.

B. It is also suggested that an orientation course be conducted to inform key plant officials of the importance of proper housing and installation of computer hardware, and of the capabilities and limitations of computer applications.

C. A verification procedure will be necessary to eliminate data input errors.

8.4 KARABUK COST SYSTEM

An actual cost system is used. Unit costs are developed for in-process and finished goods for the steelmaking process. Costs are also accumulated for products from the foundry, the pipe mill, the machine shop, and other production areas. Inventory values are carried in the ledger on a moving average basis. Property and depreciation records are maintained by the Cost Accounting Section.

Cost tables are prepared monthly for each producing unit comparing production quantities and costs to the approved annual budget. Prior to the UEC review, reports were distributed from 88 to 143 days following the month being reported. During the September review, it was noted that June 1982 costs had been distributed on September 9, 1982 (71 days) (see Appendix 8.6.1).

Financial statements are prepared on a monthly basis for submission to General Directorate. These statements have been received from 92 to 143 days following the month being reported (Appendix 8.6.2).

A special report to the President of the Turkish Iron and Steel Industry was initiated in June 1982, displaying prior month and trend production statistics, sales and selected costs. The target date for this report is the 20th of each month.

A balanced annual budget is prepared for the plant with each production unit preparing its own budget. Production quantities are generally based on recognized capacity adjusted for known factors which adversely affect the ability to produce to capacity.

The Cost Accounting Section dollarizes the budget based on current costs. Planned maintenance expenditures are estimated by the Maintenance Department. The completed plant budget report, including projected financial statements, is sent to the Managing Committee of the plant for approval prior to submission to General Directorate and the Board of Directors. Final approval is given by the State Planning Organization.

The approved budget serves as guidance to all areas of the plant. Requisitions for raw materials and operating supplies are checked by the Accounting Department to verify comprehension in the annual budget. The Karabuk Managing Committee can initiate recommendations for revisions to the budget to recognize changes of more than 5% on an annual basis in raw materials, production, sales and cost levels. Monthly reports comparing current month actuals to 1/12 of the annual budget are made to General Directorate. Quarterly and annual reports are a State requirement.

While the actual cost system used at Karabuk offers adequate cost information, there are several advantages which could be gained through the adoption of a standard cost system. In a standard cost system the main objectives are better managerial control and effective analysis of cost data. The success of such a system, however, is largely dependent on the reliability and accuracy of the standards used, the cost consciousness of plant management and its ability to correct adverse cost conditions.

It is estimated that a minimum of five man-years of Industrial Engineering effort will be required to develop detailed standards covering all aspects of plant operations. These detailed standards are fundamental and essential elements of a standard cost system.

Revisions of standards are necessary to recognize significant changes in equipment, method of manufacture, levels of production, raw materials and prices of purchased goods and labor. During periods of high inflation revisions may be required several times per year in order to maintain meaningful standards.

Efficient maintenance of a standard cost system requires a computer with considerable storage capacity. The IBM 4331 to be received in 1983 is probably capable of handling a standard cost system, or could be easily upgraded to do so.

8.4.1 Recommendations

A. Proposed changes in the Karabuk Works' Financial and Commercial Department are discussed in Section 9.1 of this report.

B. Karabuk should continue to use the present actual cost system at least until Turkey has achieved a stable economy. A future decision to change to a standard cost system should be made only after full realization and evaluation of the time and effort necessary to develop detailed operating standards and to install and maintain the system.

Karabuk is cautioned that a standard cost system is not an end in itself. While it can be an invaluable tool in the analysis of cost deviations, corrective action can be taken only by Management.

8.5 COST ANALYSIS SERVICE

Cost analysis service is minimal. The 20th of the month special report prepared by the Cost Accounting Section provides the earliest opportunity for pertinent analytical comments. This should be expanded as experience is gained. Comments on comparisons of actual results with the annual budget are included in the monthly, quarterly and annual reports prepared by the Budget Control Section.

Cost analysis service should be increased and improved. If possible, additional personnel should be hired to promptly provide analytical and statistical service to Plant Management so that corrective action can be initiated on a timely basis. (Section 9.1.4.5.)

APPENDIX 8.6.1

DATES FINANCIAL STATEMENTS WERE
RECEIVED BY GENERAL DIRECTORATE

MONTH		DATE RECEIVED BY GENERAL DIRECTORATE	NUMBER OF DAYS ELAPSED
1981	January	June 17, 1981	137
	February	July 21, 1981	143
	March	August 21, 1981	143
	April	September 1, 1981	124
	May	October 19, 1981	132
	June	October 25, 1981	117
	July	November 20, 1981	112
	August	January 10, 1982	132
	September	February 1, 1982	124
	October	February 8, 1982	100
	November	March 2, 1982	92
	December	April 27, 1982	117
1982	January	June 7, 1982	127
	February	June 24, 1982	116
	March	July 12, 1982	103
	April	August 17, 1982	109
	May	September 22, 1982	114

APPENDIX 8.6.2

DATES COST TABLES WERE DISTRIBUTED TO
KARABUK OPERATING MANAGEMENT

MONTH		DATE DISTRIBUTED TO OPERATING MANAGEMENT	NUMBER OF DAYS ELAPSED
1981	January	May 29, 1981	119
	February	July 7, 1981	129
	March	July 30, 1981	121
	April	August 31, 1981	123
	May	October 21, 1981	143
	June	October 28, 1981	120
	July	November 5, 1981	97
	August	December 14, 1982	105
	September	January 11, 1982	103
	October	February 12, 1982	104
	November	February 26, 1982	88
	December	April 12, 1982	102
1982	January	May 14, 1982	103
	February	June 11, 1982	103
	March	July 16, 1982	107
	April	July 16, 1982	77
	May	August 13, 1982	74
	June	September 9, 1982	71

SCHEDULE FOR TRAINING OF COMPUTER PERSONNEL
AND DEVELOPMENT OF NEW COMPUTER APPLICATIONS

ACTIVITY	TIME PERIOD
PERSONNEL SELECTION (Two Programmers)	
PERSONNEL TRAINING	1/10/82 - 30/11/82
GENERAL SYSTEM DEVELOPMENT	1/ 7/82 - 31/ 9/82
DETAIL SYSTEM DEVELOPMENT	1/12/82 - 28/ 2/83
PROGRAM CODING	1/ 2/83 - 30/ 4/83
PROGRAM TESTING	1/ 3/83 - 10/ 5/83
PREPARATION OF NEW SYSTEM	1/ 9/82 - 1/ 4/83
NEW SYSTEM DEVELOPMENT	1/ 5/83 - 20/ 5/83
DUAL APPLICATION	20/ 5/83 - 30/ 6/83
INSTALL NEW SYSTEM	1/ 7/83

CONSULTING SERVICES FOR
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KARABUK WORKS

United Nations Industrial Development Organization

9.0 ORGANIZATION REVIEW

9.1 FINANCIAL AND COMMERCIAL ORGANIZATION

9.1.1 Introduction

During the UEC/USS mid-mission review meeting in Ankara on June 7, 1982, with Mr. T. Aktutay, President, top priority was placed by Mr. Akutay on the consulting team making a review of the Karabuk Financial and Commercial organization. Mr. Aktutay further directed that following the review he be given any recommendations for changes which would improve the effectiveness of the Financial and Commercial organization's efforts in aiding Karabuk executive and operating management to obtain maximum production at the lowest possible cost.

A detailed review of the present Karabuk Works Financial and Commercial organization was conducted by the consulting team. First, the present organization as it appears on the official organization charts supplied by the Job Evaluation & Organization Department was studied. Following this, extensive detail review meetings were held with the Assistant Plant Manager-Financial & Commercial and with each of the Financial & Commercial Department Managers. During these meetings, department objectives and goals, responsibilities, actual work force size, information flow and timing, problems affecting optimum performance of the department, and suggestions for improving the department's effectiveness, were reviewed and documented. The cooperation of all department managers and other officers was excellent during these review meetings.

9.1.2 Present State

Successful operation of the Karabuk Works to produce steel and related products at a rate sufficient to meet or exceed annual program tonnages within the forecasted expenditures requires timely and accurate production and cost data. Without these very necessary tools, decision-making by all levels of management (regardless of technical competence) is restricted, and inefficiencies result. Also, identification of operating problem situations is difficult and often confusing. Delays in publishing cost tables for use by Karabuk's operating and financial management varied from 88 days to 143 days following the month ending for the period from January 1981 through March 1982. Thus, daily decision-making and problem identification and solving are often done without the benefit of timely and accurate production and cost information and trend data. This condition creates a severe limitation in the execution of managerial responsibility for the operation of Karabuk Works.

The present Financial & Commercial structure contributes in part to the delays in cost table preparation. Clerical personnel in the plant's operating and service departments presently work for and are responsibile to the operating and service managers to whom they report. Thus, priorities, work schedules, attainment of due dates to meet or expedite monthly closings, and other measures of efficiency for these clerical personnel are the responsibility of operating managers. These types of work scheduling assignments are clerical in nature and necessarily have a lower priority for production and service managers than do operating problems and decisions. Inefficiencies in data generation and late reporting are often the result.

The present Karabuk Work's Financial & Commercial Department organization chart is displayed for review and study in Appendix 1.

9.1.3 Recommendations

Six major changes are proposed in the structure and/or functions of the Karabuk Financial and Commercial organization.

These changes, reviewed in the following subsections, are displayed on the proposed organization chart in Appendix 2. Terminology used is in USS plant nomenclature, as are the more comprehensive charts.

Descriptions of the proposed changes are listed below.

9.1.3.1 The title of the proposed top Financial & Commercial position in Karabuk Works is Manager-Accounting. This position reports and is reponsible to the Vice President-Accounting, General Directorate, while responsible for providing financial and commercial service to the Karabuk Works as presently required.

9.1.3.2 The position of Assistant General Manager-Accounting is established. Need for this "make things happen" position is anticipated to permit the smooth transition of mill clerical personnel into the new Mill Accounting Department in the minimum time possible. Also, installation of the new computer equipment and its optimum use on a timely basis will consume more time than a single accounting executive position has available in light of the many duties that now exist.

9.1.3.3 The Computer and Statistics organization is transferred to the Karabuk accounting organization. Service performed by this group for the General Directorate will continue as now.

9.1.3.4 Clerical personnel in operating and service departments are reorganized into a group titled "Mill Accounting". A newly-created position, namely, General Supervisor-Mill Accounting, is established to supervise and coordinate the efforts of this group.

9.1.3.5 Karabuk's sales organization is combined with the plant's Purchasing Department. This change has been recommended to General Directorate by Karabuk Works and is supported by the review team. The transition is desirable as the duties of the sales organization are the "paper transfer" of Karabuk's production to the General Directorate Sales organization and the maintenance of various sales statistics.

9.1.3.6 Responsibility of the Cost Accounting Department is expanded to include analysis of reasons for variations from annual program production and costs, for publication with the monthly cost tables. The department's name is changed to "Cost Accounting & Analysis" to recognize this additional responsibility.

9.1.4 Benefits

The ultimate goal of the recommended changes in the accounting organization is the generation of accurate and timely monthly production and costs statistics for use by General Directorate and all levels of Karabuk management. Benefits from the individual proposals as they impact on attaining this goal of optimum service to operating management are as follows.

9.1.4.1 Realignment of the top accounting organization from reporting to the Manager-Karabuk Works to the Vice President-Accounting/General Directorate is recommended. This change will increase the emphasis on "lowest cost" operations and accuracy of statistical reporting. Also, reasons for deviation from program production and costs will be reported without bias. This proposed type of organization structure is common in large manufacturing organizations (the size of Karabuk Works) in the USA and other highly industrialized countries. Emphasis on lowest possible cost of products must be increased if Karabuk Works is to be competitive in worldwide steel markets.

9.1.4.2 Transfer of the Computer & Statistical Department into the Accounting organization will permit optimization of the use of the computer in serving Karabuk Works. Maximum accounting service to the operating divisions requires use of computer time on a "priority basis". Since there is never enough computer time to satisfy all requests for automatic data processing, it is logical to give the Manager-Accounting, who is responsible for the accounting service provided to Karabuk Works, control of this powerful accounting tool. This will maximize the service his responsibility is able to provide.

9.1.4.3 Consolidation of mill clerical personnel from the major operating and service units into a new "Mill Accounting" group is proposed. This change will strengthen the Accounting Department by providing authority to control the accuracy and timing of data required for month-end closing and other vital production and cost data. Presently Accounting has responsibility, without authority, over generation and submission of this data. Initially, clerical personnel from coke ovens, blast furnace and sintering, steel producing, rolling mills, limestone and dolomite, machine shops, fabricating, foundry acid and super phosphate, and pipe departments, should be consolidated. The group will include 56 clerical employees and have a General Supervisor-Mill Accounting to schedule and sequence their work functions. Additional benefits will result if training to fill temporary and permanent clerical personnel vacancies is a regular part of the department's function, thus avoiding reporting delays that now occur due to no trained replacements available to fill in for clerical personnel who are absent for any reason.

9.1.4.4 The function of Karabuk's Sales Department is the paper transfer of production from the Karabuk Works to the General Directorate-Sales. This is a routine, semi-automatic duty and does not require a separate department or organization. Inclusion of this responsibility into the Purchasing Department will provide the necessary product transfer service while minimizing personnel requirements.

9.1.4.5 Inclusion of significant reasons for deviations from production and cost goals in the annual program should be an integral part of the cost tables. Problems thus identified and highlighted will remain prominent for top management's review and direction for implementation of the required corrective action. For these reasons, the cost accounting organization is renamed "Cost Accounting & Analysis" with the responsibility to develop and provide the required analysis of significant deviations with the monthly cost tables.

If possible, an analyst to perform this function should be added to each major producing division and a central analyst appointed to coordinate and control this reporting. However, if this increase in organization is not possible at this time, existing personnel should be assigned this duty.

9.1.4.6 In summary, many of the reasons for delays in producing the monthly cost statistics following the month ending are due to weaknesses and inflexibility of the present organization structure. Accounting has responsibility for closing but lacks control of source data and clerical personnel in operating and service departments. Also, operation and scheduling of computer time is presently outside of this responsibility's jurisdiction.

Implementation of the recommended changes will provide the opportunity for Karabuk's Accounting Department to better serve operating management. The ultimate goal of maximizing steel production at Karabuk requires the most timely and accurate production and cost data to assist operating management. Implementation of these proposed changes will contribute measurably toward achieving this goal.

9.1.5 Time Schedule

It is suggested that installation of the recommended changes be made immediately. This is the most practical approach, since none of the proposed changes are dependent on other changes and are not part of a step program. If this action is taken, benefits will be realized in the shortest possible time.

9.2 OPERATING AND STAFF ORGANIZATION REVIEW

9.2.1 Introduction

Upon completion of the financial and commercial organization review, Mr. Aktutay requested that the UEC/USS consultants next review the Karabuk operating and staff organization, providing recommended courses which would assist the plant and its management team in their efforts to optimize production quantity and quality at the lowest possible cost consistent with sound management policies.

A review of the present Karabuk operating and staff organization was conducted, along with an analysis of required information flow and use. This analysis was conducted in a manner similar to that used in reviewing the Financial and Commercial organization, involving the use of charts supplied by the Job Evaluation and Organization Department together with extensive and detailed reviews with the Vice Plant Managers and Department Managers. Cooperation during these review meetings was excellent.

9.2.2 Present State

There are 12 separate Vice Managers and/or group heads reporting to the Karabuk Plant Manager, and 3 of these subordinates share in steel production responsibility. Because there is not an Assistant Plant Manager, coordination of plant operations requires daily involvement by the Plant Manager into the details of operating matters, coordinating the efforts of his subordinates, and adjudicating differences that arise when the Plant Manager is out of the plant. There is no one position automatically designated and adequately knowledgeable to meet the need for continuing executive direction when this situation occurs. At Karabuk there are very heavy demands on the Plant Manager position for establishment and administration of policies and objectives, direction and coordination of company programs, and fulfillment of obligations in the areas of government, public, and commercial relations. Karabuk's major role in Turkey's economy requires the participation of the Plant Manager to a degree not experienced by his counterparts in developed industrialized countries. The absence of any intermediate executive position between the Plant Manager and the Vice Managers places an unreasonable, if not impossible, load on the Plant Manager, and efforts to obtain maximum steel production suffer.

Secondly, exclusion of General Foremen, Shift Foremen, and Assistant Foremen from management status creates a void in both motivation and a sense of belonging for these "supervisory" employees. The artificial ruling that only engineers and other university-educated employees are worthy of management positions is neither realistic nor efficient in promoting the long-term growth and health of the Turkish iron and steel industry. Attainment of company goals and company objectives is bound to suffer due to this arbitrary ruling.

The present Karabuk Works organization chart is displayed for review and study in Appendix 3.

9.2.3 Recommendations

The chart in Appendix 4 represents UEC's recommended organization structure for Karabuk Works.

UEC's proposed organization includes a number of important changes from Karabuk's present organization structure.

The most significant change contained in the recommendations is the establishment of a new position, Assistant General Superintendent, to be responsible for steel operations, both line and staff. This will free the General Superintendent to concentrate on policy, objectives, growth, public and commercial relations, and government matters. Five operating divisions and six staff departments are responsible to the Assistant General Superintendent, with duties as outlined below.

Second, it is strongly recommended that all supervision -- General Foremen, Shift Foremen, and Assistant Foremen ("blue-collar") -- be given equal status to that of the "white collar" managers. These "blue collar" positions must be able to view themselves as part of the management team. Without a feeling of belonging, it is not possible for the General Foremen, Foremen, or Assistant Foremen to be dedicated, effective supevisors capable of leading the work force in attainment of the company's programs and goals.

9.2.3.1 Engineering Department

Consolidation of all engineering and facility planning functions into the Karabuk Engineering Department is proposed. Stronger emphasis should be placed on developing both short- and long-range facility plans that will not only satisfy future program requirements but will also fall within anticipated annual capital budgets. Also, responsibility for completion of capital improvement projects must include authority to take the action required to insure satisfactory operation of the new facility within an acceptable time frame.

9.2.3.2 Industrial Engineering Department

Industrial Engineering has been given department status, in keeping with the expertise it has to offer. This group is capable of providing to management advisory services not normally available from engineering or accounting staff functions. Industrial Engineers can be viewed as internal business consultants to management, as they are engineering, operations, and business oriented. Studies and evaluations of potential operating plans and expansion possibilities, together with raw material use variations, can provide management with invaluable tools to aid in optimizing decision making. Also, computer process control systems and results from operations research efforts are viable aids desirable to maximize production of Karabuk's operating units.

9.2.3.3 Metallurgical Department

Karabuk's Quality Control and Laboratories Departments should be strengthened and reorganized into a Metallurgy Department, with responsibility for quality control in addition to the physical and chemical testing and reporting now performed. Field monitoring and process control, starting with raw materials through iron and steel production, plus rolling and finishing operations, possess an unlimited opportunity for quality improvements, with major associated financial benefits. Strong aggressive action directed toward consistent attainment of acceptable product quality must be the goal of the Metallurgical Department. Product quality standards need to be established and variations met with suitable corrective action. Also, provision for giving upgraded technical service to customers, either for claims or new product inquiries, is required.

9.2.3.4 Personnel Services Department

The Personnel Services Department has been restructured to include the plant safety responsibility. This is a staff function requiring total objectivity, and it can best serve the plant's interests if it is not biased by allegiance to any operating organization. Also, Job Evaluation & Organization duties have been relocated to Industrial Engineering, where they technically belong.

Consideration should be given to storing all plant personnel records on computer files, to improve their effectiveness.

9.2.3.5 Security Department

No change is proposed to the Civil Defense organization structure. Security and Civil Defense requirements as established appear to be effectively satisfied with the present organization structure.

9.2.3.6 Production Planning Department

Karabuk's present production planning organization consists of 3 employees and currently performs only clerical duties related principally to reporting production statistics to state offices on a regular, after-the-fact basis. It is recommended that all production planning type functions now carried out by Vice Managers and operating division supervision be transferred to the Production Planning Department. This will establish the production planning function as a "total plant" centrally coordinated responsibility. Also, Production Planning should be the single and effective interface between Karabuk's Production Department and General Directorate's Commercial organization.

Three Production Planning regional subgroups, responsible for scheduling and coordinating iron and steel, rolling mill, and commercial products production, are established. Statistical reports now prepared by this department should be reviewed to determine if they can be generated mechanically using data from existing computer files. Participation in a competitive steel market, be it domestic or foreign, requires the coordination and service of a forceful and well-informed production planning department.

9.2.3.7 Preparation & Refining Division

The Preparation & Refining Division includes the 4 departments whose combined efforts and responsibilities range from raw materials through steel production. Objectives for plant program tonnages can thus be seriously addressed in a closely coordinated manner with control to make things happen -- required to meet present and future program commitments. Challenges created by realistic goals must be met with meaningful and aggressive plans and action to attain (and surpass, where possible) establisned objectives.

9.2.3.8 Rolling Mill Division

Rolling mill operations are estabished as a separate division, with 4 Rolling Mill Department Superintendents and a Roll Shop Superintendent. The magnitude of potential improvements available from optimum solution of the many problem situations associated with rolling operations warrants establishing the Rolling Division as a separate entity.

9.2.3.9 Commercial Products Division

Creation of a new division, namely, Commercial Products, containing the machine shop, foundry, pipe casting plant, and sulfuric acid and super-phosphate departments, is proposed. These operations mold well into a homogeneous group for the following reasons:

A. Products are not normal steel mill tonnage type ordered items.

B. Products are/can be custom-tailored to meet customers' needs and specifications.

C. Aggressive commercial effort for these product lines is required to insure a continuous full order book from both domestic and foreign customers. Customers' needs should be solicited by a dedicated commercial group.

D. Present labor-intensive operations performed by these departments will respond favorably to methods analysis and objective cost reduction efforts, thereby establishing a competitive advantage for these product lines.

E. Detailed review of the charging rate development for these operations is required to determine that fixed costs carried by their products are accurate and minimal.

9.2.3.10 Maintenance & Transportation Division

Maintenance and Transportation share a common superintendent, as before; however, a Maintenance Planning Department has been added to provide the necessary coordination and guidance to upgrade the effectiveness of these vital services to the operating divisions. Numerous on-site observations confirm that both preventive and corrective maintenance efforts require this type of direction to provide acceptable maintenance support for the Karabuk plant. The maintenance planning function can be readily adapted to computerization to insure its maximum effectiveness and provide the required flexibility for a satisfactory plant maintenance effort.

Power station and gas heating departments have been separated from this responsibility and are combined into the newly-formed Power & Fuel organization, covered in 9.2.3.11.

The question whether maintenance should be assigned or centralized remains unanswered. Either system can be made to work effectively, and both have advantages and disadvantages. It is recommended that the existing mode, namely, centralized crews, be continued under the new organization structure for the immediate future.

9.2.3.11 Power & Fuel Division

Total responsibility for energy distribution and use has been centralized into the Power & Fuel Division. The present organization structure provides inadequate direction and motivation to operate all Karabuk energy consumers on the basis of what is best for the total plant. Consequently, energy generation and use decisions are often short-sighted and excessive in both initial cost and unfavorable impact on product quality and quantity.

Creation of an energy dispatching organization within the Power & Fuel Division, whose primary function is to develop, install, and monitor energy conservation methods and programs, will have a significant, positive impact on production and quality improvement, with an associated cost reduction impact on Karabuk's products.

9.2.3.12 Operations Transferred to General Directorate's Responsibility

Operations within the Karabuk Works neither directly concerned with the production of steel mill products nor lending themselves for inclusion in the newly-formed Commercial Products Division are the Fabricating Shops, Expansion & Erection, and Civil Engineering & Maintenance Departments from the present Engineered Products Division, plus the Raw Material Programming Department from the Works Division. The first 3 of these operations deal with domestic and international construction ventures and should be organized into a Construction Division (as the American Bridge Division of USS) under General Directorate control. The Raw Materials Programming Department performs planning service jointly with representatives from Eregli, Iskenderun, and the State Mines, and likewise properly belongs under General Directorate responsibility and control.

9.2.4 Benefits

Installation of the proposed organization structure will provide Karabuk Works with the opportunity to maximize its productive effort using the following management techniques.

A. Shortest possible lines of communication established.

B. Similar and closely related operations placed under the same responsibility.

C. Staff heads equated to operating superintendents, thereby strengthening staff contribution to decision-making.

D. Accounting is upgraded, reinforcing its auditor role in minimizing production costs.

E. Operations not closely aligned with steel production are transferred to General Directorate responsibility.

The proposed organization is designed primarily to plan for and guide the Karabuk plant, rather than react after the fact to "surprises". It is a "make things happen" type of organization.

9.3 SUMMARY

The organization proposed for the Karabuk Works was developed using the guides most effective in highly-industralized countries to efficiently operate a steel mill the size of Karabuk Works.

However, it must be remembered that it is the people in an organization that produce the results by which an organization's accomplishments are measured and judged, and not the structure or layout of the organization itself. Given proper direction and leadership, almost any type of organization can be successful and achieve the identified goals. Revised blocks and lines on an organization chart are but the primary tools for improving an organization's efficiency and effectiveness -- a strong and properly directed commitment and follow-through is then required to attain the desired results.

Although the Turkish Iron & Steel Company has a long history of utilizing two categories of supervision, namely, "white collar" and "blue collar", it is paramount that both groups be combined into a single, unified group, accurately classified and rewarded in relation to responsibilities and individual performance. This transition will be difficult, but the potential benefits justify the planning and work required to install the change. Deferring action on this change will continue to erode the productive capability of Karabuk Works through loss of many competent people to enterprises in the private sector plus de-motivation of those remaining from the present illogical system with its inequitable compensation policy.

Equally paramount to the success of Karabuk's management organization is its ability to quickly and effectively communicate with the entire management team. As a minimum, regular weekly meetings must be held with all division and department heads by executive management to review progress together with required action by responsibility and inform managers of policy matters and objectives.

Each of the above items is an important factor in Karabuk's achievement of an effective management organization. Each one deserves careful study. It is understood that resourceful and persistent efforts will be necessary to secure approvals for change and to depart from historical precedents and conventions in the Karabuk/Turkish environment.

Although crew size requirements were not part of the objective during the organization study, significant overmanning (by USA stadards) was observed. UEC/USS suggests that Karabuk executive management undertake (or have made) a detailed manning study to determine reasonable requirements for effective manpower utilization.

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY
KARABUK WORKS

United Nations Industrial Development Organization

FINANCIAL AND COMMERCIAL ORGANIZATION:

PRESENT

- MANAGER-KARABUK PLANT
  - Assistant Plant Manager-Financial & Commercial
  - Manager-General Accounting
  - Manager-Purchasing
  - Manager-Budget Control
  - Manager-Stock Control
  - Manager-Sales

APPENDIX 2

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
KARABUK WORKS

United Nations Industrial Development Organization

ACCOUNTING ORGANIZATION:

PROPOSED

- VICE PRESIDENT-ACCOUNTING - GENERAL DIRECTORATE
  - General Manager-Accounting
    - Assistant General Manager-Accounting
      - General Supervisor-General Accounting
      - General Supervisor-Cost Accounting
      - General Supervisor-Budget Control
      - General Supervisor-Purchasing & Sales
      - General Supervisor-Stock Control
      - General Supervisor-Mill Accounting
      - General Supervisor-Computer & Statistics

NOTES:

1. General Manager-Accounting reports to Vice President-Accounting - General Directorate. No reduction in service to Karabuk Works.

2. Assistant General Manager-Accounting is a newly-established position.

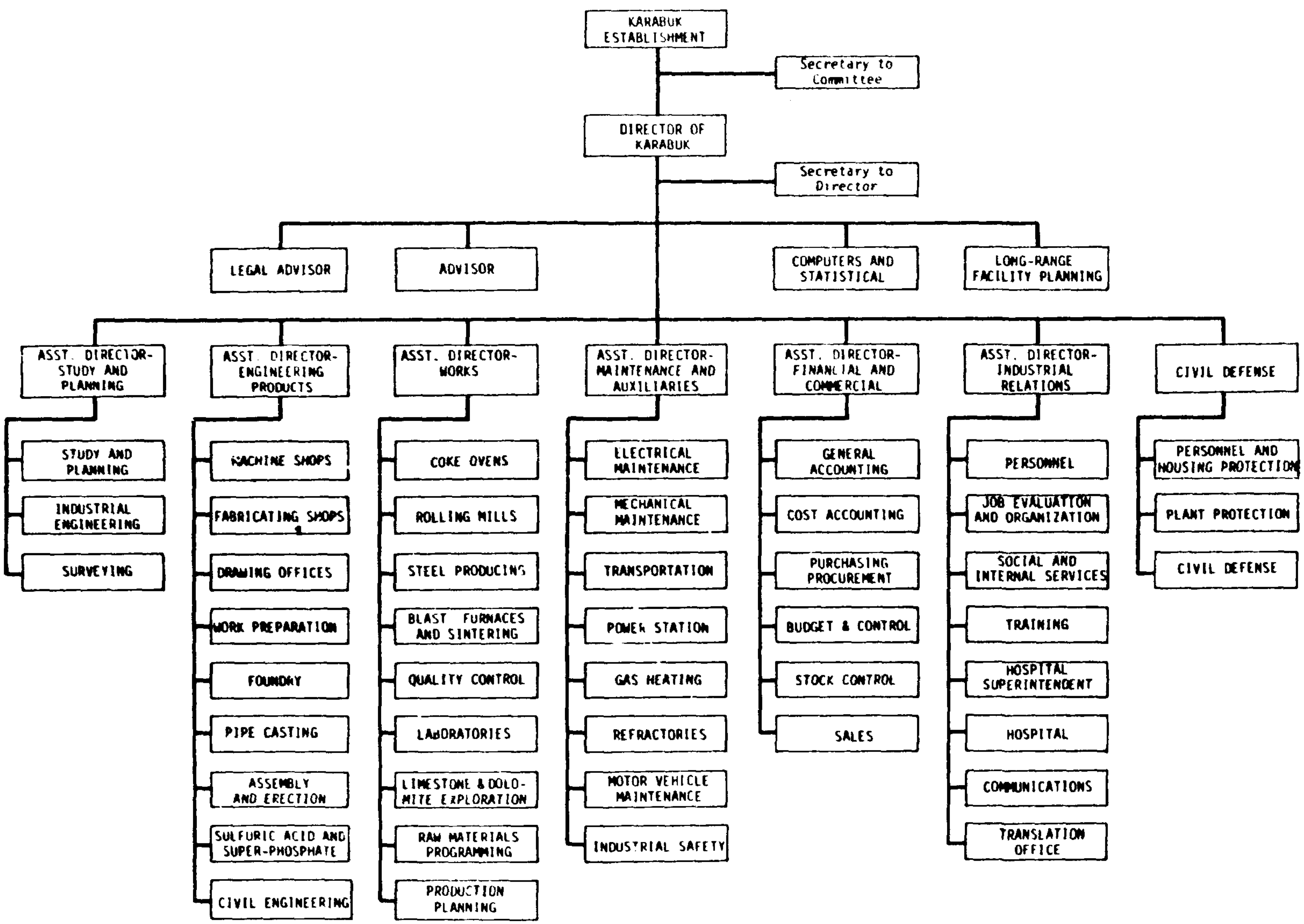
3. Computer & Statistics Department transferred to Accounting responsibility.

4. Mill Accounting is a new department responsible for mill clerical personnel, including accuracy of data and attainment of reporting due dates.

5. Karabuk Sales and Purchasing combined.

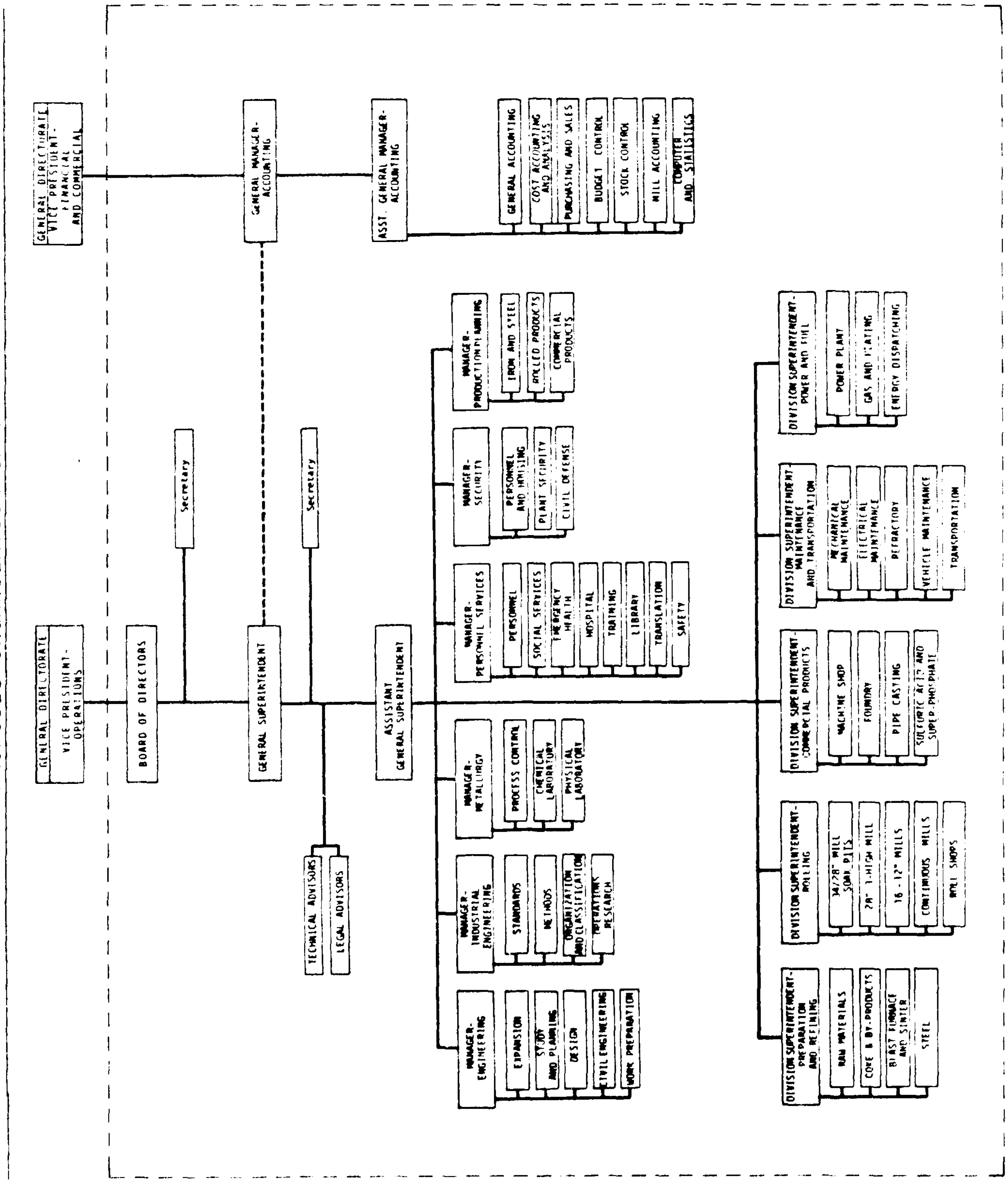
6. Cost Accounting Department name changed to Cost Accounting & Analysis; duties expanded to include analysis of program misses.

PRESENT ORGANIZATION CHART



APPENDIX 4

PROPOSED ORGANIZATION CHART



EXECUTIVE ORGANIZATION:

PROPOSED

- GENERAL SUPERINTENDENT
  - Assistant General Superintendent
    - Manager-Engineering
    - Manager-Industrial Engineering
    - Manager-Metallurgy
    - Manager-Personnel Services
    - Manager-Security
    - Manager-Production Planning
    - Division Superintendent-Preparation & Refining
    - Division Superintendent-Rolling
    - Division Superintendent-Commercial Products
    - Division Superintendent-Maintenance & Transportation
    - Division Superintendent-Power & Fuel
  - General Manager-Accounting
    - Assistant General Manager-Accounting

ENGINEERING DEPARTMENT:

PROPOSED

- MANAGER-ENGINEERING
  - Assistant Manager-Work Expansion
  - Assistant Manager-Study & Planning
  - Assistant Manager-Design
  - Assistant Manager-Civil Engineering
  - Assistant Manager-Work Preparation

INDUSTRIAL ENGINEERING ORGANIZATION:

PROPOSED

- MANAGER-INDUSTRIAL ENGINEERING
  - Assistant Manager-Standards
  - Assistant Manager-Methods
  - Assistant Manager-Organization & Classification
  - Assistant Manager-Operations Research

METALLURGICAL DEPARTMENT:

PROPOSED

- MANAGER-METALLURGY
  - Assistant Manager-Process Control
  - Assistant Manager-Chemical Laboratory
  - Assistant Manager-Physical Laboratory

PERSONNEL SERVICES DEPARTMENT:

PROPOSED

- MANAGER-PERSONNEL SERVICES
  - Assistant Manager-Personnel
  - Assistant Manager-Social Services
  - Assistant Manager-Emergency Health Treatment
  - Assistant Manager-Hospital
  - Assistant Manager-Training
  - Assistant Manager-Library
  - Assistant Manager-Translation
  - Assistant Manager-Safety

SECURITY DEPARTMENT:

PROPOSED

- MANAGER-SECURITY
  - Assistant Manager-Personnel & Housing
  - Assistant Manager-Plant Security
  - Assistant Manager-Civil Defense

PRODUCTION PLANNING DEPARTMENT:

PROPOSED

- MANAGER-PRODUCTION PLANNING
  - Assistant Manager-Iron & Steel
  - Assistant Manager-Rolled Products
  - Assistant Manager-Commercial Products

PREPARATION AND REFINING DIVISION:

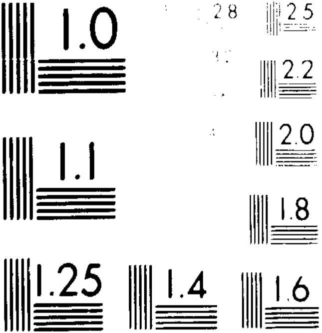
PROPOSED

- DIVISION SUPERINTENDENT-PREPARATION & REFINING
  - Superintendent-Raw Materials
  - Superintendent-Coke & By-Products
  - Superintendent-Blast Furnaces & Sinter
  - Superintendent-Steel Producing

ROLLING MILL DIVISION:

PROPOSED

- DIVISION SUPERINTENDENT-ROLLING
  - Superintendent-34"/28" 2-High Mill & Soaking Pits
  - Superintendent-28" 3-High Mill
  - Superintendent-16"-12" Mills
  - Superintendent-Continuous Mill
  - Superintendent-Roll Shops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COMMERCIAL PRODUCTS DIVISION:

PROPOSED

- DIVISION SUPERINTENDENT-COMMERCIAL PRODUCTS
  - Superintendent-Machine Shop
  - Superintendent-Foundry
  - Superintendent-Pipe Casting
  - Superintendent-Sulfuric Acid & Super-Phosphate

MAINTENANCE AND TRANSPORTATION DIVISION:

PROPOSED

- DIVISION SUPERINTENDENT-MAINTENANCE & TRANSPORTATION
  - Superintendent-Mechanical Maintenance
  - Superintendent-Electrical Maintenance
  - Superintendent-Refractory
  - Superintendent-Vehicle Maintenance
  - Superintendent-Maintenance Planning
  - Superintendent-Transportation

POWER & FUEL DIVISION:

PROPOSED

- DIVISION SUPERINTENDENT-POWER & FUEL
  - Superintendet-Power Plant
  - Superintendent-Gas & Heating
  - Superintendent-Energy Dispatching

ACCOUNTING DEPARTMENT:

PROPOSED

- GENERAL MANAGER-ACCOUNTING
  - Assistant General Manager-Accounting
    - Manager-General Accounting
    - Manager-Cost Accounting & Analysis
    - Manager-Purchasing & Sales
    - Manager-Budget Control
    - Manager-Stock Control
    - Manager-Mill Accounting
    - Manager-Computer & Statistics

CONSULTING SERVICES FOR
TURKISH IRON AND STEEL COMPANY,
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10.0 GENERAL MANAGEMENT

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CONSULTING SERVICES FOR
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10.0 GENERAL MANAGEMENT

10.1 SUMMARY

The UEC Project Leader covered the field of general management and staff functions by working closely with the Plant Manager and Vice Plant Managers of Production, Study & Planning, Maintenance & Services, and Industrial Engineering. Assistance was rendered in matters requiring policy decisions.

Favorable results were achieved by the Plant Manager applying modern management principles to the following projects:

A. Expedite the sinter plant ignition hood change.

B. Start operation of the coke crusher.

C. Initiate a project for external desulfurization of hot metal.

D. Place a contract for recovery of roll scale.

E. Elimination of platform hold time on semi-killed steel.

F. Reverse pouring of ingots from Furnaces C, D, and F.

Recommendations that require further active participation by the Plant Manager include:

A. Develop an effective communication system between departments in the plant. A weekly staff meeting should be held.

B. Expedite completion of the basic sinter project and follow up to see that expected results are attained.

C. Coordinate the plant activity in energy savings in accordance with specific programs that have been recommended by UEC.

D. Initiate action on the ingot mold preparation and cooling project.

E. Expedite the purchase of mechanical cleaning equipment for the soaking pits.

F. Insist on proper maintenance of the plant equipment in accordance with UEC recommendations.

G. Use the staff departments to develop and plan alternate recommendations for use of the additional hot metal to be produced as a result of the present modernization program.

H. Establish a plan for a comprehensive repair program at the coke batteries and obtain the funding based on the importance of the coke battery rebuild program in terms of energy savings to be realized.

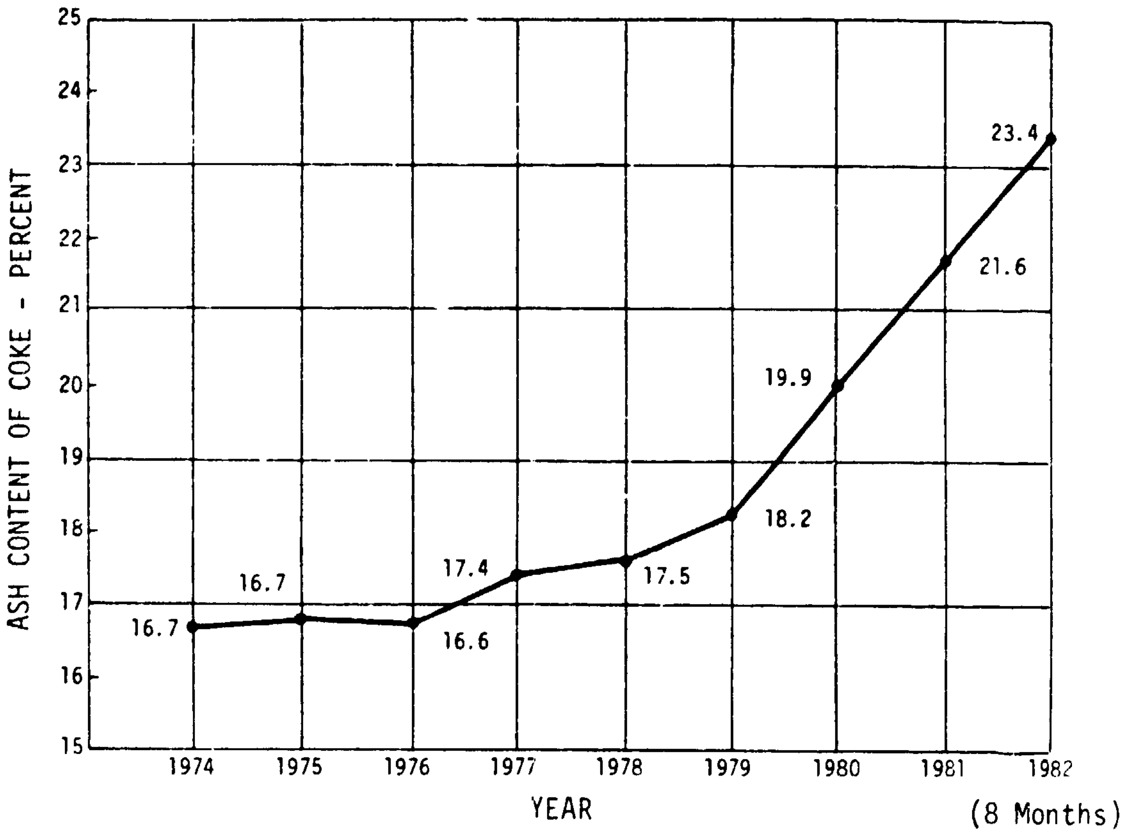
10.2 DETAILS OF SPECIFIC PROJECTS REQUIRING ATTENTION OF PLANT MANAGER

10.2.1 Coke Ash

The detrimental effect of high coke ash content is well known both to Karabuk and the general management of the Turkish Iron and Steel Company. It must be stressed again because it is probably the single most important factor affecting hot metal production and coke rate. The ash content of the coke has been historically high in comparison to world standards which is 8 to 10% but until recent years has been relatively constant, as indicated in Figure 1.

Figure 1.

COMPARISON OF COKE ASH CONTENT BY YEAR



Iron production has decreased from 1,710 tons per day in 1978 to 1,440 tons per day in 1982. Coke consumption has increased from 889 kg per MTHM in 1978 to 998 kg per MTHM in 1982.

The Vice Plant Manager has developed a graphic presentation of the effect to be expected on hot metal production and coke consumption in relation to coke ash based on Karabuk experience (see Appendix 1). Coke rate figures are in fairly good accord with what can be expected in USA practice. The effect on production is more severe at Karabuk because the alkali content is much higher. The increased alkali recirculation causes hanging and wind volume restrictions. Unfortunately, there is no known blast furnace technology which can be applied to overcome the loss in hot metal production and increase in coke rate.

The trend in coke ash content must be reversed. The present level is cause for concern as to serious problems developing in the furnaces. The proper authorities must supply a better grade of coking coal at Karabuk, at least equivalent to that supplied in 1978.

10.2.2 Coke Crusher

The benefits to be derived from operating the coke crusher as detailed in the Blast Furnace section of the report are a decrease of 15 kg per MTHM in coke rate and a 3.7% increase in hot metal production. The reason for mentioning it further in this section is that bringing the plant into operation required a coordinated effort on the part of plant management.

Due to a combination of personnel, maintenance, and operating problems, the plant had remained idle for nearly 4 years. Previous experts had recommended strongly that the plant be placed in operation to aid in reducing coke rate. However, no comprehensive solution was found.

The UEC Project Leader worked closely with the Plant Manager, providing guidance and motivation in the proper approach and the use of staff assistance in problem solving. The plant was placed in operation in the interim between visits to the Works. It is now in full production and the benefits are apparent at the blast furnace.

This type of mission permitted the consultants to follow up on the problems, encourage solutions, and assist in fulfilling the recommendations. It is reasonable to conclude that the plant would have remained idle without the impetus provided by the UEC team.

10.2.3 Quality Control Program

An extremely comprehensive study of total product quality and quality control at Karabuk Works, along with recommendations for an entirely new quality control system, was completed under UNIDO Contract No. 76/26, Project DP/TUR/72/5. The 5 volumes of the report contain over 500 pages, including complete equipment specifications and numerous reporting forms, as well as 26 sketches and drawings. The report was prepared as a joint study by Marmara Scientific and Industrial Research Institute (MSIRI), who relied heavily on work done by the Metallurgical Institute, Hasan Brkic of Zenica, Yugoslavia. The study was over 4 years in preparation and involved the work of more than 20 highly qualified experts. An additional study and clarification of the initial report is presented as UNIDO Project DP/TUR/77/020/11-08, dated February 5, 1980, by Prof. Dr. Kemal Kapetanovic. These reports have been completely reviewed by the UEC Team Leader and discussed with the Quality Control Manager, Laboratory Manager, and Vice Plant Manager-Planning. They are excellent reports and a tribute to those who prepared them. The premise on which the reports are postulated is that Karabuk Works will produce 873,000 tons of high quality steel products in the future, most of which will require certification. There are 6 major recommendations:

A. Extension of quality control processes and procedures.

B. Extension and improvement of sampling system.

C. Improvement of recording system using computerized data processing.

D. A new organizational structure with proposed manning and qualification level of personnel.

E. Purchase of new equiment at current cost of approximately $5,000,000.

F. Construction of a new laboratory building, a bridge over the Soganli River, and modification of existing buildings.

As previously indicated, the reports are complete in every detail and full endorsement is given to the recommendations as desirable in the long range when the plant produces the forecast product mix.

While the Zenica study is all-inclusive, this discussion will be confined to the steel product area, which is the primary subject of this mission. Of the steel produced, 94% is in 3 common semi-killed grades. The product mix has not changed materially in recent years. Planned production for 1977 and 1982 is as follows:

Product	Tons 1977	Tons 1982
Rounds	310,000	284,000
Angles	68,500	91,000
Shapes	43,000	55,500
Mine Roof Bolts	14,500	14,500
Rails	7,500	6,500
Billets and Blooms	105,000	48,500
TOTAL	548,500	500,000

The decrease in forecast production is caused mainly by a decrease in imported semi-finish material.

There is little possibility of a major product change in the near term because of the quality of raw materials, the lack of desulfurization equipment, and the general condition of the mill equipment. Until such time as equipment changes are made, the plant should concentrate on bringing the current product line to a competitive level that would be acceptable in the export market.

Existing laboratory equipment is adequate to perform all of the functions necessary to control quality of the current product. The laboratories are decentralized and some equipment can be utilized more fully than at present.

The present organization reports, in theory, to the Manager of Laboratories. In practice, reporting is generally to the Department Manager. There is no coordinated control of quality starting with raw materials so that the best final product quality is attained. Essentially, each producing unit operates independently, with little regard for the finished product quality. There are adequate reports generated for control purposes if standards were established and the reports were properly utilized.

UEC's recommendations are as follows:

A. Agreement should be reached to implement the organization recommendations in the Zenica study.

B. Establish a time schedule for gradually phasing in the new organization. First priority should be given to implementing field control in the iron and steel producing sector.

C. Survey present equipment and maximize utilization of the most modern. Defer the purchase of most of the recommended new equipment.

D. Postpone consideration of new building construction and computer processing.

E. Use the present reporting system for control; and as new reports are phased in, they should be compatible to the proposed long-range computer system.

F. Presently, qualified metallurgists are on uninspiring assignments throughout the plant. They can man the new organization in line with the report recommendations.

G. After the organization changes are approved, a metallurgical expert experienced in process control (field control) should be utilized for 6 months to assist in implementation.

10.2.4 Current Modernization Program

The 1983 budget request from Karabuk to the General Directorate contains a number of items; however, only 3 are reported to be active at this time due to financial restrictions. In the order of priority, they are:

A. Blast furnace stove modernization;
B. Replacement of boilers and turbines; and
C. Coke battery rebuilding.

The main emphasis of the current modernization program, including projects under construction as well as those being given priority, is on increasing production from the blast furnace. What is lacking is a viable plan for utilizing the 300,000 additional tons of hot metal that will be produced.

A BOF steelmaking shop and continuous caster plan was developed in 1977. The estimated cost was $250 million, with $150 million required in foreign costs. The project was set aside at that time because of high cost. Obviously, the current cost will be considerably higher.

Another solution to utilize the additional iron, offered by the Head of Planning for the General Directorate, was that a pig machine be built and the plant sell pig iron. The feasibility, cost, and profitability of this approach has not been determined by the General Directorate's planning group.

10.2.5 UEC Recommended Program to Utilize Added Hot Metal

A. The UEC team recommends that priority be given to improving productivity of the open hearth shop. Short-term, low-cost programs for improved scrap handling, mold cooling, furnace rebuilding, and improved operating practices, have been detailed in the Steel Producing section of this report. As a longer-range project, the use of oxygen roof lances should be considered. This program will require an oxygen plant which can be compatible with any long-range plan for a BOF shop.

B. External desulfurization of hot metal is an absolute necessity for quality products as well as productivity. The Karabuk engineering organization is very capable and, with some assistant from a consultant, the desulfurization project can be initiated.

C. As iron and steel production increase, the bottleneck will shift to the rolling mills. The recommendations for improvements at the soaking pits and continuous mill, when fully installed, should provide a balanced plan from iron production through finished product.

D. After analyzing the energy cost and fuel problems of the plant, particularly at the rolling mills, the UEC team recommends that the Government give a higher priority to the coke battery rebuild program. The Vice President-Raw Materials advised that, except for the purchase of brick, most of this work can be accomplished internally. Consideration should be given to substituting this project for the proposed new sinter line.

E. The productivity and quality control at the limestone and dolomite mines must be improved.

F. Karabuk Works has a well equipped, relatively modern iron foundry; a cast iron pipe plant, also relatively new; and a good machine shop. A market and profitablity study should be made to determine whether the increased hot metal from the modernization program should be diverted into these products rather than steel or pig iron.

10.2.6 Training Programs

The Senior Industrial Field Development Advisor and Deputy Resident Representative made a specific request at the mid-session meeting for UEC to translate the problems of the plant into specfic training needs. The consultants' individual comments are combined and presented as a group for the consideraton of Karabuk's general management

10.2.6.1 Upper Level Management and Engineers

A. English Language

There is a need for training in the English language with emphasis placed on technical English. The benefit to be gained is access to the vast amount of current technological and management information that is available in many publications. The plant library is stocked with magazines and books which for the most part are unused. This need was discussed with the UNIDO representatives and as a result the training expert currently on assignment for UNIDO at the Karabuk Works is developing specifications for a course.

B. Modern Management Methods

This course should include the structure and function of organizations, interpersonal relationships, motivation, effective communication, effective listening, problem-solving, and decision-making. The course should be assembled by a qualified organization such as UEC, for example, using visual aids and programmed training methods. It should be given in Turkish by training leaders instructed in its use.

C. Seminars and Trade Fairs

Selected personnel should be given the opportunity to attend trade fairs, seminars and technical society meetings in Turkey and abroad to learn up-to-date methods, materials, and practices.

D. Introduction to Computers

This course is designed to include the function, capabilities, limitations, and operation of computers. It should be designed to help those who will receive and interpret data from them. Simple exercises using the computer should be included.

E. Safety

Fundamentals of an effective safety program should be taught by an American consultant. This program is best conducted away from the plant site and will require 8 to 10 full days to complete

F. Accounting ,Industrial Engineers and Engineers

Selected personnel from these departments should be given training in:

1. Statistical analysis.

2. Use of computer terminals.

3. Use of computers for engineers.

These courses can be taught as extension courses from the university or by well-qualified consultants. They can be conducted at the plant site.

10.2.6.2 Special Training and Technical Assistance

A. IBM Programs

Considerable outside help will be needed to attain expected benefits from the proposed new computer. The need extends from the installation of the hardware to development of the software packages. Consulting service should be sought from a qualified source possessing programs which can be adapted to Karabuk needs.

B. Energy Saving Program

There is a tremendous potential saving to the plant through proper energy management. Complete development of this program requires knowledge and experience not currently available at Karabuk. Repetitive services of a qualified consultant should be used in split missions of approximately 2 months' duration, with 2-month intervals, over a period of at least one year.

C. Combustion and Instrumentation

The plant needs full-time combustion engineers. Two sons should be selected from the instrument group [illegible] sent abroad for 3 months to receive extensive training in combustion control techniques. A consultant should be used at Karabuk for 3 months to work with these trained individuals in implementing a combustion department.

D. Open Hearth Steelmaking

A consultant with considerable practical experience in open hearth steelmaking is needed for a period of 3 months to work directly with the foremen on each turn to show effective temperature control, use of burnt lime, bottom repair methods, and other operating practices.

E. Key Personnel Orientation

The manager-steelmaking, chief engineer, set practice engineer, stockyard engineer and raw material engineer, should all have an opportunity for orientation at a USA open hearth steelmaking shop. The training period should be for 2 to 3 weeks on a 6-day basis.

F. Refractory Department

The refractory manager should be given a period of 4 weeks orientation in a foreign open hearth steelmaking plant. Upon his return, a refractory consultant should be used for one month to assist in installing proper maintenance procedures.

G. Quality Control and Inspection

After the metallurgical department manager is selected and the key supervisors are appointed, a metallurgical consultant experienced in process control (field control) should be used for 4 to 6 months to assist in the implementation.

10.2.7. SAFETY

While not a subject of this mission, the members of the UEC team would be remiss if they failed to mention this matter. "SAFETY FIRST" has long been the policy in USS. The UEC team members are concerned about the apparent lack of emphasis on safety within the Karabuk operating departments. Experience in the USA and other heavily industrialized countries has shown that the best results are obtained when safety is considered a prime duty of operating management. It must receive the full backing and support of top management. Further, a job that is performed safely, is performed efficiently.

Safety should be made an operating responsibility and receive the full backing and enforcement by top management. The safety program developed by USS is in use worldwide. Consideration should be given to a similar program by the Turkish Iron and Steel Company.

10.2.8. COMMENTS REQUESTED BY UNIDO

The UNIDO Deputy Resident Representative requested comments on two subjects at the Progress Review Meeting held in June at the mid-point in the mission.

A. What is the effectiveness of Karabuk Management?

B. What will happen when the UEC team has gone?

By USA standards, management effectiveness is measured by profit contribution, productivity and development of people. At the Karabuk Works, except for the plant manager, only productivity is used as a measure. Even this is a poor yardstick because production objectives apparently are established by State Planning using only theoretical production capacity as the goal.

Assuming no good absolute measurement is available, there is no question that Karabuk management can be more effective than at present. The managers in general are capable, intelligent people. For all practical purposes they are self-motivated. Management methods should be changed and, in some cases, people should be changed.

Some recommendations for consideration are:

A. Realistic objectives should be established by the General Directorate in agreement with plant management. They should be based on such things as market forecasts, condition of equipment, raw material quality and quantity, product mix, planned outages, capital spending plans, to name a few. Management should be held to these objectives.

B. All levels of management should be responsible and accountable for profitability and cost.

C. Plant management should be instructed in modern management methods and then use them.

D. The plant manager should hold regular operating and staff meetings. Communications must be improved and all managers should be held to the common plant objectives.

E. Maintenance should be improved and the managers made more responsive to the needs of the operating departments.

F. Management should ensure that the daily problems are solved before they become major disasters. It should make things happen, not wait for things to happen and record the results.

G. There are many highly-skilled and educated young engineers in uninspiring positions. They are frequently lost to the private sector or to foreign countries. They should be given responsible, challenging assignments and the results of their efforts used to better the plant operation. There are too many good investigations on which no action has been taken. Elimination of the dual system of blue-collar foremen and white-coller engineers and combining them into one responsibility, as in USA practice, would go a long way toward solving this problem.

H. Upper-level management positions should be filled on the basis of demonstrated ability. Therefore, a management appraisal system is needed.

What will happen when the UEC team is gone is a matter of conjecture.

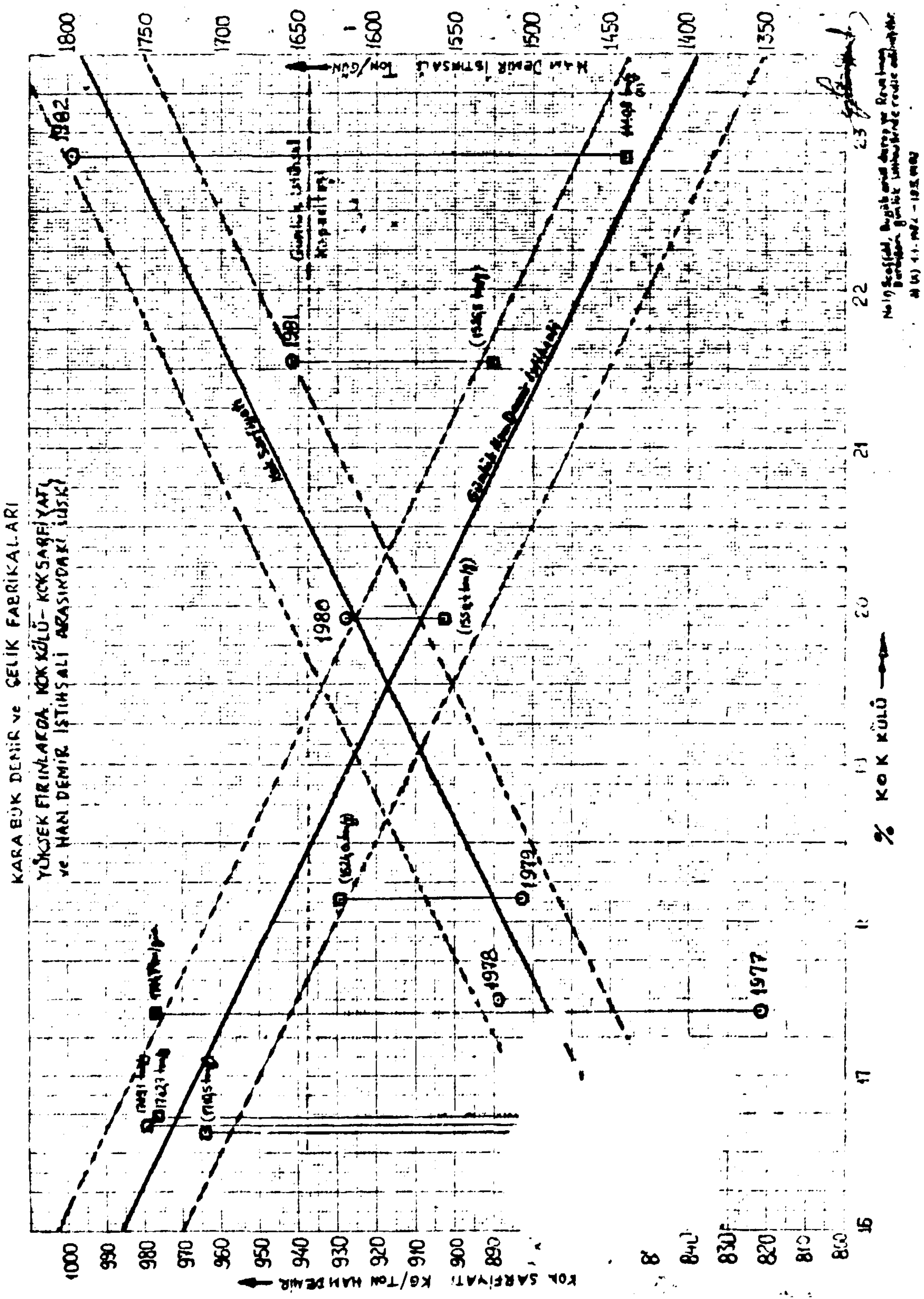
Results were good on getting projects installed in the interim between visits to the plant, even though this was during the vacation season for many of the key managers.

This was a hands-on type mission. On-the-job-training was given and many things are now being done right just as easily as they were being done wrong before the UEC team visit. It is logical to assume they will continue to be done right.

Through daily contact, ideas were exchanged, recommendations accepted and concurrence reached on installation by Karabuk personnel. The comment was made frequently that the recommendations of previous consultants were made at a higher level and did not get passed down to the people responsible for taking action.

In conclusion, there were many positive indicators, but in the final analysis management gets only as much as it demands. The current system does not encourage or reward initiative. Therefore, it will probably be necessary to repeat this type of mission to maintain the momentum.

APPENDIX 1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