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SYRIAN ARAB REPUBLIC

# Technical report: Study and analysis of the technical viability of utilizing installed electric arc furnace for low-alloy steel production*

Prepared for the Government of the Syrian Arab Republic
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of the United Nations Industrial Development Organization (UNIDO). Mention of company names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

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## INTRODUCTION

In 1972 Syria increased the numbers of those Arab World's countries which possessed their own metallurgical industry.

Started with reinforced steel bars Rolling Mill based on imported billets the first Syrian Enterprise "The General Company of Iron & Steel Products" (GECOSTEEL) in 1978 commissioned Electric Steel Plant aimed to produce steel billets for feeding the Rolling Mill.

Nowadays a new Project for the constraction of iron and steel complex in Syria is in progress.

In the circumstances it is of interest to make the acquaintance of update state of affairs to find out the problems, which are arised after 10 years in the steel melting experience of GECOSTEEL as well as to estimate what capabilities it possess.

Such outlook on the point will be more significant if take into account that so far have not been made close steel making practice inspection and assessment of GECOSTEEL.

From these considerations and on the basis of Job Description's main objective - to study the technical viability of utilizing of existing Arc Furnaces for the low alloyed steel production - The Author has realized his activity and attempted to formulate this Report.

More general data concerning GECOSTEEL activity for some last years and new "Iron & Steel Project in Syria" one can find in the "UNIDO Study on Industrial Development Prospects in SAR. The "Iron & Steel Sector", prepared by Mr. A.B. Mourad, B.Sc. ARTC, Ph.D. UNIDO Industrial Expert, on April, 1985.

With this in mind the Author omitted some information not concerned with Steel Melting practice of GECOSTEEL.

The Author's activity on GECOSTEEL Steel Melting Plant started on 17.10.1988 and lasted till the end of January, 1989. On the Author's opinion all the theoretical objectives formulated in the Job Description have been attained.

Unfortunately, as for the practical steps which Author intended to realize (e.g. the carrying out of Low-Alloyed Steel Melting to make the melters' stuff familiar with the appropriate technology and steel melting procedure), they have been faced with a great deal of interior GECOSTEEL's problems, which have not allowed these intents to be performed, at least, up to the writing of this report date.

# I. STEEL MELTING PLANT

Background information (See Annex No. 1)

## A. Scrap Yard

The scrap yard consists of two parallel bays each of 204 m in length and 36 m in width. The adjacent to the furnace bay is under the roof and the rest part of scrap yard is not covered. The scrap yard is served with five overhead electrically driven 10 tons capacity magnetic cranes provided with grabs.

For the scrap preparation purpose there are two press-shears with 300 tons press power and 150 tons/day of the scrap rated capacity. A hand acetylene torch is used for cutting of large dimentioned scrap pieces (e.g. automobile bodies and axles).

The scrap yard is provided with branch line in case the scrap is supplied by rail vans. As a rule scrap is supplied by trucks.

## B. Scrap quality

The quality of the scrap which are delivered to the GECOSTEEL is far from satisfactory as far as its dimensions, cleanliness and volume weight are concerned.

The scrap is involved mostly the automobiles bodies, axles, engines, gas cylinders, tin-plate strips, chips. It is rusted, greased, mixed and unsorted. It contains too much a non-ferrous metal: copper, tin, lead.

The return plant scrap consists of spoilage products of Rolling Mill (wire coils, semi-finished rejected rolled products) and SMP emergency castings, formless and large in dimensions, contaminiated with slag.

Practically, the volume weight of the saleable scrap is estimated as little as 0.40 ÷ 0.45 ton/cubic meter in comparison with electric arc furnace specification scrap with volume weight 2.5 ÷ 2.8 ton/cubic meter.

If take into consideration a very limited scrap preparation SMP facilities it would be clear that hydraulic Press for bailing of this light and oversized scrap is highly needed for scrap yard.

Searching of a new reliable sources of mettalurgical scrap is also a very important task.

## C. Scrap requirements and its delivery

Table 1

| Consumption, tons | | | Actual delivery, tons |
|---|---|---|---|
| Period | Rated | Actual (approx) | from 1.01.88 up to 1.12.88 |
| Year | 135.000 | 40.000 | 23.480 |
| Month | 11.250 | 3.300 | 2.135 |

Table 1 shows that present quantity of the scrap is delivered to GECOSTEEL is not sufficient. Deficiency is amounted around 1,000 tons/month under the present production capacities utilization and considerably more if keep in the mind rated capacity of SMP.

The up-date actual scrap store on the GECOSTEEL premises is not estimated but may be considered as unreliable, as it is required a great deal to be selected and prepared.

Only 100% domestic scrap is consumed nowadays and as may be seen from the above data an external marketing is imperative.

The scrap deificiency one of the key problem which restrains steel melting shop production at present and will not allow to boost it in nearest future.

D. **Electric Arc Furnace bay**

This bay comprises the following equipment:

1. Two B.B.C. designed Electric Arc Furnaces of 25 ÷ 30 tons tap weight each, equiped with 15 MW transformers.
2. Two overhead travelling charging cranes with load carrying capacity 35/5 tons each. The cranes are equiped with lifting magnets.
3. Belt conveyer gallery feeding the EAFs with limestone and coke.
4. Two electrically driven charge bucket transborder bogies. According to design they were equiped with weighing control monitoring system.
5. Six charge bucket stands
6. Furnaces dust exhaust pipe-line
7. Electrodes screwing stands.

E. **Casting bay**

This bay comprises the following equipment and production places:

1. Two 2-strand's continuous casting machines "Concast" which are integrated on one common platform.

2. Two overhead travelling casting cranes with load carrying capacity 50/15 tons each. At the commissioning stage these cranes were equiped with weighing and monitoring system.
3. Ladie relining pit
4. Three ladle preheating oil burner stands
5. Tundish preparation site
6. Cassette slide gate valves assembling stand
7. Emergency casting pits
8. Tundish preheating stands (2 numbers)

F. <u>Billets withdrawal and storage bay</u>

This bay incorporates:

- 2 two-strands withdrawal conveyers (from each continuous casting machine);
- Billets cooling beds;
- Billets storage stands.

This bay is served by 2 overhead magnetic electrically driven cranes with load capacity of 10 tons each.

G. **The SMS proximate analysis laboratory** is equiped with computer aided spectral quantometer and facilities for the chemical analysis. The slag chemical composition is not analysed at present steel melting practices of SMS.

## II. RAW AND CONSUMED MATERIALS

### A. Slag Forming Consistuants

Domestic limestone of good quality and well crashed in lumps of 10-15 mm with sulphur and phosphorus content less than 0.030% is available.

Fluorspar is imported product, available on the plant but is not used in practice as a rule.

The lime and crashed fireclay (chamotte) bricks are not available.

### B. Coke

For the carboruzation purposes the coke is occasionally used.

It is imported material with sulphur content less than 1.5%.

### C. Ferroalloys

While producing plane carbon steel GECOSTEEL consumes a limited set of alloying materials. They are:

1. Ferromanganese - 75% Mn, 4% C
2. Ferrosilicium - 75% Si
3. Silicocalcium - 60% Si, 30% Ca
4. Aluminium (secondary, in form of bars of 1.0kg by weight casted in subsidiary casting workshop from Al-content machinery scrap which is selected in the scrap yard).

No other allay materials are available at the Plant.

For the low alloyed steel production GECOSTEEL intends to salvage machinery plant scrap which contains such alloying elements as chrome, nickel, molybdenum and manganese.

## D. Electrodes

The graphite electrodes of "SIGRI GROUP" are used at GECOSTEEL.

Following are the main physical properties of the electrodes:

Table 2

| Items No. | Description | Features |
|---|---|---|
| 1. | Weight of the electrode | 371 kgs |
| 2. | Electrode diameter | 405 mm (16)" |
| 3. | Electrode length | 1800 mm |
| 4. | True specific gravity | 2.23 g/cm3 |
| 5. | Compressive strengh | 200 – 450 kg/cm2 |
| 6. | Tensile strengh | 35 – 175 kg/cm2 |
| 7. | Flexural strengh | 60 – 250 kg/cm2 |
| 8. | Thermal conductivity at 20 C | 100 – 160 Kcal/mhC |
| 9. | Specific electrical resistance | $6 - 10.10^{-4}$ ohm.cm |
| 10. | Conical nipple thread | 4 pitches |
| 11. | Nipple diameter | 222 mm |
| 12. | Nipple length | 304.8 mm |
| 13. | Nipple weight | 15.7 kgs |

## E. Refractory materials

All refractories used by GECOSTEEL are imported from Europe countries, mainly from Austria, Germany, Greece. The Table 3 shows the type of refractory materials used at SMP:

Table 3

| Item No. | Description | Refratory's Type |
|---|---|---|
| 1. | Furnace Lining: | |
| 1.1 | Hearth or bottom | magnesite bricks and magnesite ramming mix |
| 1.2 | Lower sidewalls, slag line | magnesite bricks with carbon additions |
| 1.3 | Middle and upper sidewalls | magnesite - spinal bricks |
| 2. | Cover lining | High-Alumina bricks |
| 3. | Steel casting ladle lining | High-Alumina bricks |
| 4. | Tundish lining | Silica sand, graphite asbestos plates, high alumina central bottom plate |
| 5. | Tundish nozzles | Zircon-silicate (62% $ZrO_2$) |

## III. THE GENERAL TECHNICAL DATA OF STEEL MELTING PLANT MAIN EQUIPMENT

### A. Electric Arc Furnace

Table 4

| Item No. | Description | Features |
|---|---|---|
| 1. | Type | SSK DH-390 |
| 2. | Manufacturer | Brown Boverie and Cie (BBC) |
| 3. | Capacity | 25 - 30 tons |
| 4. | Shell diameter | 3900 mm |
| 5. | Electrode holes pitch dia | 1130 mm |
| 6. | Graphite electrode dia | 405 mm (16") |
| 7. | Forward tilting angle | 42° |
| 8. | Backward tilting angle | 15° |
| 9. | Furnace cover swivelling angle | 70° |
| 10. | Electrode stroke | 2350 mm |
| 11. | Electrode regulation | Hydraulic |
| 12. | Cover swivelling stroke | 468 mm |
| 13. | Total stroke time of cover lifting device | 75 sec. |
| 14. | Door opening | 800 x 500 mm2 |
| 15. | Weight of Furnace shell with lining, about | 60 tons |
| 16. | Weight of Furnace cover ring with lining, about | 11 tons |

### B. Transformer

Table 5

| | | |
|---|---|---|
| 1. | KVA output | 12500 KVA *) |
| 2. | Primary voltage | 66 KV (50Hz) |
| 3. | Secondary voltage | 110-300 V |
| 4. | Secondary current | 25770 A |
| 5. | Secondary power range | 4900-12500 KVA |
| 6. | Transfo taps' numbers | 15 |
| *) | Permissible overload capacity | 20% for 1.5 hour |

## C. Continuous Casting Machine

Table 6

| Item No. | Description | Features |
|---|---|---|
| 1. | Manufacturer | Schloeman-Siemag AG |
| 2. | Electrical equipment make | BBC |
| 3. | Casting radius | 4 m |
| 4. | No. of strands | 2 x 2 |
| 5. | Specified unit sizes | 80 x 80 mm2<br>100 x 100 mm2 |
| 6. | Cutting equipment | Mechanical shear |
| 7. | Cut length | 3.0 and 6.0 m |
| 8. | Machine speed | 0.8 ÷ approx. 8,0m/min |
| 9. | Elevation of casting platform above mill floor | 4.6 m |
| 10. | Overall height from cellar to top edge of ladle<br>of which above floor | approx. 12 m<br>approx. 9.5 m |

## IV. THE CURRENT STATE OF STEEL MELTING PLANT EQUIPMENT

In the course of initial observation of the installed equipment it became quite obvious that no any routine maintenance have been carried out for a long time and that present condition of it to be qualified as a very unsatisfactory.

The relevant comments have been made by Author in the Report of 27.11.88 for General Manager of GECOSTEEL.

Alongside with this the following malfunctions are to be noted here:

1. The Electric Arc Furnaces operate in most adverse conditions:

1.1 A constant leakage of the aqueous emulsion out of hydraulic control and drive systems is taking place: the furnace tilting cylinders, furnace cover lifting cylinders, door lifting and elctrodes displacement cylinders.

1.2 The water cooling system is deteriorated. Some furnace units which are subject to stress and particularly to heat and to be water cooled have been disconnected from water pipe-line: furnace cover rim, furnace shell ring, furnace door.

The water leakage out of water supplying rubber hoses connected with current carrying units continuously takes place.

1.3 The furnace cover rim edge which serves for sealing between the furnace shell and cover has been cutted out by reason "there was no proper cover accommodation on the furnace shell." But it is the consequence of upper shell ring deformation as a result of poor cooling of it.

1.4 The electrodes cooling rings have been given up and not used for a long time.

2. Another essential point to be emphasized is foult state of all the weighing devices at the SMP. The only cperating scales are the truck ones.

Under such conditions it is impossible to make correct charge preparation for melting of alloyed steel. It is also one of the reasons for excess of liquid steel which remains in the bath after each tapping.

3. The absence of continous casting machine routine maintenance causes such undesirable effects as numerous breakdowns resulting in emergency pouring of steel on the shop floor into the limestone - made pits, to say nothing of the billets output losses.

It results in turn, in occurrence of large store of useless metal sculls which blocked up the SMP casting bay and plant surrounding premises.

## V. THE PRODUCTION PROGRAMME OF STEEL MELTING PLANT AND APPLIED TECHNOLOGY

The feeding of Rolling Mill Plant with steel billets for further manufacture of reinforced bars is the main objective of SMP production activity.

Starting with designed capacity of 120,000 tons per year the SMP is planned to operate with two Electric Arc Furnaces uninterruptedly on the basis of three shifts per day with tap-to-tap time schedule of 3.5 - 4.0 hours and with daily production of approximately 165 tons for each furnace (and even more, if take into account scheduled furnace relining outages).

The actual annual SMP production efficiency is considerably below of the rated one.

Until 1985 steel production did not exceed 39% (see "UNIDO Study" of April 1985).

In 1985 the SMP capacity utilization reached around 73%. These best to date results were gained under the technical assistance with Polish firm "Centrozap".

The plain carbon steel grades (such as "ST-37" of DIN STANDARD) are basic for GECOSTEEL.

The specified chemical composition of steel grade in ST-37 is as follows :

Table (7)

| Elemen | C | Mn | Si | Cr, Ni | Si, P | Mo , Al | Cu |
|---|---|---|---|---|---|---|---|
| % | 0.10 | 0.50 | 0.13 | ≤ | ≤ | ≤ | 0.10 |
| | 0.13 | 0.55 | 0.18 | 0.30 | 0.040 | 0.30 | 0.30 |

Cu + 8 Sn ≤ 0.80%

The tensile strength of the reinforced steel bars rolled of this grade steel ranges of 42.0 - 55.0 Kgs/mm, and yield point - of 30.0 - 40.0 Kgs/mm.

A. **Steel Melting Technological Process**

1. Charging buckets are filled up with scrap by magnetic crane and delivered by the electric transborder bogies to the furnace bay.

2. During melting period the furnace is charged with five buckets of scrap with approx. weight of 5.0 - 6.0 tons in each charge. The bucket volume is 12 $m^3$. Interchanging delays amounted 15 - 20 minutes , while melt-down time is only 10 - 15 minutes.

3. The Limestone is put into the furnace with the belt conveyer through the hole in the furnace cover.

   The weight of limestone as well as coke are used to be monitoring on the control panel in the control desk room. At present the monitoring system is out of order.

4. After melt-down and sampling a decarburization starts with gaseous oxygen pressure of up to 10 bar.

   Refractory uncoated steel pipes dia 1" are used for oxygen blowing, In approx. 1-2 minutes the pipe is burnt out.

5. In case of gaseous oxygen lack the wet rolling mill scale is used.

6. After the required carbon content is achieved a Ferromanganese additions are made.

7. In case the steel is heated up to 1700° c and continuous casting machine is ready the steel is tapped.

8. During tapping the deoxidizing and alloying additions of ferrosilicon and silicocalium are made into the ladle.

9. Two sacks of metal surface covering material - vermiculite are put into the ladle at the tapping end.

10. The casting overhead crane raises the ladle on the casting platform.

11. The ladle sample for final chemical analysis is taken while casting.

12. Some quantity of steel and slag remained in the furnace buth after tapping. Deslagging and cleaning of the buth after tapping is not applied.

13. The patching of deteriorated walls by magnesia (Mgo-92%) wetted with water is made with help of pneumatic fettling machine.

14. The tap-to-tap time found as arithmetic mean out of 168 heats is amounted up to 5.5 hours. (observations were made on the furnace No2 at the period from 20.12.88 till 29.01.89).

15. As it was found the charge-to-tap (under electrical current heat duration) time is instable and varried from 2.5 up to more than 6.0 hours.

16. Specific energy consumption calculated on the basis of above 168 heats averaged out at 710 KWh/ton.

## 2. Findings

The applied stell melting technology benefits in shortening tap-to-tap time. The total heat time of 3.5 hours is well accessible providing elimination of some obstructions, main of which are :

- Scrap deficiency and its bad quality ,
- Electrodes breakdowns ;
- Continuous casting machine idling;
- poor condition of furnace refractory lining and mechanical equipment.

The introduction of the intensive salary system will contribute the achievement of above objective.

2. The applied technology is not aimed for steel treatment under reduction conditions and so the removal of such elements as oxygen, hydrogen, nitrogen and sulphur do not take place in this practice.

The dephosphorization is also do not aimed.

3. The specific energy consumption is higher by approximately 200 - 250 KWh per ton of steel as compared to similar kind of furnaces. It is the consequence of enlarged heats duration.

## C. Continuous casting general features and practice.

After measuring of the steel temperature (as a rule it is approx. 1670 - 1690°C) the lalde is mounted over the tundish on the ladle stand.

Approx. 20 Kgs of crashed CaSi is given into the tundish just at the beginning of its filling with metal.

The tundish has no stoppers, it is open nozzles teeming practice.

In the table No. 8 it is shown the rated values for casting speed and throughput (for specific steel weight 7.6 g/$cm^3$).

**Table 8**

| | | |
|---|---|---|
| 1. Heat weight, Kgs | 25000 | 25000 |
| 2. Section, $mm^2$ | 80 x 80 | 100x 100 |
| 3. Casting speed range m/min | 4.0 | 2.8 - 3.0 |
| 4. Throughput range Kgs/min | 194.5 | 213.0 -228.0 |
| 5. Casting time, min | 128.0 | 117.0 - 110.0 |

At the point of 13 metre (measured from the mould level along the strand pass) the running strands are being cutted by the shears.

The hand acetylene burner is applied in case of the shears failure.

The main troubles in the continuous casting practice:

1. Poorly positioned tundish steel stream resulting in sculling of the mould cover plate and mould walls.

2. The strand withdrawal failure.
3. The shears operating failure
4. The liquid metal break-out
5. The low steel temperature in the ladle resulting in tundish nozzle and mould walls sculling.

It should be noted that numbers 2,3 and 4 troubles to a great extent depends of mechanical maintenance, its quality and periodicity.

## VI. Some key points hindering the effective performance of the steel melting plant and recommendations on their possible elimination:

It is beyound doubt that only coordinated uninterrupted operation of both electric Arc Furnaces simultaneously with two continuous Casting machines would allow steel melting shop and GECOSTEEL itself to approach the rated production capacity. At present time it is the matter of equipment spare parts availability and proper maintenance organization.

Otherwise it is no use in attempting to solve the matter of boosting production capacity.

In turn, the revealing of the key bottlenecks of SMS will contribute the settlement of them.

The rated annual capacity of 120 000 ton of steel assumes tap-to-tap time around 4 hours. The used technology allows to hold this time. But manifold furnace delays prolong it up to more than 5 hours. The main obstruction to the optimal heat time have been already mentioned above in connection with melting technology . Now we consider them more attentively.

A. Scrap deficiency and scrap quality:

It have been already pointed out that at present SMS is faced with severe problem of scrap deficiency and its bad quality.

Following are the measures which would be able to solve those problems to a degree.

1. The Hot Briquetted Direct Reduction Iron is to be introduced into the batch charge up to 30% to compensate the deficiency and light volume weight of domestic scrap. The advantages of HB DRI are the resistence to reoxidation and to corrosion while shipment and storage.

2. To eliminate the negative effect of light volume weight of scrap the compacting and baling of latter should be applied. The appropriate facilities, such as power hydraulic press have to be acquired .

3. The arrangement of proper sorting, separating and cropping of the scrap available on the GEOSTEEL stock storage is urgently needed on a large scale.

**B. Electrodes Consumptions:**

The numerous electrodes breakings involved in SMS practice resulted in increased consumption of them as well as melting time extension.

The following table No. 9 shows the electrodes consumption in 1987 in SMS.

**Table 9**

| | |
|---|---|
| 1. SMS Steel production, tons... | 26,899.526 |
| 2. Total electrodes consumption, ton | 342.544 |
| 3. Rated specific electrodes consumption kg/t steel | 5.83 |
| 4. Actual specific electrode consumption kg/t | 12.73 |
| 5. Total overconsumption of electrodes, tons | 185.723 |

Taking into account the total electrodes changing time amounted to 15 minutes as minimum, it may be calculated the annual steel output loss evaluated as approx. 200 tons.

It is noteworthy more than two-fold actual electrodes consumption as against rate.

The following are the good grounds for electrodes breaking and recommendations to decrease them.

1. Poor performance of electrodes movement automatic as a result of bad state of hydraulic system.

Restoration and regular maintenance of the hydraulic system will improve the situation.

2. Utilization of emergency casted steel sculls not being preliminary cutted one of the main reasons for electrode breaking.

The teeming steel into emergency ingot moulds is the best solution of this matter.

3. The strict observation of electrode handling instruction and carefull manipulation with them will prevent electrodes multiple breaking.

Here are some recommendations to be followed while electrode handling :

- Never must the electrode be clamped at the nippling point (this point is boundered with two white strips).
- In case of loosening in the nipple socket and appearance of gap between two electrodes ends the gap should be eliminated by screwing and tightening with help of tongs.

4. The determental practice to recorburize the metal by immersing of electrode into the bath resulted in excess electrode consumption and should be abondoned.

For the purpose of recorbirization the crushed electrode lumps are usually to be used. In this case deslagging is needed.

5. The gap between furnace cover and shell rim contributes inflow an air and increases electrode surface consumption while gases escape at high velovity through

the electrode holes. From this point of view a water cooled sand seal at upper part of shell and the closing edge at the cover ring are very essential for electrodes economy.

And finally, a question which have not to be ommitted At present a huge uncounted amount of broken electrodes are randomly scattered all over GECOSTEEL scrap storage area. It is really wasted currency ! By all means they should be collected to a certain place and a first step have to be undertaken to sell them. It must be remembered that each piece of a new electrode is priced at 790$.

C. The Oxidizing Period duration and lancing steel pipes consumption :

The steel pipes now used for oxygen lancing serve during 1.5 - 2.0 minutes.

Accounting decarbonization velocity at the range of 0.025% to 0.10% per minute and based on average carbon amount to be oxidized of 0.40% the required lancing time is calculated as 4-16 minutes. So, steel lancing pipes required number amounted to 8 pieces and pipes changing time accordingly up to 10-15 minutes.

To save this time and steel pipes it is recommended to apply the refractory coating of the lancing pipes with mix of following composition :

- Silica sand 90%
- Fireclay 10%
- Sodium silicate solution (water glass) as a bond .

The coated pipes are to be dried at 150° - 300° c during approx. 12 hours.

The sequence of pipes coating and the required facilities are shown on Fig. 2 (see annex No. 4)

## D. The Furnace Refactory lining and measures to be taken to extend the furnace life-time :

The state of refactory lining and its behaviour in service have to be particularly considered as these factors to a great extend affect the furnace output.

### 1. Bottom construction and behaviour :

According to the Desing project a sub-hearth lining to be made of three flat layers of Magnesite bricks by total thickness of 225 mm.

The working hearth is rammed by thickness of approx. 35o mm.

Under these conditions the total bath depth is accounted of 750 mm by measuring from sill level.

It should be noted that ramming procedure is not adhered as it had to be in accordance with technical support documentation (TSD).

Because of this the required density of rammed materials is not observed and above accounted bath depth is not reached.

See Annex No.5 for observations made during cold furnace repair and some recommendations in accordance with this .

2. **The back-up linning (or Banks) at present practice is not applied thought it is recommended by TSD.**

The bricks - made back-up linning is of great importance from the point of view the bottom life-time and routine Refactory lining maintenance. The relevant drawing as a pattern of such linning has been handed on to the SMS management.

3. **The Walls' linning :**

It have been observed that there are some walls zones which are subjected to intensive deterioration :

- Slag zone;
- Opposite second phase walls' zone,
- Area beneath the working window (or door) foreplate,
- Around tap hole area;

What are the general reasons for this effect ?

3.1 In metallurgical practice it is well known fact, that as a result of uneven phase power distribution the walls' lining is worked out non-uniformly. Most vigorous deterioration is usually taking place just opposite central, i.e. second phase.

The power phase equalization could be obtained by means of individual voltage and current phase control. The present furnace design does not provide such facilities.

3.2 From the other hand refactory lining life-time to a great extent depends of the shape and dimensions of the furnace shell and melting chamber itself .

In this connection it should be acknowledged that the furnace under consideration are not satisfactory from the above point of view.

For the electric Arc Furnaces of 25-30 tons capacity the favourable internal shell diameter is in range of 4400 - 4600 mm. whereas GECOSTEEL furnaces' shell dia is only 3900 mm(!).

As far as furnace melting chamber is concerned it should be pointed out that under present condition the obconical shell form with inclined walls is more favourable.

In addition to other advantages it would facilitate the fetting procedures, while using pneumatic machine and magnesite dry powder.

3.3 One of the main reasons for tremendous wear of the around tap hole and beneath door zones consists in the large quantity of oxidizing slag, which constantly presents in the bath.

The following steps are to be taken to improve the working condition of the above mentioned zones :

- Once a day the bath should be completely drained and the bottom and banks state to be inspected,

- In case some localized wear is found they should be promptly repaired by magnesite mix with help of the fetting shovel. (The sketch of such shovel is handed to the SMS management).

- It should be remembered that the fettling or patching procedure have to be proceeded by the proper cleaning from slag and steel remainders, which should be removed from the furnace with the help of the steel rakes or scrapers. At present they are not used but are available on the SMS Spare parts store.

- The intensive fettling of the sidewalls' slag line as well as the banks with the help of pneumatic machine should succeed after that.

- The use of water in each case should be as minimal as possible;

- The partial deslagging during meltdown and oxidizing period will contribute not only to the dephosphorization but also to the favourable refactory lining's service conditions.

3.4 The upper part of the furnace walls is subject to accelerate wear on the reason of the presence of large gaps between cover and wall rim. The hot gases continuously escape through these gaps resulting in considerable reducing of brick thickness.

To prevent this effect the proper sand sealing with cover ring edge have to be restored.

**4. The furnace tapping spout or runner is observed in anextremely bad state.**

The stringent regulations should be issued to keep the runner continuously in good state. It have to be cleaned from the steel skulls after each tapping. Weared and repaired zones should be dried by wood fire (or gas burner for the future) during the melting period.

The tap hole, before the heat is started, should be enlarged, if needed, and closed from outside with brick. Before tapping the latter should be removed.

**NOTE !** : The shop management and chief mechanical service should pay more close attention to the state of the runners' platform. It should be made more reliable and rugged, to gurantee the safety of the workers.

5. It was repeatedly observed that at the refinning period just before tapping the melters have used one of the high voltage taps to rise the steel temperature.

It should be remembered that if the higher voltage tap of the transformer is used the more length of the electric arc is produced and therefore the heavyer deterioration arc effect is on the walls' refractory.

To eliminate this undesirable effect the $\Delta$-to-Y (delta-to-star) switching of the primary windings of the transformer should be used after melt down to lower the secondary voltage by a factor of 1.73.

However, at present the voltage changeover switch is not used practically by melters.

6. **The furnace roof**:

The life-time of the furnace roof (or cover) is considerably less than that of the furnace walls.

The necessity of the cover changing within the melting campaign resulted in multihours furnace delay with significant output losses.

The furnace cover is subject to great stress and particularly in its central part.

It have been already pointed out that multiple chargings and consequent arcings during each heat cause accelerated wear-out of the close located to the electrodes central cover part.

That is why elimination of multiple chargings will contribute better cover service conditions and its life-time prolongation.

At the present state of conditions the following measures may be recommended :

- To start each arcing with lowest voltage tap while electrode is submersing into the scrap.
- To reinforce the central part by grouting it with refactory concrete.

## VII. Low - alloyed steel production . The possibilities and problems :

**A. Technical Provision :**

From the all formerly mentioned demerits the following are the most strong barriers to low-alloyed steel production:

1. Absence of serviceable scales; before charging or adding into the furnaces all batch and alloying components are to be precisely weighted.

2. Fault condition of conveyer feeder weighing system.

The quantity of limstone which are feeded into the furnace have to be weighed.

3. Difficulties in creation of reducing atmosphere inside the furnace because of uncealed melting chamber (presence of the gaps between furnace cover and walls shell rim).

4. Difficulties of carefull deslagging caused by ;

- Lack of appropriate facilities (wooden rakes);
- Improper operating of furnace tilting mechanism;
- Small furnace working window dimensions : 500 mm in width by 600 mm in height.

Such a relatively small window dimensions oppose to the proper observation of the bottom, banks and walls as well as their fettling by shovel, and deslagging.

In steel melting practice the acceptable width of working window accounts for approx. 0.3 of furnace chamber dia. In our case it would be accounted for approx. 900 mm.

5. Lack of crushing and milling facilities for obtaining of the slag reducing powedered materials, such as FeSi, CaSi and coke.

**B. The low Alloyed grades which are aimed to be produced at GECOSTEEL.**

Alongside with the plane carbon steel grades routinely produced at GECOSTEEL an orders for low alloyed steel for machinary factories occasionally engendered.

By way of example of such kind of steel is grade EN-35A " with following chemical composition (DIN Standard)" : (in %).

Table 10

| C | Mn | Si | Cr | Ni | Mo | S,P |
|---|---|---|---|---|---|---|
| 0.17 | 0.60 | 0.15 | 0.35 | 0.40 | 0.15 | less |
| 0.23 | 0.90 | 0.40 | 0.65 | 0.70 | 0.25 | 0.035 |

As long term goal GECOSTEEL assumes to produce some other low alloyed steel grades, characteristic of them are the following alloying elements and their contents :

**Table 11**

| Grade | Chemical element and their content range % |
| --- | --- |
| F 1250 | Cr : 0.15 - 0.85 |
| | Mo : o.15 - 0.25 |
| F 1202 | Cr : 0.90 - 1.20 |
| SAE 4620 | Ni : 1.55 - 1.85 |
| | Mo : 0.20 - 0.30 |
| SAE 4140 | Cr : 0.85 - 1.15 |
| | Mo : 0.15 - 0.25 |
| SAE 8622 | Cr : 0.40 - 0.60 |
| | S : less than 0.015 |
| | Ni : 0.70 - 0.90 |
| | Mo : 0.30 - 0.40 |
| SAE 4137 | Cr : 0.90 - 1.20 |
| EN 207 | Cr : 0.60 - 1.00 |
| | P : less than 0.020 |

**C. The needed alloying materials and their availability :**

For the production of the above mentioed low alloyed steel grades the following alloying materials are necessary :

- Ferromolybdemim (60 - 70% of Mo)
- Nickel or ferronickle
- Ferromanganese;
- Ferrosilicium- (40-70% of Si)
- Calcium - silicon (30.0 % Ca + 60.0 Si)
- Aluminium (Secondary, approx. 97% AL)
- Ferrochrome (approx. 70.0% Cr, 8.0 % C)

At present such materials as FeGr, FeMo and Ni are not available at GECOSTEEL.

**D. The experience of the melters' stuff :**

There are some special features in alloyed steel melting technology which are unlikely familiar to the present-day GECOSTEEL melters' stuff.

Therefore, a training course for the melters would have been useful. They have to master an experience of carrying out the following procedures :

- Steel dephosphorization and desulphurization;
- High chromium steel decarbonization;
- Chromium reduction and slag treatment;
- Steel carbonization;
- Steel dioxidation during reduction period.
- Careful deslagging with help of wooden rakes and a new slag making;
- Cleaning the furnace banks and bottom after tapping and proper fettling of them.
- The improvement of general attitude to the furnace maintenance.

E. **Summary**

From the foregoing it became clear, that a lot of factors opposed to the Low Alloyed Steel production at GECOSTEEL at present.

But, for all that there have been real opportunity to carry out one or two heats of Low Alloyed Steel using some kind of available alloyed machinery scrap.

The appropriate charge calculations and heat technology procedure have been prepared by Author and handed on to the SMS management (see Annexes No.2 and No.3)

Unfortunately, by the time of this Report preparation no any essential actions have been undertaken by the SMS management to realize this opportunity.

To be true, however, it should be pointed out that after repeated remindings and pressing by Author a certain work on scrap preparation has been done to the end of his mission: the heavy and large in dimentions machinery alloyed scrap had been cutted on acceptable pieces and chemical analysis had been made. But the weighing of this scrap has remained unresolvable problem.

Some satisfactions presents the SMS management activity which have been undertaken on the main equipment maintenance: at the end of the November the two-weeks hard reconditioning works were carried out on the continuous casting machine No. 2, at the end of December - on the EAF No. 2 and at the end of January on the EAF No. 1.

Along with these the GECOSTEEL and SMS management intend to undertake some actions to improve the manpower situation in the SMS.

All these and some other facts allow to expect that GECOSTEEL administration will keep the situation under close control and in consequence the SMS production performance will improve.

**ANNEX No. 1**

Steel Melting Plant Layout
(see the Figure No. 1)

I. SCRAP YARD

II. FURNACES BAY

III. CASTING BAY

IV. BIL..TS DISCHARGE AND STORAGE BAY

I. **SCRAP YARD**

1. Press shears (2 nos.)

2. Coke and limestone receiving bin.
O.M.C. - overhead magnetic cranes (5 nos.)

II. **FURNACES BAY**

3. Charge basket bogies (2 nos.)

4. Electric Arc Furnaces (EAF)

5. Coke and Limestone bins & belt conveyor

6. Electrode screwing stands

7. Overhead charging cranes (2 nos.)
R.R.P. - Furnace Roof relining place.

III. **CASTING BAY**

8. Continuous Casting Machines (2 nos.)

9. Tundish assembling place

10. Cassette slide gate valve assembling stand

11. Ladles relining pits

12. Ladles preheating stands (3 nos.)

13. Tundish preheating stands

14. Overhead casting cranes (2 nos.)

15. Ingot Mould Place for emergency casting

16. Actual area for emergency teeming
    and slag draining

IV. <u>BILLETS DISCHARGE AND STORAGE BAY</u>

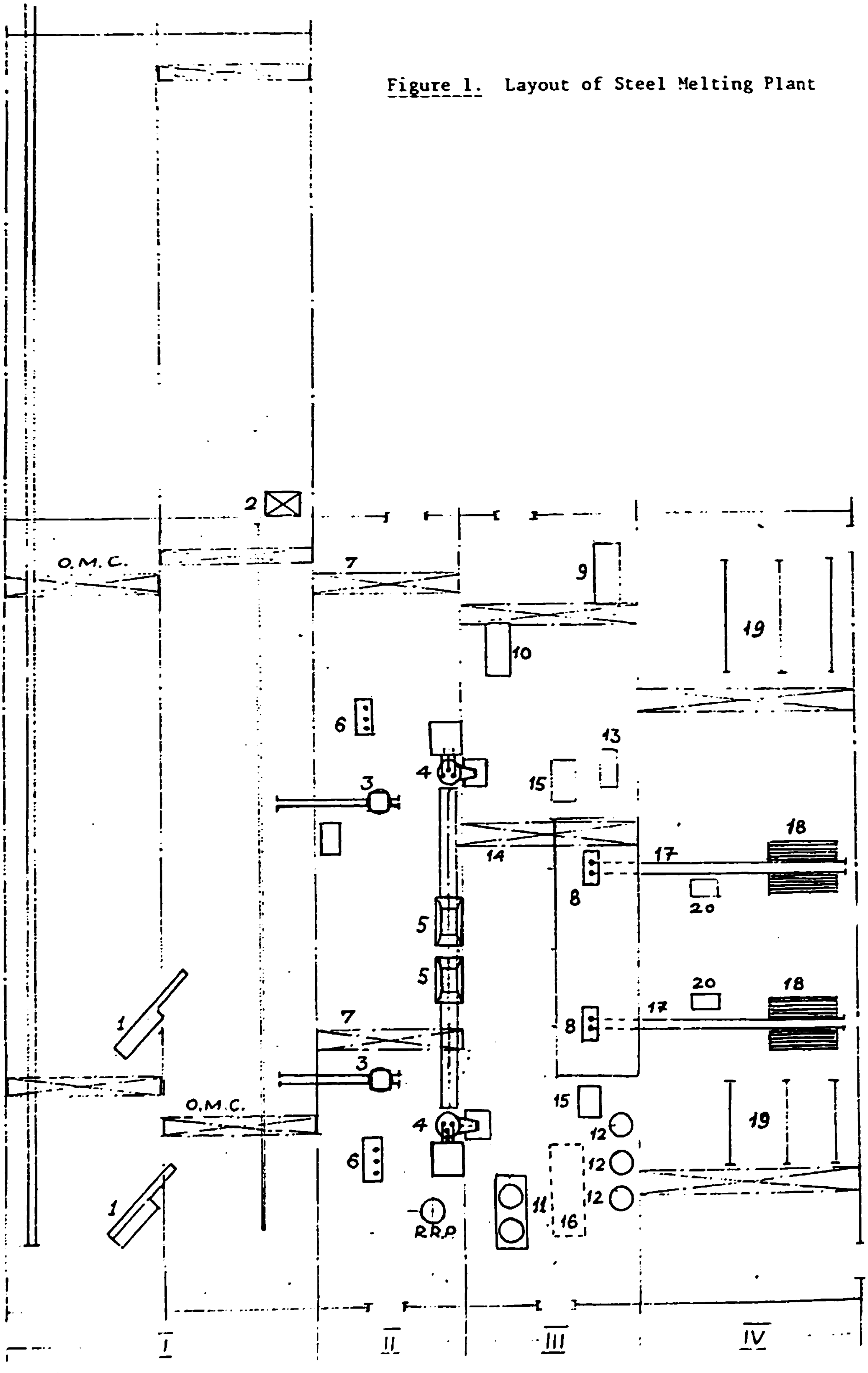
17. Two-stands withdrawal lines (2 nos.)

18. Billets cooling bed

19. Billets cold storage stands

20. Control room for withdrawal and discharge line.

Figure 1. Layout of Steel Melting Plant



**ANNEX No. 2**

Low Alloyed Steel charge calculation utilizing alloyed machinery scrap.

Note: By the time of this Report writing (13.01.89) no any prepared scrap was available and chemical composition cited below is subject to change depending on the actual scrap composition to be determined as scrap preparation will proceed.

Therefore the particular calculation to be considered as a pattern.

**Table 12** The chemical composition of the steel grade to be produced

| EN-35A | C | Mn | Cr | Ni | Mo | Si | S.P |
|---|---|---|---|---|---|---|---|
| % | 0.17 | 0.60 | 0.40 | 0.40 | 0.15 | 0.15 | less |
| | 0.23 | 0.90 | 0.60 | 0.70 | 0.25 | 0.40 | 0.035 |

**Table 13** The chemical composition of the machinery scrap (%)

| Scrap No. | C | Mn | Cr | Ni | Mo | Si | S. | P |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.22 | 1.37 | 0.98 | 1.28 | 0.19 | 0.26 | 0.032 | 0.018 |
| 2 | 0.23 | 0.34 | 1.95 | 0.44 | 0.26 | 0.28 | 0.032 | 0.030 |
| 3 | 0.39 | 0.48 | 1.10 | 1.9 | 0.30 | 0.33 | 0.030 | 0.020 |

<u>Charge Calculation</u>

<u>Variant No. 1</u>

**Table 14**

| Scrap No. | Scrap Amount Kg | C Kg | Mn Kg | Si Kg | Cr Kg | Ni Kg | Mo Kg |
|---|---|---|---|---|---|---|---|
| 1 | 9,000.0 | 19.8 | 123.0 | 23.4 | 88.0 | 115.0 | 17.1 |
| 2 | 12,700.0 | 29.2 | 43.0 | 35.6 | 248.0 | 55.0 | 33.0 |
| Routine Scrap | 3,300.0 | 6.0 | 6.0 | 3.3 | 6.0 | 6.0 | 0.9 |
| Total Charge Weight | 25,000.0 | 55.0 | 172.0 | 62.3 | 342.0 | 127.0 | 51.0 |
| Estimated Meltdown Composition | % | 0.22 | 0.69 | 0.25 | 1.40 | 0.50 | 0.20 |

From the above table it is seen that estimated meltdown chromium content is approximately 2.5 fold as more as specified.

In this case the cromuim is element which is subject to be oxidized during oxygen blowing. It is recommended to add into the bath approximately 250.0 kgs of ferrosilicium before lancing. It will contribute the better decarburization condition and will prevent the complete chromium oxidation.

If the chromium content after lancing is less than 0.40% the reduction of it from the slag would be needed.

For this purpose a slag reducing mixture consists of crashed and powdered materials would be used (FeSi, CaCi and coke).

**ANNEX No. 3**

Variant No. 2

**Table 15**

| Scrap No. | Scrap Amount Kg | C Kg | Mn Kg | Si Kg | Cr Kg | Ni Kg | Mo Kg |
|---|---|---|---|---|---|---|---|
| 3 | 9,000.0 | 35.0 | 43.0 | 29.7 | 99.0 | 171.0 | 27.0 |
| Routine Scrap *) | 16,000.0 | 27.0 | 40.0 | 16.0 | 32.0 | 16.0 | 4.8 |
| Total Charge Weight | 25,000.0 | 62.0 | 83.0 | 45.7 | 131.0 | 187.0 | 31.8 |
| Estimated Meltdown Composition % | | 0.25 | 0.33 | 0.18 | 0.52 | 0.75 | 0.13 |
| *) Assumed average routine scrap composition,% | | 0.17 | 0.25 | 0.10 | 0.20 | 0.10 | 0.03 |

The following are expected ferroalloys additions to be made (kg):

**Table 15 (Extension)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fe Mn(75%) | 140.0 | ? *) | 104.0 | | | | |
| FeSi(75%) | 50.0 | | | 37.5 | | | |
| Final Total charge Weight | 25,190.0 | | 187.0 | 37.5 | 131.0 | 187.0 | 31.8 |
| Tapping Analysis | % | | 0.74 | 0.15 | 0.52 | 0.74 | 0.13 |

*) If high carbon FeMn is used it should not be overlooked.

As it may be seen from the above Table 15 Variant No. 2 assumes some deviations from specified chemical composition, namely: Mo - 0.02%, Ni + 0.04%. These are an appropriate figures, but such possibility have to be taken in the mind and to be reconciled with the customer in advance.

SUMMARY

These patterns of charge calculations are given to meet the present conditions of ferroalloys' absence.

If the needed ferroalloys are available all calculations and melting procedure would be alleviated and more reliable.

ANNEX 4

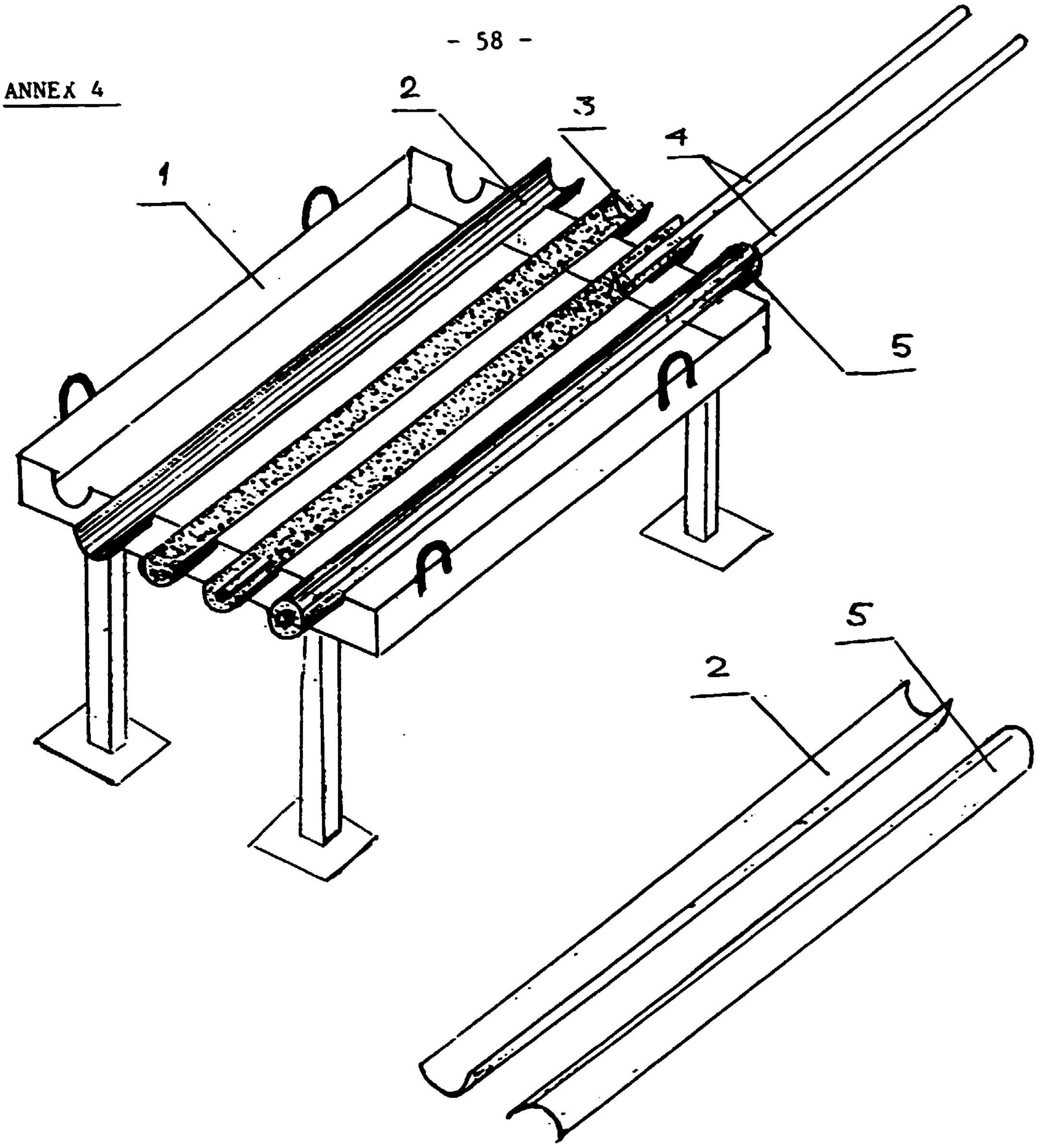



Figure No. 2   The coating of lancing pipes with refractory mix

1. The frame for assembling
2. Lower shaping semi-pipe
3. Refractory mix
4. Lancing pipe
5. Upper shaping semi-pipe

Remarks

1. The paper may be used as a separator between the mix and shaping pipes.
2. After mix drying the shaping pipes are to be removed.

## ANNEX No. 5

The furnace refactory lining state observed after furnace No.2 shut-down for cold repair.

1. Electric Arc Furnace No.2 has been shut-down for cold repair on November 14 1988, after 142 heats.

2. The fig. No. 3 shows the state of refactory lining observed by Author.

3. The following remarkable points are to be noted in this connection :

3.1 The refactory bricks are totally worned out at the walls area located against the phase No.2 approx. 600 mm above the slag level zone by the size of 1 $m^2$, as a result of this the furnace shell was burnt out in this area.

3.2 The similar poor state of lining have been observed in the area beneath the working window and around the tap hole.

3.3 The upper part of the furnace walls was deteriorated to a great extent and there was no refractory protection of the upper shell ring. This was a sequence of poor sealing between the roof and the shell ring.

4. The figs. No. 3 and No.4 shows the state of the bottom lining.

4.1 There was no observation for any signs of banks or steps. And it is not surprizing, as it was clear, that made of magnesite mix in unproper manner, they are being deteriorated totally just after some first heats.

4.2 The thickness of the baked layer was accounted approx. 40 - 50 mm on the perephery area and approx. 80 mm in the central part of the bottom.

4.3 Beneath the baked layer there was a white powder magnesite zone.

4.4 Some magnesite bricks of the subhearth were worned out and lost their strength.

4.5 The baked magnesite layer have been penetrated with steel fins. They are likely to be of a tin or lead .

4.6 Beneath the furnace bottom shell have been found the stalactities of above mentioned metals.

All above said are the results of unproper ramming and sintering of the freshmade magnesite bottom.

To eliminate these demerits the Technical Support Documentation (TSD) on installation of refactory materials should be stricktly observed while ramming.

Undoubtably the sintering conditions are very important for the further behaviour and the life-time of the bottom.

As a rule the first heat should be of high carbon steel grade with low tap temperature . During the melting the current should be periodically switched off for gradual heating of the refactory lining.

As far as walls life-time prolongation is concerned the following steps were taken during this cold repair of No.2 EAF.

The wall area which are subject to accelerate deterioration has been reinforced with additional layer of magnesite bricks by thickness of 75mm on the surface of approx. 1 sq.meter.

As it became clear this measure contributes the longer life-time of this furnace operational campaign, which has been lasted up to 168 heats in comparison with 140 as an average and has been stopped because of furnace roof water cooled ring failure.

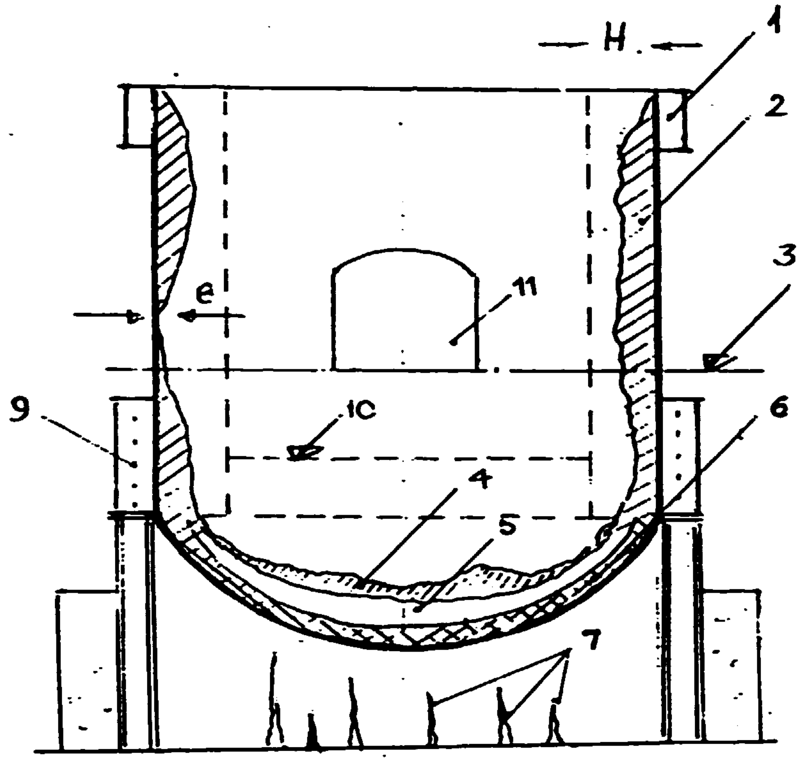



Figure 3 The general view of refractor lining after furnace shut-down for cold repair

1. Furnace-shell water-cooled ring
2. The worked-out walls refractory lining
3. The sill level
4. The baked magnesite layer
5. The white color magnesite powder
6. The 2 layered bricks lining
7. Steel stalactites
8. The burn-out shell zone
9. The toothed tilting cradle
10. The initial level of the bottom rammed lining
11. Working door

H.— The initial thickness of the wall refractory lining

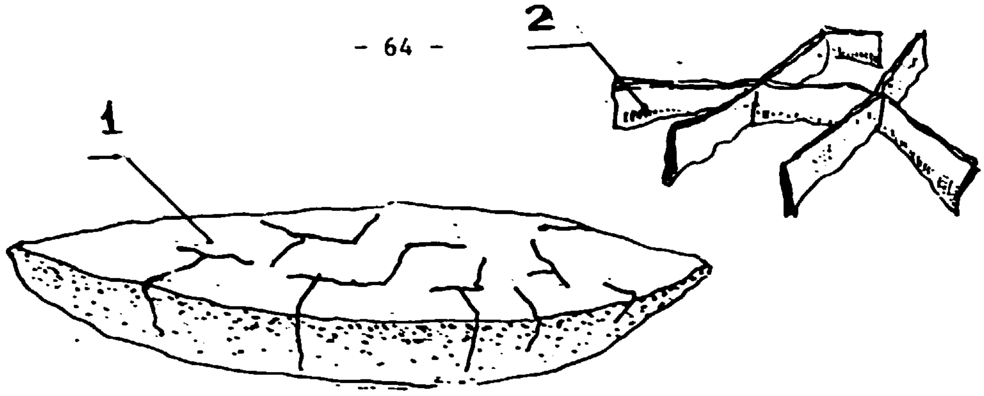



Figure 4 The sketch of the baked magnesite block penetrated with the steel fins:

1. The general view of baked magnesite block
2. The view of extracted steel fins.

**ANNEX No. 6**

The list of documentations handed on to the Steel Melting Shop Management :

1. The drawing of the Electric Arc Furnace refractory brick bottom lining.

2. The list of general preliminary measures to be taken up by the management of SMS which will allow to proceed to the Low Alloy Steel Production Programme (26.10.88)

3. The technological recommendations on the Low Alloy Steel Melting procedure (2.11.88)

4. The technological instruction on the EAF maintenance and scrap preparation (2.11.88)

5. The sketches of steel melting operational tools, including the fettling shovel.

Prepared for the consideration of General Manager of Gecosteel
Mr. Walid Asfar
by UNIDO Expert Mr. Glazkov

**REPORT**

Regarding some technical points which highly affect the present production conditions of S.M.S.

*1. Main equipment*

1.1. Electric Arc Furnaces

The S EAF are working under very difficult conditions, because of absence of any slightest visibility of technical maintenance. The following are the number so of the technical troubles which may be observed during their performance.

1.1.1. Constant leakage of the liquid out of the hydraulic control system which results in unproper functioning of electrodes motion and leads to breakage of them.

1.1.2. Absence of strict control of water cooling of different parts f the furnace constructions leads to shortening the period of their life (e.g. the failure the central part of thereof, deformation of furnace shall ring) and resulting in long idling of furnaces with out put losses (e.g. long idling time of furnace N1 on 21.11.88 as a result of failure of current bar caused by poor cooling of it).

1.1.3. By the reason of absence of water cooled sand seal at the upper shell ring there is no possibility of proper accommodation and sealing of the furnace roof. In turns it prevents to keep the required reduction atmosphere inside the furnace and leads to increase consumption of electrodes as well as electric energy.

1.1.4. The hydraulic tilting devices on the furnaces ar not operate in proper way, the backward tilting is not possible, so there is no possibility to carry out deslagging while melting alloyed steel.
It is also opposed to proper cleaning the furnace bath out of the steel and slag with subsequent fettling the bottom and the banks of the furnace.

1.1.5. In operable instrumentation on the control panel (e.g. - Wattmeter on furnace N2 control desk) doesn't allow carrying out of the efficient heat regime during different periods of melting.

1.2. Continuous casting installation

1.2.1. The absence of complete withdrawal roll sets for two machines doesn't give opportunity to achieve the rated capacity for billet production.

1.2.2. The permanent restaining factor to higher productivity and smooth running of the CC is unreliable operation of the shears.