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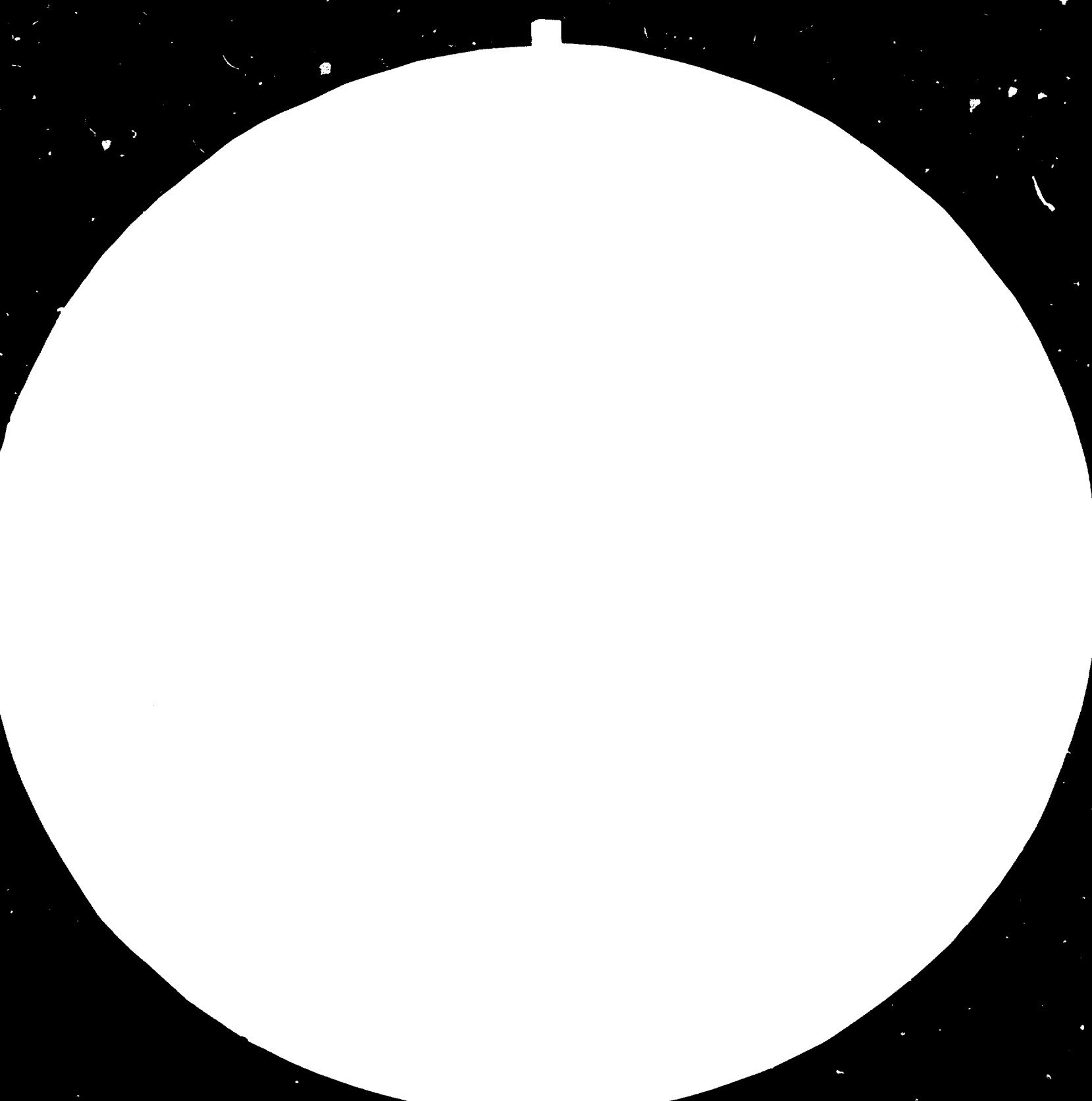
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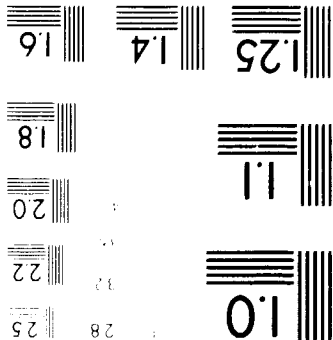
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PROVIDING OF TRAINING AND CONSULTANCY
SERVICES TO THE TURKISH CONTINUOUS
CASTING PLANTS

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Technical report: Turkey.
Visits in the Turkish steel industry
to review working methods of continuous
casting and to prepare a training
programme.

Prepared for the Government of the Republic of
Turkey by the United Nations Industrial Development
Organization, executing agency for the United
Nations Development Programme

Based on the work of Mauri O. Peltonen Training Expert in
continuous casting technology

United Nations Industrial Development Organization
Vienna

This report has not been cleared with the United Nations
Industrial Development Organization which does not, therefore,
necessarily share the views presented.

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I. INTROCUCTION

The steel industry in Turkey is surprisingly young. It was at the instigation of Atatürk that the first state-owned steelworks was built at Karabük in Anatolia in the late 1930s and more than 20 years were to pass before any private companies entered steelmaking.

It is same thing with continuous casting of steel, although the start-up of Turkey's first continuous caster, a 2-strand concast billet machine happened relatively early 1964. To a great extent the continuous casting technology was introduced about 7 - 8 years ago, and therefore many problems in this field remain to be solved. Problems arise mostly from refractories, the caster itself, maintenance and from the lack of knowledge and experience.

The Industrial Training and Development Centre (ITDC=SEGEM) is a joint project of Turkish Government and the United Nations which provides training and consultancy services to the industrial sector.

Mr Türker Aykal from SEGEM had prepared a programme to visit practically all steelworks with continuous casting and some rolling mills, which are planning continuous casting. A four days continuous casting seminar in Istanbul was planned too.

The undersigned was prepared to give a course to engineers, foremen and key workers about continuous casting.

Material for the course was prepared more than enough. Unfortunately a great part of material was in Swedish. Before the plant visits and seminar it was reserved a week in Ankara to prepare overhead films and other material in English.

The visits to different plants was planned so, that the main part of time was used for discussions and for visits to steelplants itself. About 30 % of time was used for different seminars in most of steelworks.

Before the round trip many papers and reports were copied by SEGEM in Ankara, because the undersigned had over 50 kg papers and reports, the main part of copy works were made in the steel plants we visited.

II. TECHNICAL REPORT: VISITS IN THE TURKISH STEEL INDUSTRY
TO REVIEW WORKING METHODS OF CONTINUOUS CASTING AND
TO PREPARE A TRAINING PROGRAMME

1. Iskenderun Demir Celik Fabrikalari (7 - 10.6.-84)

Iskenderun Demir Cel'k is a state own integrated steelworks near the town of Iskenderun on the Mediterranean sea. Production was started 6 - 7 years ago. Steelworks is planned and built by Russians in two different steps. Production capacity of the first step was 1 mil. tpy. and the capacity of the second step 2,2 mil. tonnes. It should be mentioned, that commissioning of these second step is now proceeding.

The whole production rate of the first step is not yet reached, but the production has been increased recently. The production mainly consists of unalloyed low carbon steels like st37, st50, and st34.

1.1 Steelmaking

For steelmaking there are 3 blast furnaces, 2 x 1300 tonnes mixers and 3 x 130 tonnes LD-converters.

1.2 Continuous casting

1.2.1

During the first step of steelworks building, three vertical bloom casters were procured. Two different sizes were cast (ϕ 260 mm and 260 x 340 mm) with average casting speed 0,6 m/min. The casting floor of these machines is 24 m over the ground level, and lower part in the pit so, that the whole height of the machines is 42 m. Although the time to get familiar with these machines was very short, the following can be said:

- a. The machines are equipped with two separate tundishes, which naturally demands two stopper systems in the ladle and consumption of refractory materials will be higher. It should be mentioned, that four strand bloom casters are not normally equipped with two tundishes.
- b. The number of sequence castings is normally 2 - 3, and the changing time of the ladle is long (~ 10 min).
- c. Cutting of blooms are performed with mechanical shears, which must be maintained fairly often. The life of the cutting knives were, from the very beginning very low, but afterwards a certain improvement has been reached with the aid of deposition welding, but the situation is not yet satisfactory. In OVAKO-steelworks in Finland it was possible to make 80.000 cuttings (ϕ 100 mm) with cutting blades made from MOC 210 steel and deposition welded with special

electrodes (Heines Alloy 273 earlier and now Metalloy C from Company Metallogen in West Germany).

- d. The length of the mould is 1 m, which is very high according to the opinion of the most machine builders. We must remember that with high casting speeds a long mould is good and in case of low casting speeds a short mould is better. It depends on the air gap formation between the solidified strand and the mould wall. The internal surface of the mould is not chromiumplated. The moulds were built from two U-shaped pieces, and the inside of the mould was wavy in the longitudinal direction to get more stable solidified steel shell in the mould. How much this kind of mould shape improves the steadiness of the steel shell, no figures were available, but at least no deteriorating effects were found. The corner radius of the moulds was fairly big ($r = 20$ mm).
- e. The quality of the blooms was mostly satisfactory or good although longitudinal corner cracks or slag defects on the bloom surface were present.
- f. Instead of casting powder, carbon powder was used for mould lubrication. Carbon powder is naturally a good lubricant, but can not fulfil all functions of a good casting powder. These functions are generally as follows:
- * thermal insulation of the steel meniscus
 - * protection of the metal against oxidation
 - * absorption of inclusions rising to the surface of the liquid steel (carbon powder can not perform this function)
 - * lubrication and transfer of heat between the solidified steel shell and the mould wall. Molten slag creates a thin layer between the mould wall and the steel shell. This layer has the following functions:
 - lubricant between the mould and steel shell
 - fills up the air gap between the mould and steel shell (an air gap does not form before the temperature of the surface of the shell is $\sim 1340^{\circ}\text{C}$)
 - makes the heat transfer and growth of crystallization front more even
 - prevents the direct contact between the mould and steel shell

It was told me that in the near future different kinds of casting powders will be tested.

1.2.2

During the second step of building, three new and modern bloom casters of s-type have been erected. Two of them are casting sizes 260 mm and 260 x 340 mm and one only the size 200 mm. During our visit only one of these machines was in normal production and the other two in commissioning.

General Technical Data of these continuous casting installations are following:

Type of machine	arc type machine
Casting radius	12 m
Number of strands	3 x 4
Overall height above floor approx.	13 m
Cast sizes	260 mm, 260 x 360 mm, and 1 machine 200 mm
Cutting equipment	hydraulic shears
Casting ladle	130 tonnes
Dummy bar	solid dummy bar

Solid dummy bar is very unusual in case of the big bloom casters. Some of billet casters are using this system successfully (Rokopp).

Problems may occur if the foot rolls below the mould have been assembled with a close fit. Following can be said about these machines:

- a. Contrary to the vertical machines these new machines are equipped only with one tundish, which is fairly deep (height of the steel level approx. 900 mm), which facilitates flotation of slag from steel. I was told that sometimes it was necessary to hold a low steel level in the tundish because some problems with stoppers, and so this benefit was lost. Monoblock tundish stoppers were used. The original stopper mechanism had caused many problems. Therefore it was in many tundishes substituted with a new better mechanism.

Between tundish and mould a normal Al_2O_3 + grafit immersion nozzle with two downward outlets was used. Inclination of outlets was $\sim 15 - 20^\circ$.

Tundish lining was made from bricks and before casting the bricks were coated with ramming mass of magnesite basis. Cold tundish lining has not yet been used.

- b. Many problems with moulds have occurred and still many unsolved problems are there. Normal plate moulds with skewed corners were used. Water canals were drilled inside the mould plates. I was told that the radius of mould plates was not always right, and after few castings the mould plates have moved, so that a possible tapering of the mould walls was disappeared. The stroke of the mould movement was 13 mm. It is possible to use much shorter stroke, in which case the depth of oscillation marks will decrease. Because a low casting speed it is possible to

increase oscillation frequency. By increasing oscillation frequency, transverse corner cracks on 0.1 % carbon steel blooms can be successfully minimized along with the depth of oscillation marks.

The mould length is 1 m like in the case of the vertical machines. Max. casting speed of the new machines has been 0.9 m/min, but normal casting speed has been only 0.7 m/min, and so the mould length of 1 m probably is too much.

c. There was no bigger bulging of bloom walls present, but many blooms had a light rhombic shape. On many blooms there were longitudinal corner cracks and big slag defects present. These defects are naturally depending on the use of carbon powder as mould lubricant. Longitudinal corner cracks can have many different causes:

- bad cooling condition in the mould corners (deformations, too big corner radius etc.)
- bad alignment between the mould and foot rolls or roller apron
- uneven mould cooling

1.3 Continuous casting seminar

During three days (4 - 5 hours/day) a continuous casting seminar was held. In average there were 25 participants in these seminars. Mr Türker Ayk 1 and Mr Tuncer Cakici were as interpreters.

The following main topics were dealt with:

- primary cooling (mould cooling)
- surface and internal defects of continuously cast billets and their effects on rolled products
- inspection and conditioning of CC-billets, blooms and slabs
- maintenance of continuous casting machines
- different metallurgical actions, which are possible to make during casting operation

1.4 Technical reports and papers concerning continuous casting

Because Iskenderun Demir Celik has not very much technical papers about continuous casting, I also handed over several technical reports and papers concerning steelmaking and continuous casting mostly in English language and some in German. Iskenderun Demir Celik has taken copies of them. All papers were not possible to copy, because the undersigned received the main part of papers one day before we left.

Iskenderun. SEGEM promised to copy some papers in Ankara and send to Iskenderun and I shall send some other papers from Sweden.

1.5 Recommendations

a. Moulds

Because the mould is the most important part of the casting machine, attention must be paid to its control and maintenance. First it is important to buy some instruments for mould profile control, control of mould movements and maybe friction control. Information concerning these instruments will be sent by the undersigned.

When all imperfections concerning moulds, mould tables and mould reciprocation systems are revealed, the necessary construction changes must be made, in case it is easily possible.

b.

Using of casting powder must be performed as soon as possible. Literature concerning using of casting powders has been handed over and some more papers will be sent by undersigned.

c.

Assembling of foot rollers and guides below the mould and the upper rollers in the secondary cooling roller apron must be controlled accurately by means of proper instruments.

d.

Attention must be paid to maintaining the right casting temperature. All instruments for temperature measurement must be held in good condition.

Whenever casting temperature is mentioned it normally means tundish temperature in connection with continuous casting. This temperature is slightly higher than the temperature of the casting stream into the mould. The casting temperature should be high enough to allow troublefree starting and finishing of casting. For a proper quality and operation need, the casting is to be done at as a low temperature as far as possible. As a golden rule, the difference of temperatures of deoxidized steel in ladle and solidifying steel in the mould should be minimum.

The following are the important disadvantages of high steel temperatures:

- Internal and surface cracks will increase.
- Central porosity and segregation of alloy elements in steel will increase.
- Consumption of refractory material increases at each step.

- Breakout rate increases and repair of breakouts becomes more difficult.

e.

Protection of casting stream between ladle and tundish is important in casting of more demanding steel grades.

f.

Mould cooling water circulation is not completely closed and therefore it is possible, that some solids can stick in the water canals of the mould. This kind of deposits has been found sometimes. During maintenance of the moulds attention must be paid to prevent foreign materials from entering into water canals.

Some slag pieces has been found in water canals but not normally lime deposits. Mould life is varying between 100 - 180 castings and 4 - 5 machinings are possible. The low number of remachinings depends on the construction of mould plates (water canals in the plates).

g.

One of the most important things is to organize an effective schooling system for the personnel of different categories.

h.

Finally the undersigned must say, that the time available was too short to become familiar with all functions of these machines. Generally speaking it can be said, that the construction of the new S-machines was proper and steady. To make a complete analysis demands much time with different measurements and trials.

2. Metas Izmir Metalurji Fabrikasi T.A.S.

Metas Izmir is one of the oldest steel makers in Turkey. When steel production began in 1960, the works was equipped with one 10-tonne electric arc furnace with a capacity of 20.000 tpy. Three years later a 15-tonne electric arc furnace was installed and 1964 started up the first continuous caster in Turkey, a 2-strand Concast billet machine. The first continuous caster produced billets 100 mm.

Today Metas Izmir has for steelmaking 2 x (35 - 45) tonnes electric arc furnaces (20 KVA each). Both furnaces are equipped with water cooled panels and roofs. It is possible to make daily 30 - 32 charges, which is a good production. Yearly production has been 280.000 tonnes, but production over 300.000 tonnes is possible.

About produced steel grades we can say following:

30 %	reinforced concrete steels
30 %	low carbon and low silicon steels
10 %	construction steels
30 %	spring steels, wire ropes etc.

For continuous casting they have two 3-strand Demag machines extended the maximum size possible to 220 mm, although in practice sizes 100 and 160 mm are cast. Production capacity of these machines is 320.000 tonnes/year.

2.1 Continuous casting problems

Production in Metas Izmir is going very well compared with other similar plants. About casting disturbances it should be mentioned break out rate.

Ø 100	0.8 - 1.5 %
Ø 160	0.5 - 3.0 %

These figures are satisfactory.

The biggest quality problem was longitudinal corner cracks on Ø 160 mm billets. The problem was bigger in case of medium carbon steels, when casting speed exceeded 1,4 m/min. The main reason of these defects is bad cooling conditions in the mould corners (deformations, too big corner radius).

2.2 A short CC-seminar for 8 - 9 persons was held during the second visit day. The main topic was different defects in CC-billets.

2.3 Recommendations

a. It is important to buy some instruments for mould profile control, control of mould movement and maybe mould friction control. Information concerning these instruments will be

sent by the undersigned.

- b. It is recommended to make trials with mould with smaller corner radius (4 - 6 mm).
- c. Some other reports with recommendations concerning this kind of defects will be sent by undersigned.

3. Cukurova Celik Endüstrisi A.S.

Cukurova Celik Endüstrisi began steel production in the very beginning of 1982 at its works at Aliaga, some 60 km north of Izmir. For steelmaking they have two Brown Boveri electric arc furnaces of 75 tonnes nominal capacity, and 36 MVA rated transformer capacity. Tap to tap time is in average 120 min. For casting they have available two 4-strand concast continuous billet casters which can cast sizes 100 - 150 mm. Bending radius of the machines is 6 m and casting time 80 - 90 min.

The function of continuous casting machines itself has been troublefree, but they have had many problems with the hydraulic turn over cooling beds made by Concast Iberica. The max. billet length is 12 m. They have often had problems with the start of casting, because all alloy elements are added into the ladle before tapping, and therefore the first steel from the ladle is cold. It should be mentioned that they had no gas stirring in ladle available. After starting of casting steel temperature was often too high. During my visit tundish temperature 1575 C was measured, which is 50 - 60°C over liquidus. Breakout rate was fairly high ~5 %. A high casting temperature is one of the main causes of breakouts.

A high copper and sulphur content of steel resulted in sometimes large transversal cracks on the billets. Because of longitudinal corner crack they had no problems at all.

It should be mentioned following details about operation practice

- Mould cooling water system is not closed and therefore sometimes problems occur because of dirty water. At the moment there is no dust collecting system in steel work, and so dust can come to connection with mould cooling water. After few months a new dust collection system for electric arc furnaces will be started.
- After 40 castings moulds are dismantled, cleaned and control measured.
- Because of construction of concast machines it is possible to make some maintenance actions during casting too.
- No problems because of rhombic shape of billets were reported.

About 350 persons were working in the steelworks and 15 out of them were engineers. Mostly simple plain carbon steels

were produced ($C = .05 - .30 \%$).
Steel production has increased as follows:

<u>year</u>	<u>production/year</u>
1982	18.700 tonnes
1983	307.000 "
1984	~350.000 "

which means that the nominal capacity tpy. has been exceeded.
A good deal of steel production is exported to Egypt, Libya and Nigeria.

It should be mentioned that new rolling mills will be installed in the near future. The production of the rolling mills will be 250.000 tonne/year flats and rounds. There are plans too: to install two 75 tonnes electric arc furnaces and two continuous casting plants more.

Lot of technical papers and reports were handed over and Cukurova has taken copies of them. Some other papers will be sent afterwards from Sweden.

3.1 Recommendations

- a. Some kind of desulphuration possibilities must be available. Later, if more demanding steel grades will be cast, ladle injection is recommended.
- b. Quality of mould cooling water must be controlled. In the future a closed mould cooling water system is recommended (new machines).
- c. Measuring instruments for mould controll is recommended. Information about some instruments will be sent later by the undersigned.
- d. Maintenance of tundish temperature during casting is very important. Gas stirring in the ladle has a beneficial effect on the tundish temperature. Every continuous casting plant today must have some kind of ladle rinsing system. In case of Cukurova gas stirring is very important, because alloy elements are put on the bottom of the ladle before tapping.

4. Izmir Demir Celik Sanayi A.S.

Izmir Demir Celik Sanayi A.S. (IDC), which already has a bar and rod mill and section mill near Izmir. The present production consists of rod \emptyset 8 mm - \emptyset 20 mm, L 60 - 100 mm, T-beams S 80 - 140 mm and channels 65 - 140 mm. In the near future IDC is currently installing melting plant and expects to begin steelmaking in end of 1985. They will install two 50-tonnes electric arc furnaces and two 4-strand continuous billet casters as well as expanding its section mill to 300.000 tpy. Billet sizes will be 100 - 130 mm. A possibility to use only one 5 - 6 strand CC-machine has been considered too. Tap to tap time will be around 80 min.

Steelworks will be built in two etaps. The first etap consists of one electric arc furnace and one continuous casting machine.

Three different layouts has been prepared. The main discussions dealt with layouts and different builders of continuous casting machines. A lot of technical papers and reports concerning continuous casting were copied by IDC.

5. Eregli Demir ve Celik Fabrikalari T.A.S.

Turkey's only other integrated steelworks is at Eregli on the Black Sea coast and roughly equidistant from Istanbul and Ankara. The steelworks was built originally by the private sector it is now government-controlled, although private interest continue to have a substantial holding in the company. Construction of Eregli steelworks began in April 1961 and it came on stream in 1965, with a capacity of 450.000 tpy. This has since more than doubled and the company's current phase 2 expansion project should raise raw steel capacity to 2 m tpy and rolled steel capacity to 1.5 m tpy by 1984 - 85. Currently Erdemir is a steel manufacturing complex comprising of an harbour, raw material manipulation facilities, two coke plants, two blast furnaces, a three furnace B.O.F. steel making shop, two concast continuous casting machines, hot and cold rolling mills. Principal products of the plant are plate, hot and cold rolled sheets and tin plate.

Erdemir is the only flat product supplier for the turkish market, and is at present capable of meeting about 45 % of the domestic marked demand.

5.1 Steelmaking

The liquid steel is supplied from 2/3 x 90 tonnes L.D. Converter transferred in 90 ton ladle by a 125 ton crane to the two-stand rinsing station, which is equipped with: two rinsing stands, hoists for immersing slabs, argon or nitrogen blowing lances, Al-wire feeding device and auxiliary equipment. After rinsing the ladles are transferred by two electrically driven transfer cars which are equipped with turntables to compensate for the 90° difference of the E.O.T. crane gantries between the steel shop and the caster.

In the ladle bay of the casters the liquid steel arrives on a transfer car, there is one 150/30T. overhead crane. Also in this area are the slag pots and emergency ladles for each machine and an emergency teeming platform for teeming the ladles of interrupted casts.

5.2 Continuous casting machines

Both machines are of single strand concast-s-type with a radius of 9.8 meters and are designed to cast sections:

machine No. 1 850 - 1300 x 200 mm

machine No. 2 1000 - 1600 x 200 mm

More accurate specifications of the machines are summarized in the appendices 1 - 2.

Concerning the machines and operation of the machines following can be said:

- a. The tundish preparation area is located between the casting platform of the two casters. The whole platform is serviced by two overhead cranes. The both machines are also equipped with ladle turrets and two tundish cars for each machines.
- b. All ladles are equipped with Flocon 6300 -type slidegate mechanisms with paralld wall-block system. For the present teeming rate: 57 mm. I.D. inner nozzle 50 mm I.D. extended collector nozzle type gate valve set combination was found to be the optimum considering the wear of slide gate plates due to unavoidable throttling.

Stream protection between ladle and tundish is not yet performed in normal practice, but trials has been made by using ceramic tubes.

- c. Tundishes are relatively small (7 tonnes) and steel depth in the tundish during casting is ~ 800 mm. Tundishes are equipped with stopper mechanism and monoblock stoppers are used. Depending on steel quality to be cast fused silica or Al_2O_3 +grafit immersion nozzles with two downward outlets were used. Inclination of outlets was ~15 - 20.
- d. During operation the mould taper and mould top zone alignment is controlled at every other 15 heats. Radial taper of wide faces is not allowed to exceed -0.3 mm. Generally moulds are changed when the wide faces becomes parallel. This requires remachining of the mould after every 100 - 120 heats due to the wear. By now, with 10 to 12 remachining it has been possible to make 1600 heats per wide face on CU-plate and about 1200 heats per narrow face. For the mould narrow side taper, since the nominal casting speed was around 1.0 m/min., the nominal taper selected as 1 %/m and for shrinkage a factor 0.015 applied to calculate the proper mould width.

- e. Every month two roller apron segments per machine are sent to the central machine shop for refurbishing. The total life of 200 \emptyset mm and 245 \emptyset mm (16 CrMo 44) segment rolls after several remachinings are around 5000 to 6000 heats. The life of 180 \emptyset mm top zone rolls (16 CrMo 44) are around 2300 heats.
- f. The production of crude steel is about 1.3 mil. tpy, and around 60 - 65 % is continuously cast. Appendices 3 - 5 show how production of CC-steel has increased.
- g. Concerning casting parameters following should be mentioned: According to the section size of the slab to be cast, the casting speed varies in the range of 0.9 to 1.3 m/min.

Oscillation:

Since start up, the machine No. 1 has run with an oscillation stroke of 8.5 mm and 30 % negative strip. At machine No. 2 they are 7.0 mm and 40 %. No major problem was observed from the point of oscillation marks hence no attempt has been made to change to these parameters.

The total amount of secondary cooling water: 1.0 lt water/kg steel for 1.0 m/min casting speed 1.20 water/kg steel for 1.2 m/min casting speed.

h. Sequence castings

After the slidegate system became available, making long sequences was possible. Currently average number of ladles emptied in sequence is five. During long sequences flying tundish changes are made after every four successive casts. Starting with the fifth cast, wear on tundish refractories becomes excessive and for that reason it is decided not to make more than four casts in a tundish.

It should be mentioned that the longest sequence casting was made in machine No. 1. 32 heats were cast within 28 hours and 10 minutes, yielding 2807 tonnes of 1035 x 200 mm slabs. Totally 1. flying tundish was made to empty the 32 ladles.

i. Steel grades

In five-year-operation 29 grades were developed to cast in the caster (appendix 6). Being made all the preparations for casting aluminum killed grades upon completion of the aluminum wire feeding device, it was decided to cast tinplate and A.K. grades.

Product line now covers

- * cold rolled coils
- * Hot rolled sheet and coils
- * tinplate (under trial)
- * ship building and structural steels
- * pipe and general constructional qualities

j. Slab defects

Longitudinal cracks on the wide face of the slab are found either as a shallow crack or in context with a longitudinal depression. These cracks are found at the middle of the wide face and removed generally with a light scarfing. Cracks that are in context with the surface depression are deeper and requires medium conditioning. Casts with sulphur levels over .025 % have a greater tendency to longitudinal cracking.

Subsurface blowholes are the second common slab defect. It is rather difficult to notice the blowholes from the surface but they are visible at the cross section. Blow holes are found 2 - 3 mm below the surface and requires 100 % scarfing and are directly associated with underdioxidized steel.

Slag deposits and slag entrapment also observed from time to time.

5.3

A short continuous casting seminar where some new developments for continuous casting were dealt with. Following topics were discussed:

- a. Electromagnetic stirring
- b. Control of slabs quality on discharge roller table (very important in case of hot charging of slabs)
- c. Air mistcooling
- d. Automatic mould level control (± 5 mm max fluctuation)
 - control with radioactive isotope
 - eddy current mould level control
 - methods using infra red or normal light
 - electro magnetic methods (for instance ALCEM)
- e. Electromagnetic brake
- f. Oscillation pattern recorder of slab moulds
- g. Automatic powder feeding equipments
- h. ML-Tektor (friction detector) can indicate poor surface quality
- i. Breakout detectors (based on measurements of friction, acceleration, tension, temperature and hear extraction from the mould)
- j. Automatic casting control
- k. Computerized quality control is based on following data:
 - analysis
 - sulphur content
 - aluminum addition etc.
 - casting powder
 - mould taper
 - runout of rollers

- temperature trajectories
- cooling
- casting speed

There were around 20 participants in the seminar.

5.4

Many technical papers and reports were copied by Erdemir. The undersigned promised to send from Sweden some additional papers from following topics:

- Al-wire feeding
- maintenance
- automatic mould level control
- casting of tinplate and oil pipe steels (A.P.I. -qualities 52 - 60)

5.5 Recommendations

- a. Automatic mould level control must be procured as soon as possible.
- b. When more demanding qualities will be taken in production programme, ladle injection station and later on maybe ladle furnace are recommendable.
- c. When new steel qualities for high quality applications are taken in production programme more resources for research and development work is needed.
- d. Stream protection between ladle and tundish and argon blowing through the tundish stoppers must be taken in normal casting practice as soon as possible.

5.6 Some general comments

It was a pleasure for us to visit Erdemir and see the enthusiasm of the personnel to find new solutions to increase the production and improve the quality of steel. The production figures are comparable with good European steel works. The further improvement of quality and taking new more demanding steel grades in production programme presuppose naturally besides the skill and enthusiasm of personnel, implementation of new methods and equipments.

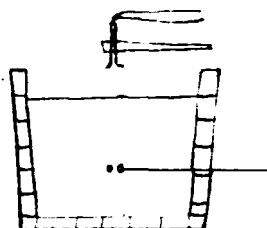
5.7 References

1. Operational results. maintenance and quality control of the two casters at Erdemir Steelworks
I Öztürk, Köserreisöglu, Cıkic. Erdemir Steelworks Eregli, Turkey
This paper is presented in 7th Concast Technology Convention 1984
2. Steel: A symbol for modern Turkey
Metal Bulletin July 1983

6. Kroman Celik Sanayii A.S. Gebze

Kroman Celik is a small steelworks in Gebze near by Istanbul. For steelmaking they have 2 x 15 electric arc furnaces (5 MVA), and for casting one 3-strand CC-machine from Continua. Production consists of different kind of ordinary steels, construction steels, spring steels and low alloy steels. They have cast steels with analysis C .06 %, Si .06 % and Mn 0,2 %, but some casting problems have occurred. The main part of the production is cast to ϕ 100 mm billets but size ϕ 120 mm belongs to production programme too. Breakout rate was 2 - 3 %, which is perhaps a little bit over normal value in billet casting. Casting time is 30 min, and casting speed 3 m/min for ϕ 100 mm and 2 m/min ϕ 120 mm. Production rate today is in average 5.400 tonnes/month.

Steel is normally deoxidized in the furnace, but they have made trials with ladle injection. They have built injection station with powder dispenser and lance itself.



The lance is pushed against the ladle bottom so that it is stable during powder (casi) injection. They have made this lance from high alumina refractory mass. Injection itself has gone well, but the metallurgical results have not yet been evaluated.

Cold tundish lining has been used and they are making cold tiles itself. These tiles last very well the short casting time. Mould length is 780 mm and time to time they have had problems with the quality of mould tubes, but at the moment situation is satisfactory. Originally they had foot rolls below the mould but now they are removed, like many rollers from secondary cooling roller apron, where some other modifications have been made too.

No bigger quality problems of billets were reported. Sometimes ϕ 120 mm billets were showing rhombic shape.

The most problems were discussed and lot of technical papers and reports were copied.

6.1 Recommendations

1. Measuring instruments for mould control was recommended. Information about some instruments will be sent later by the undersigned.

2. In case of more demanding steel grades some kind of rolls or guides below the mould can be considered.

7. Colakoglu Metalurji A.S.

The largest private sector steelmaker in Turkey is Colakoglu Metalurji A.S., which has a raw steel capacity of 350.000 tpy. Mehmet Colakoglu, founder of the firm, set up a rolling mill to produce wire rod from imported billets in 1958 and started the present company as a bar rolling operation in 1969. Steelmaking at its Koecaeli works, which is in Asia but not far from Istanbul, began five years later and capacity was increased from an initial 30.000 tpy.

The works now has four 30 tonne electric arc furnaces and two concast 4-strand continuous billet casters; a bar and rod mill is being installed. Capacity of the mill is to be expanded to match steelmaking within about two and a half years. Other modernisation measures include the installation of water-cooled panels on the arc furnace.

7.1 Steelmaking

For steelmaking there are four 4 Tagliaferri furnaces 1 x 12 MVA and 3 x 13 MVA. All furnaces have been equipped with water-cooled panels and water-cooled roof. One of the furnaces has been equipped with oxy-fuel burners. Tap to tap time without oxy-fuel burners is 3 hours and with burners 2 hours 15 minutes. Consumption of electricity without burners is in average 580 kWh/ton and with burners 460 kWh/ton.

They have a Scandinavian Lancer ladle injection station, but at the moment they are not using injection because temperature loss is too high. With cast-injection it is possible to use higher Al-content in steel without problems with blocking of tundish nozzles. (Al^{sol} .25 - .30 %) if casting streams are protected and basic^{sol} ladle- and tundish lining is used. At present Colakoglu is making trials with basic ladle material. Dolomite and magnesitelinings have been tested, but with magnesite lining the ladle bottom has broken very soon. In case of dolomite lining steel has often penetrated between the bricks. Using of tar dolomite gives a better result, but the problem is not completely solved. The examination using magnesite walls and alumina bottom is now proceeding.

I was told that if high alumina lining is used they have blocking problems with normal Al^{sol} contents in steel, but in case of using shamot lining no blocking of tundish nozzles has occurred. It should be mentioned that they are using turkish high alumina bricks. The problem is maybe something to do with the quality of the bricks. Life of chamot lining is only 10 - 12 charges.

7.2 Continuous casting machines

Concerning continuous casting following should be mentioned:

- a. Problems with steel temperatures have often occurred. (appendix 7 "Investigation of steel temperature in ladle and tundish by Gecosteel")
- b. Surface quality of billets was mostly good, but if sulphur content was high cracks near the cutting faces of billets were reported. Sometimes there were deep oscillation marks on the billet surface.
- c. Stroke of mould oscillation was fairly long, 17 mm.
- d. They are planning the use of cold tundish tiles in the near future.
- e. They have no Al-wire feeding into mould.
- f. Foot rollers under the moulds are used.
- g. Here the personnel had the same enthusiasm as in Erdemir to find new solutions to problems.

7.3 Recommendations

- a. Concerning casting temperature it is recommended to make many trials (appendix 7).
- b. Measuring instruments for mould control were recommended. Information about some instruments will be sent by the undersigned.
- c. To reduce the depth of oscillation marks, a shorter stroke (12 - 14 mm) is recommended.
- d. In the future if more demanding steel qualities is produced, it is recommended to procure Al-wire feeding in to mould and some kind of stream shrouding between tundish and ladle.

8. Istanbul Celik ve Demir Izabe Sanayii A.S.

Istanbul Demir Celik ve Demir Izabe Sanayii A.S. (Icdas), started as rerollers in 1964, and set up in 1973 to produce billets for Karemir the rebar producer, also owned by the Arslan family. Icdas's billet capacity remains below the 150.000 tpy. capacity of Karemir's bar mill, but there are plans to expend steelmaking capacity with some improvements.

8.1 Steelmaking

For steelmaking there are available one 25 tonne electric arc furnace (15 MVA) and another 10 tonne (5MVA) furnace. There are plans to install water-cooled panels to the 25 tonne furnace and increase the effect from 15 MVA - 22 MVA. Last year 70.000 tonne of steel was produced. Main part of the production consist of steel grade st37. At present 6 - 9 charges are made daily.

8.2 Continuous casting

Steel is cast with a 4-strand concast billet caster. Billet size is normally ϕ 100 mm but ϕ 120 mm is possible to cast. Breakout rate is relatively low \sim 1 % and all disturbances, which have stopped casting are 2 - 5 %. They are not making sequence castings and therefore they have now bigger problems because of the relatively small tundish size. Mould life was 250 castings, which is at least satisfactory.

Billet quality was mostly good enough for reinforcement bars, but in some cases there were near the cutting faces transversal cracks because of too high S-content. Net cracking, which is mostly depending on a high copper content, appeared only in few cases.

8.3 Technical papers and reports

Many technical papers and reports were copied by Icdas. The undersigned promised to send some information concerning the use of oxygen in steelmaking and instruments for mould profile measurements.

Cold tundish lining was used and the cold tiles were made by Icdas.

8.4 Recommendations

1. Instruments for mould profile measurements is recommended.

9. Ekinciler Iron and steel works

Ekinciler has in Karabük a rolling mill (capacity 50.000 tpy.) and another bigger rolling mill in Iskenderun (capacity 300.000 tpy.), sizes \emptyset 8 - 20 mm are rolled. At present all billets must be bought, but now a new steelwork will be built. Production of the new steelwork will be 300.000 tpy. For steelmaking one 70 tonne electric arc furnace with 45 MVA transformer capacity has been planned. The furnace will be equipped with water-cooled panels, and with three oxy-fuel burners. As an alternative they have 2 x 50 tonne arc furnaces. Continuous casting machine will be 5-strand billet caster. Because of a short visit time we had not so much time for discussions, but many technical papers and reports were copied. Some more information will be sent by the undersigned from Sweden.

10. Asil Celik Sanayi ve Ticaret A.S.

Unfortunately we had no possibility to visit Asil Celik, but during the continuous casting seminar in Istanbul we had an opportunity to discuss with many representants of Asil Celik.

Construction work started in January 1977, and was completed in September 1979. The project was realized through international cooperation. Thyssen Edelstahlwerke provided process technology and production knowhow, IHI, the main equipment and Kaiser Engineers Consultancy services.

Today, consideration is being given for further expansion of the existing facilities and improved throughput, in order to secure a strong position in the world market for high grade and alloy steels.

The company is operating at a loss, but this is attributed to the state of the market and it expects to begin making a profit when conditions improve.

Asil Celik has two electric arc furnaces, one of 15 tonnes and another of 45 tonnes, and an RH-vacuum degassing unit. There are no continuous casters. All semis are rolled on a 820 mm blooming mill or a 750 mm billet mill, which is also used to produce large-diameter bars. Sections and bars of smaller diameter are rolled on a 4-strand medium section and bar mill. The company produces engineering, free-cutting, spring, ball bearing and tool steels and offers them for sale as ingot, semis or rolled products.

Rolled steel capacity is currently some 210.000 tpy., about 100.000 tpy. greater than melting capacity, but the company has plans to increase steelmaking to bring it into balance. At the same time continuous casting will be introduced, although the ingot route will continue to be used for certain grades a certain time. A further expansion plant could extend the product range and with the commissioning of a new section mill, smaller sizes will be reproduced.

The special steels produced by ASIL CELIK are consumed in Turkey primarily in the following fields:

- Automotive Industry
- Forging Industry
- Spring Industry
- Machinery and Equipment Industry
- Mechanical Component Industry
- Welding Electrode Industry
- Bolts and Nuts Industry
- Prestressed Concrete Wire Industry
- Wire and Wire Rope Industry
- Motor and Engine Industry
- Defence Industry
- Agricultural Machinery Industry

Appendix 8 is showing main grades of steel and appendix 9 dimensions range of products.

10.1 Discussions concerning continuous castings

Discussions with:

Ergun ONUR	Manager Metallurgy Dept.
Yavuz SAATCI	Manager Rolling Mills

We discussed mainly about different types of continuous casting machines available for special steels and steel ranges which are possible to cast continuously. Many technical papers and reports were copied also in the office of Asil Celik in Istanbul. Some other papers will be sent by the undersigned later on from Sweden.

11.1 Continuous casting seminar in Istanbul 30.5 - 2.6.1994

Seminar was held in a lecture room belonging to Cukurova group. All practical arrangements were made by SEGEM. During the seminar a half day's visit was made to Kroman Celik and Colakoglu Metalurji A.S. The programme of seminar followed a continuous casting course made by the undersigned (appendix 10). Unfortunately we had not enough time to go through the whole programme, so that the following parts were not dealt with:

- part 5 (operation technics for continuous casting)
- part 7 (maintenance of continuous casting machines and inspection and conditioning of continuously cast billets, blooms and slabs)

It should be mentioned that part 7b was translated in English, copied and handed to all participants. Part 7a was translated too and handed for copying to some participants (maintenance people). There were 24 participants in the seminar and everybody was showing a great interest and many questions were made. Some other continuous casting reports were copied by SEGEM and they were handed to the participants.

III. CONCLUSION

In this report a trip to turkish steelworks with continuous casting has been dealt with. In Istanbul a continuous casting seminar was held (30.5. - 2.6.1984) for 24 participants from turkish steel industry and highschoools. In connection with works visits shorter seminars for 10 - 30 participants were held too.

Before the trip we made together with my counterpart Mr Türker Aykal from ITDC a training and travel programme to improve existing technological applications in the Turkish steel-making industry and give appropriate suggestions/training for solving the most common problems encountered in continuous casting.

The trip has gone according to the plans without bigger problems and surprises.

The most important common findings during the trip are as follows:

1. Everywhere we visited, people working with continuous casting would really get more information and knowledge concerning their work.
2. Most of steelworks lack written technical material like articles and technical reports, books etc. In this respect there were great variations between different steelworks.
3. In many cases technical people had very seldom possibilities to have contact with colleagues in Turkey and other countries.
4. In many plants there was a shortage of certain measuring instruments and necessary tools to get their continuous casting machines in good condition.
5. Many steelworks are now considering to make better and more demanding steel grades, which means that besides the schooling and training of workers, many new facilities and auxsiliary equipments in continuous casting and steelmaking is needed (ladle, injection, ladle furnace, vacuum treatment, protection of casting streams, AL-wire feeding into the mould, etc.).
6. The quality of refractory material was not always good enough for continuous casting.

Finally I would like to say that the continuous casting plants in Turkey were in a better condition I expected, but further improvements are necessary when high grade steel are produced.

Mauri Peltonen
Mauri Peltonen

6.7.1984

TABLE I

MAIN SPECIFICATIONS OF MACHINE NO. 1

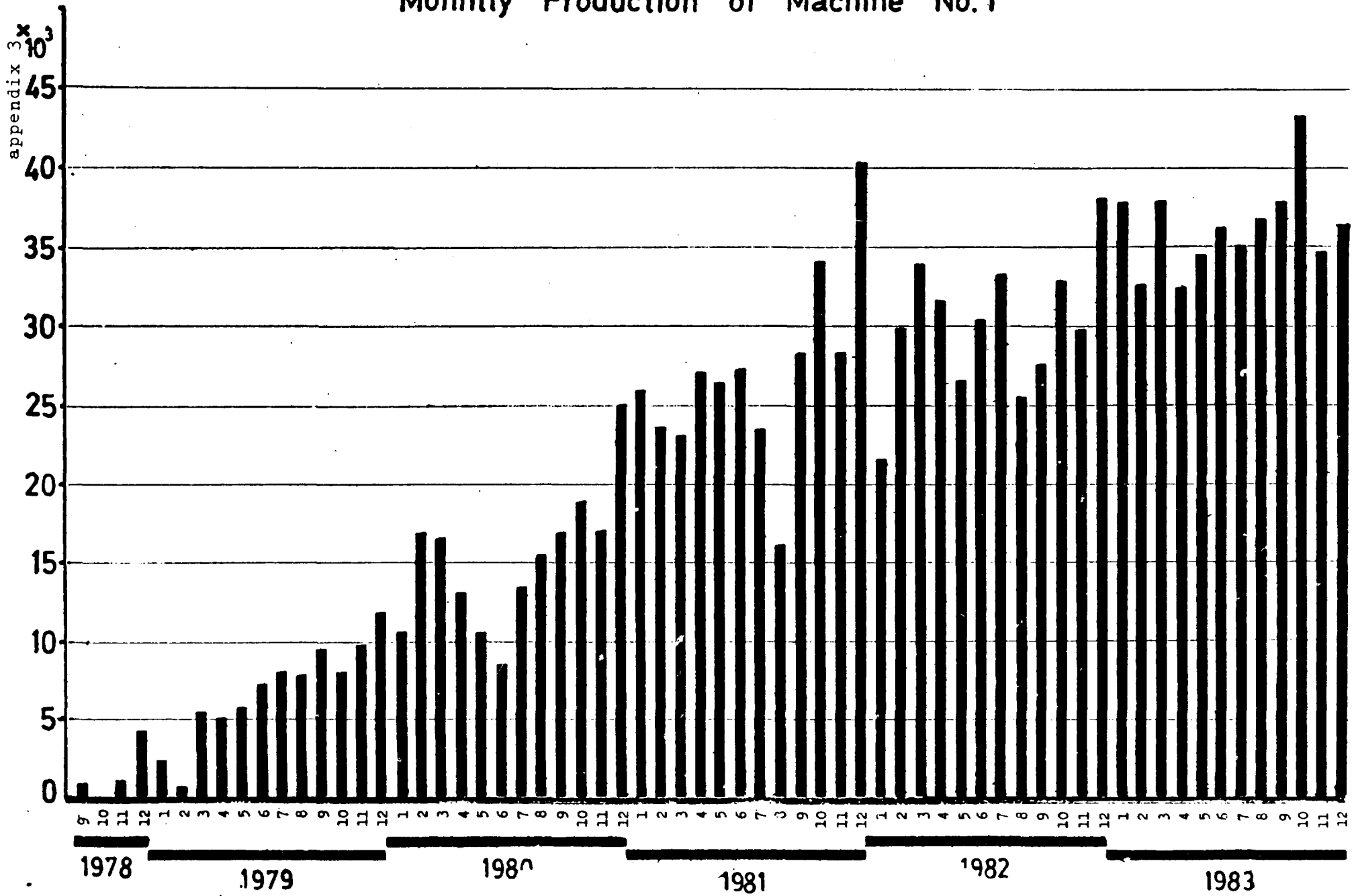
MACHINE TYPE	: CONCAST, Single strand S-Type
MACHINE BUILDER	: Schloemann - Siemag
STEEL CONSTRUCTION	: Nobels Peelman
MACHINE ERECTOR	: Turkish subcontractor Enka and ERDEMİK
SECTION SIZE	: 850 - 1300x200 mm.
CASTING RADIUS	: 9800 mm.
SUPPORTED LENGTH	: 18844 mm.
LADLE SIZE	: 90 Tons. Flocon slide gate valve fitted
LADLE SUPPORT	: Turret without lifting
TUNDISH	: Stoppered control, 8 Ton working capacity.
TUNDISH CAR	: 2 Self propelled, hydraulic lifting
MOULD	: Manually adjustable, Cu., non-plate curved mould.
OSCILLATION	: Short lever sinusoidal oscillation, 30 % negative strip. 8.5 mm. stroke.
TOP ZONE	: Two stage cooling grids, 4 pairs of rollers.
STRAND GUIDE	: Two different roll diameter type of totally 7 segments. Non-adjustable bearings. Hydraulically loaded.
WITHDRAWAL UNIT	: 5 three roll segments and plunger supported bottom rolls with 3 back-up rolls.
MACHINE SPEED	: 3 m/min max (insertion) 1.5 m/min (Casting)
SLAB CUTTING	: Ge-Ga, 2 oxy-burners, sitting on slab while cutting
CASTING FLOOR ELEVATION	: 10350 mm.

TABLE 2

MAIN SPECIFICATION OF MACHINE NO.II

MACHINE	: CONCAST, Single stand S-Type
MACHINE BUILDER	: Sumitomo Heavy Industries Ltd.
STEEL CONSTRUCTION	: Designed and manufactured in Turkey
MACHINE ERECTOR	: Turkish subcontractor Tokar and ERDEMİR
SECTION SIZE	: 1000 - 1600x200 mm.
CASTING RADIUS	: 9800 mm.
SUPPORTED LENGTH	: 18844 mm.
LADLE SIZE	: 90 Ton Flocon slide gate valve fitted.
LADLE SUPPORT	: Turret with mechanical lifting of arms.
TUNDISH	: Stoppered control, 8 Ton working capacity.
TUNDISH CAR	: 2 Self propelled, hydraulic lifting and tundish weighing system.
MOULD	: Manually adjustable, Cu., non-plated curved mould.
OSCILLATION	: Short lever sinusoidal oscillation, 40 % negative strip, 7.0 mm. stroke.
TOP ZONE	: Two stage cooling grids, 5 pairs of rollers.
STRAND GUIDE	: Three different roll diameter type of totally 7 segments. Eccentrically adjustable bearings. Hydraulically loaded.
WITHDRAWAL UNIT	: 5 three roll segments. Fixed pass line originally. One back-up roll. Later modified to plunger supported driven rolls system. Extended secondary cooling to first part of straightener.
MACHINE SPEED	: 5 m/min (insertion) 1.5 m/min (Casting)
SLAB CUTTING	: Sumitomo, 2 oxy burners, clamping on to the slab while cutting.
CASTING FLOOR ELEVATION	: 10350 mm.

Monthly Production of Machine No.1



Monthly Production of Machine No. 2

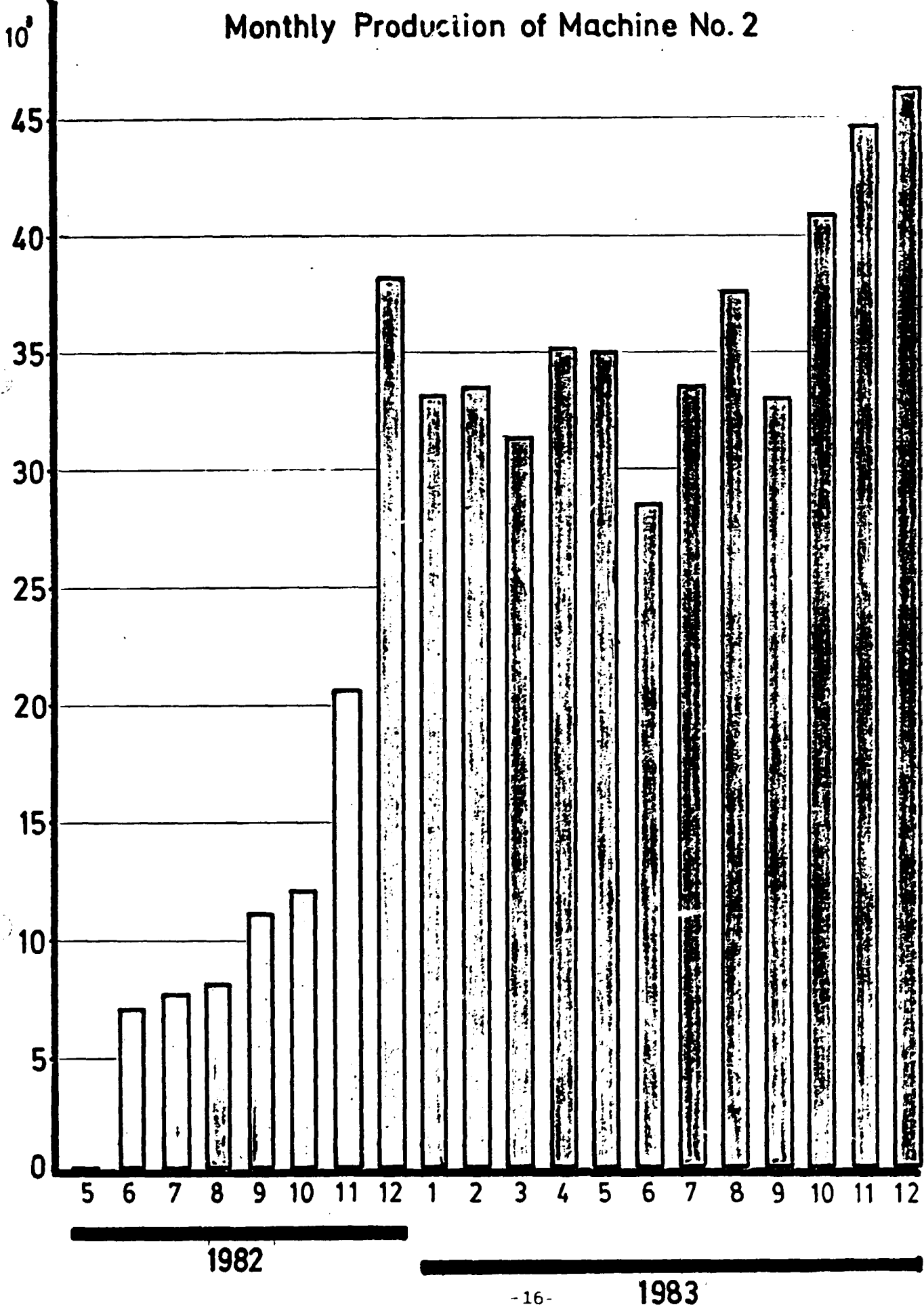


TABLE 3. YEARLY PRODUCTION AND YIELD FIGURES

		1978	1979	1980	1981	1982	1983	
YEARLY PRODUCTION (TON)	1	6094	83000	182699	324298	361851	435915	
	2	-	-	-	-	95888	428752	
	Tot.	6694	83000	182699	324298	457739	864667	
NO. OF CASTS	1	84	947	2049	3594	4095	4994	
	2	-	-	-	-	1081	4838	
	Tot.	84	947	2049	3594	5176	9832	
YIELD %	1	95.5	96.1	97.8	98.0	98.2	97.8	
	2	-	-	-	-	97.9	97.9	
	Tot.	95.5	96.1	97.8	98.0	98.1	97.8	
NO AND % OF BREAK OUTS	NUMBER	1	-	11	11	18	23	20
		2	-	-	-	-	5	51
		Tot.	-	11	11	18	28	71
%	%	1	-	1.2	0.54	0.48	0.55	0.4
		2	-	-	-	-	0.45	1.0
		Tot.	-	1.2	0.54	0.48	0.54	0.72

APPENDIX 2: Caster Steel Grades and Their Chemistry

ERDEMIR Quality	C h e m i c a l A n a l y s i s											
	C	Mn	P	S	Si	Cu	Al	Cr	Ni	Nb	V	Mo
5237 K	0.08	0.60	0.015 m	0.030 m	0.18	0.20 m	0.03	-	-	-	-	-
5242 K	0.14	0.65	0.015 m	0.030 m	0.18	0.20 m	0.03	-	-	-	-	-
6005 K	0.06 m	0.25	0.012 m	0.025 m	0.02 A	0.15 m	0.03 A	-	-	-	-	-
6008 K	0.08 m	0.35	0.015 m	0.025 m	0.09	0.15 m	0.03	-	-	-	-	-
6009 K	0.08	0.35	0.015 m	0.025 m	0.1	0.15 m	0.03	-	-	-	-	-
6010 K	0.10	0.35	0.015 m	0.025 m	0.09	0.15 m	0.03	-	-	-	-	-
6020 K	0.21	0.45	0.025 m	0.030 m	0.14	0.20 m	0.04	-	-	-	-	-
6030 K	0.30	0.75	0.020 m	0.030 m	0.14	0.20 m	0.04	-	-	-	-	-
6110 K	0.06 m	0.25	0.015 m	0.022 m	0.04 A	0.10 m	0.04	-	-	-	-	-
6114 K	0.04	0.25	0.010 m	0.020 m	-	0.10 m	0.04	-	-	-	-	-
6237 K	0.08	0.60	0.015 m	0.030 m	0.18	0.20 m	0.04	-	-	-	-	-
6242 K	0.14	0.65	0.010 m	0.030 m	0.20	0.20 m	0.04	-	-	-	-	-
6250 K	0.24	0.60	0.020 m	0.030 m	0.14	0.20 m	0.04	-	-	-	-	-
6252 K	0.19	1.45	0.015 m	0.025 m	0.40	0.20 m	0.04	-	-	-	-	-
6281 K	0.10	0.45	0.015 m	0.030 m	0.06	0.30	0.03	-	-	-	-	-
6284 K	0.14	1.40	0.025 m	0.030 m	0.40	0.30 m	0.04	-	-	-	-	-
6335 K	0.09	0.55	0.020 m	0.030 m	0.14	0.20 m	0.04	-	-	-	-	-
6341 K	0.18	0.65	0.015 m	0.030 m	0.20	0.20 m	0.04	-	-	-	-	-
6347 K	0.18	1.05	0.020 m	0.030 m	0.30	0.20 m	0.04	-	-	-	-	-
6352 K	0.19	1.15	0.020 m	0.030 m	0.50	0.20 m	0.05	-	-	-	-	-
6704 K	0.18	1.00	0.025 m	0.030 m	0.14	0.20 m	0.05	-	-	-	-	-
6837 K	0.08	0.40	0.015 m	0.025 m	0.04 m	0.10 m	0.04	-	-	-	-	-
6838 K	0.16	0.50	0.025 m	0.030 m	0.14	0.20 m	0.04	-	-	-	-	-
6850 K	0.20	1.30	0.020 m	0.030 m	0.40	0.20 m	0.04	-	-	-	-	-
6936 K	0.08	0.30	0.015 m	0.025 m	0.05 m	0.10 m	0.04	-	-	-	-	-
8414 K	0.24	0.45	0.030 m	0.030 m	0.25	-	-	1.40	0.60 m	-	0.20	0.35
8915 K	0.16	1.40	0.025 m	0.030 m	0.30	0.20 m	0.05	-	-	0.15	-	-
9024 K	0.20	1.30	0.030 m	0.030 m	0.20	-	-	0.015	-	-	0.10	-
9960 K	0.08	0.40	0.10	0.030 m	0.40	0.35	-	0.60	0.50	-	-	-

Investigation of steel temperature in ladle and tundish
by Gecosteel

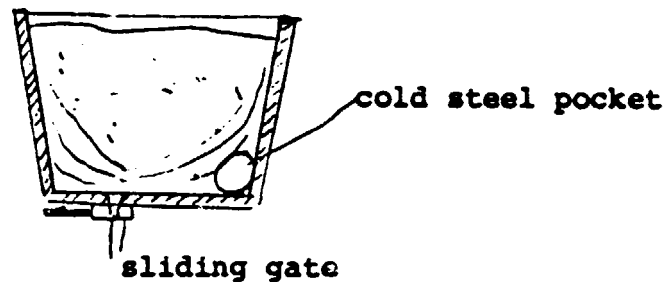
Earlier the steel temperature in the tundish could not be taken in the measuring system due to defect. This started functioning in March 1981. Measurement has mostly been taken in casting machine no 1. A form was made for recording the temperature in the tundish with other datas (annexes 1-3). The preheating temperature of the ladle was evaluated visually, as no temperature measurement is feasible with instrument.

Nine heats were analysed, seven with two strand casting and two with one strand casting. In annexes 4-5 investigation results are indicated for a similar plant (Imatra Finland). Ladle capacity of the above plant is 40 ton (18 MVA), tap to tap time 2-2½ h producing steel for merchant mill. The casting machine is 3-strand Concast S-machine and the billet size \varnothing 100 mm.

The tap to tap time being good the circulation time of the ladle was short, as a result of which the ladle lining temperature was consistent and warm. The temperature drop between the ladle and the start of the tundish is in average ca 75°C with 3-strand casting. With 2-strand the average is ca 95°C.

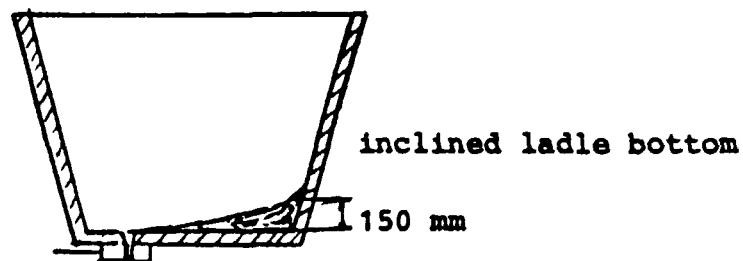
During casting the temperature drop in the tundish is about 20°C in both cases. Similar datas are shown in annex 5 for Gecosteel. The temperature drop between the ladle and the start of the tundish is 80°C for 2-strand casting and 90-95°C for 1-strand casting. The temperature drop in the tundish is 50-55°C in average in case of 2-strand casting and 30°C for 1-strand casting. The ladle lining temperature was high in case of 1-strand operation hence the drop is lower compared to that of 2-strand casting. An investigation was made 10 years ago at Imatra with stopper rod in the ladle. But after introduction of sliding gate in the ladle, the temperature drop occurred quickly at the end of the cast, when 2-5 tons steel were remaining in the ladle.

The cause of rapid drop of the temperature was investigated and it was found that a cold steel pocket was formed at the opposite corner of sliding gate (see sketch) due to slow and constant steel flow through the sliding gate. When 2-5 tons of steel were remaining in the ladle the pocket came out causing rapid temperature drop in the tundish.



By making the stopper open ca 20 seconds and closing ca 40 seconds, the steel flow rate would be increased preventing formation of cold pocket.

A solution of this problem was to use inclined ladle bottom (see sketch).



In many cases similar rapid drop of temperature in the tundish at the end of the casting has occurred in Gecosteel (sliding gates is used).

Recommendations

1. Effective preheating of the ladle, so that the temperature of lining of all ladles are more or less the same.
2. Short ladle circulation time as far as possible.
3. Implementation of gasstirring in the ladle as soon as possible.
4. Inclined bottom lining in the ladle should be tried.
5. It is very important to take 2-3 measurements of the temperature in the tundish. If the temperature goes down rapidly, more measurements are to be taken. In case of a low temperature ($T^{\circ}\text{C} < 1530$), CaSi and O_2 blowing could be used. It is not recommended to blow O_2 too early, because the tundish nozzle erosion increases.

1981-06-07

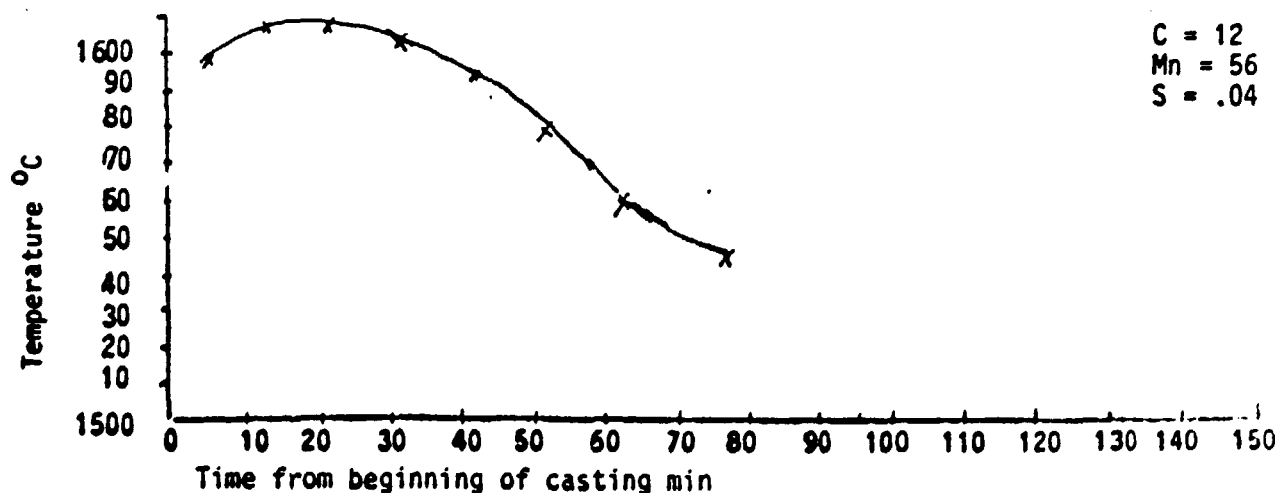
Mauri Peltonen

Temperature measurements in continuous casting plant by Gecosteel

Date 31-05-81 Shift -----Arc Furnace No 2 Charge No 392 CC Machine No B Cast No 334Ladle No ----- Ladle lining life ----- Preheating temperature of ladle $^{\circ}\text{C}$ 550 Preheating of ladle terminated at 7.00Beginning of tapping at 7.18 Tapping time min 3.5 Furnace temp. $^{\circ}\text{C}$ -----Ladle temperature in melting shop $^{\circ}\text{C}$ ----- Ladle temperature in cc-plant $^{\circ}\text{C}$ 1700 Starting of casting at 7.35

Tundish Temperatures

Time from beginning of casting min	Tundish temperature $^{\circ}\text{C}$	Casting speed		Steel level in tundish <u>cm</u> below max level	Remarks
		strand 1	strand 2		
5	1600	3.3	3.5	5	
15	1605	3.5	3.6	5	
25	1605	3.5	3.5	5	
35	1600	3.6	3.6	5	
45	1590	3.6	3.6	5	
55	1575	3.7	3.7	5	
65	1555	3.7	3.7	5	
80	1545	3.7	3.7	5	Ladle empty but tundish full of steel because of blocking of tundish nozzles
85					
95					
105					
115					Cutting faces of billets were bac
125					
135					



Date 11.5.-81 Shift -----

Arc Furnace No 1 Charge No 321 CC Machine No A Cast No 434

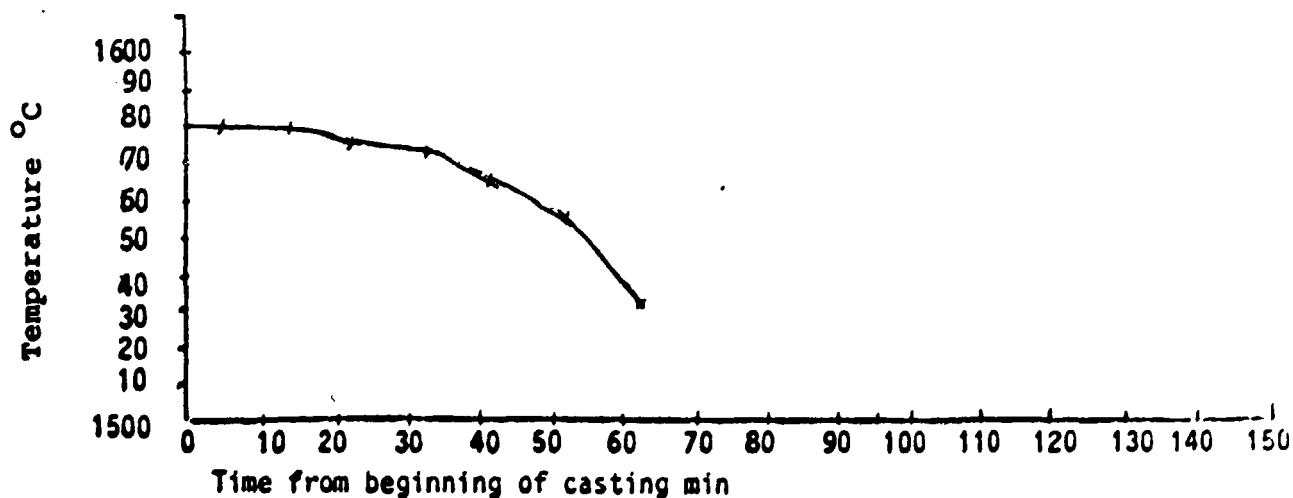
Ladle No ----- Ladle lining life ----- Preheating temperature of ladle $^{\circ}\text{C}$ 650 Preheating of ladle terminated at 9.42

Beginning of tapping at 9.57 Tapping time min 3 Furnace temp. $^{\circ}\text{C}$ 1710

Ladle temperature in melting shop $^{\circ}\text{C}$ ----- Ladle temperature in cc-plant $^{\circ}\text{C}$ 1650 Starting of casting at 10.08

Tundish Temperatures

Time from beginning of casting min	Tundish temperature $^{\circ}\text{C}$	Casting speed		Steel level in tundish cm below max level	Remarks
		strand 1	strand 2		
5	1580	2.5	2.5	5	
15	1580	2.6	2.6	5	
25	1575	2.5	2.5	5	
35	1570	2.6	2.6	5	
45	1560	2.6	2.6	5	
55	1550	2.8	2.7	5	
65	1530	2.8	2.8	5	Casting time 74 min
80					
85					
95					
105					
115					
125					
135					

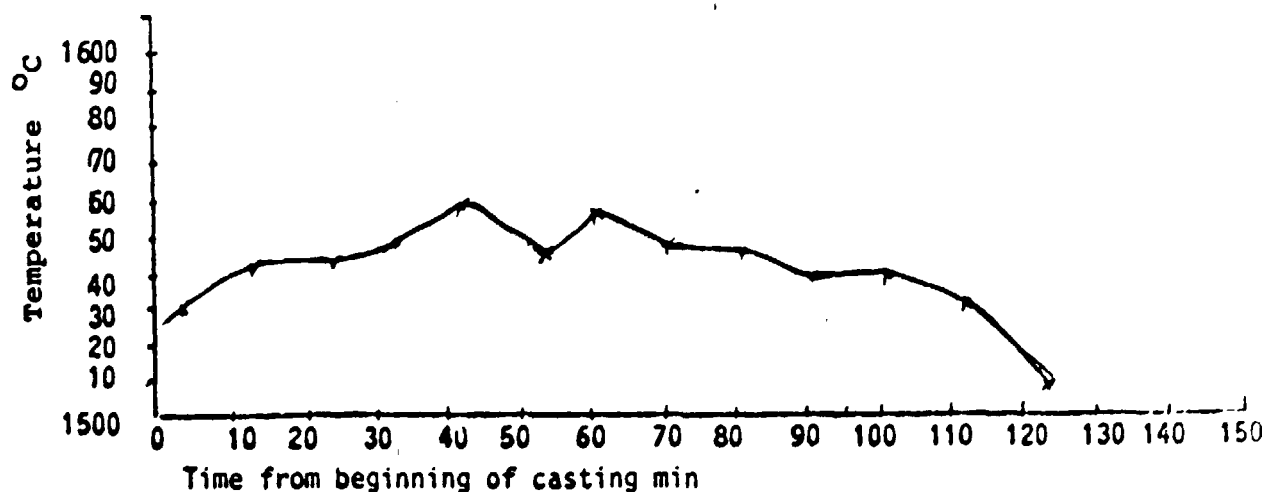


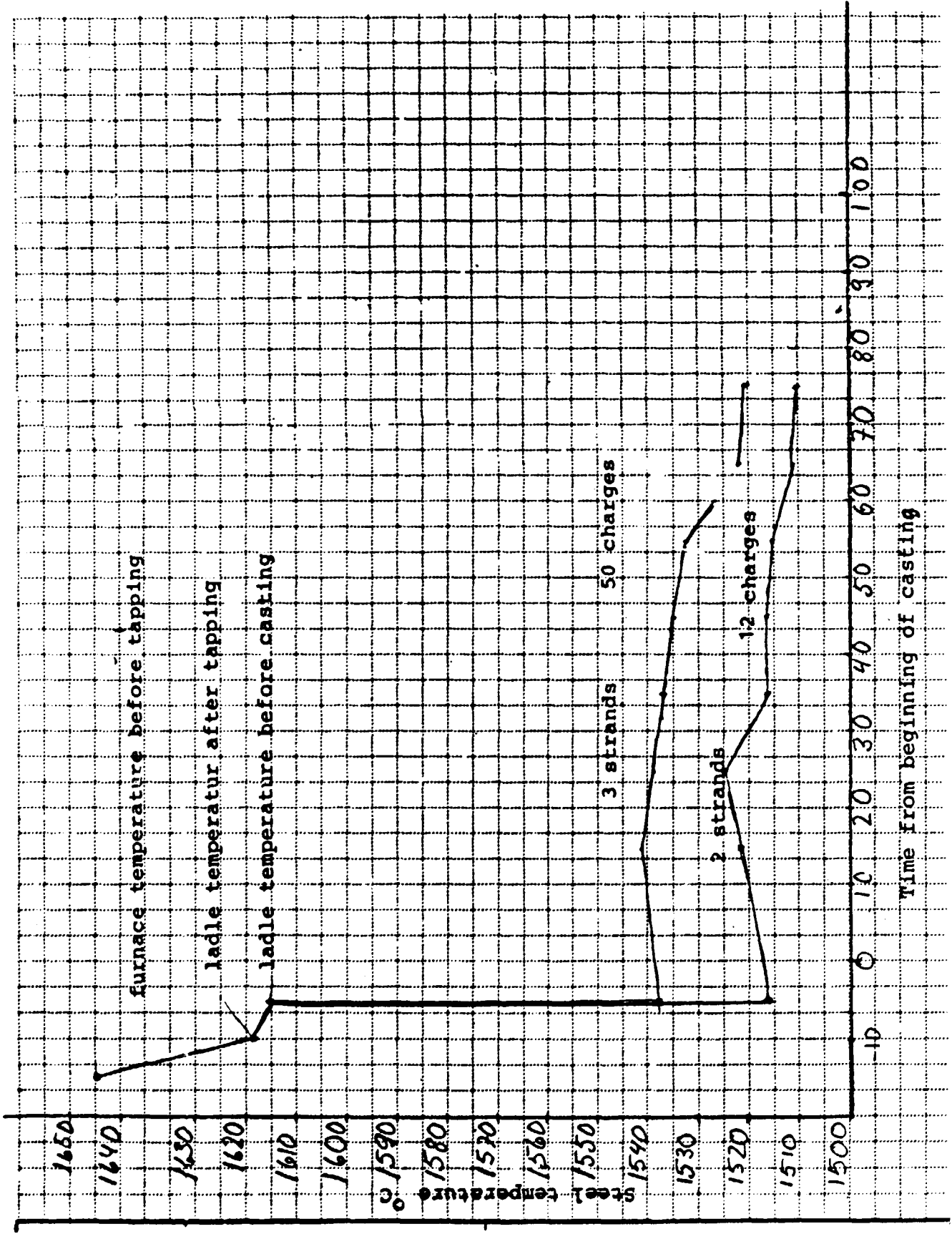
Temperature measurements in continuous casting plant by Gecosteel

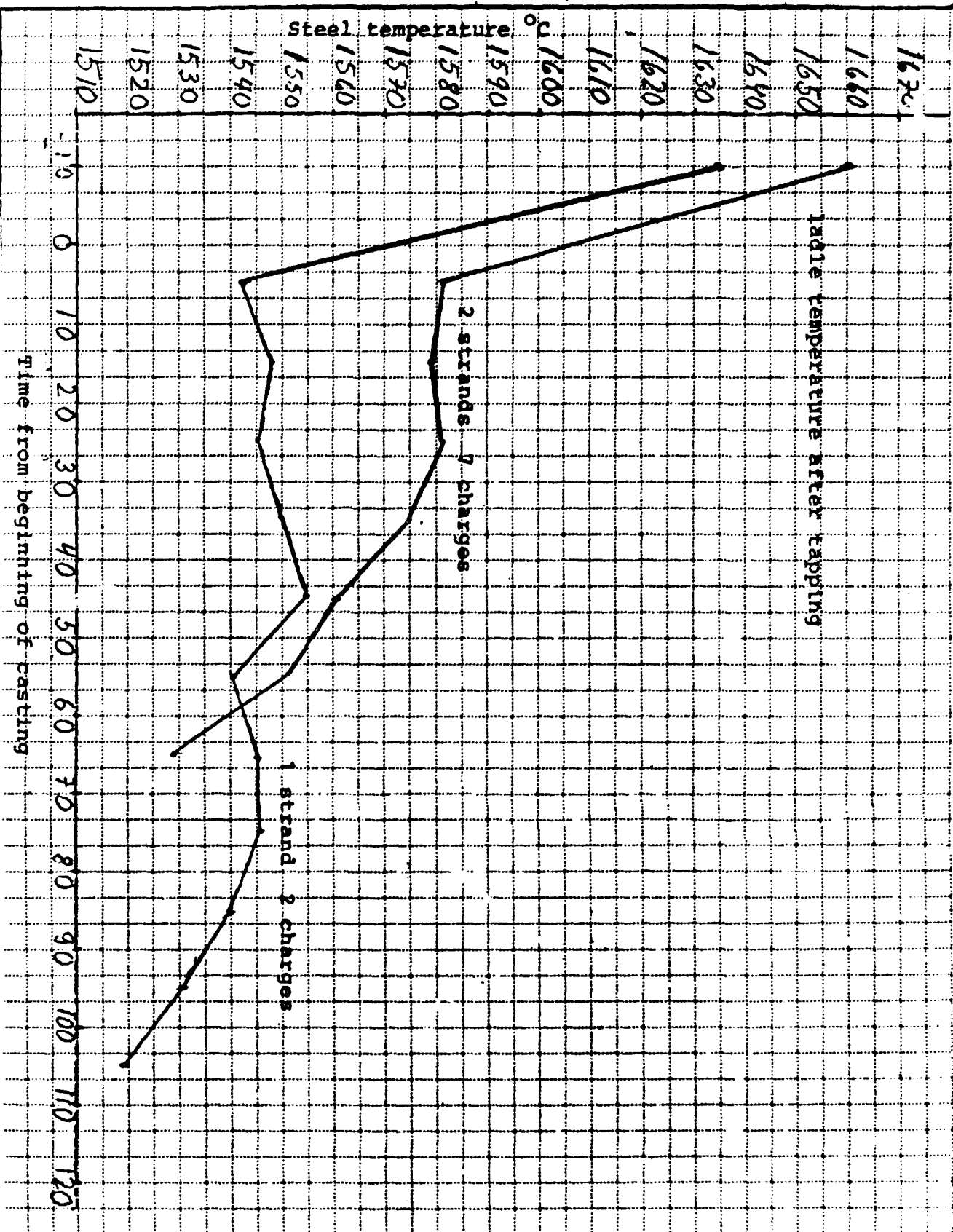
Date 6.4.81 Shift -----Arc Furnace No 2 Charge No 251 CC Machine No A Cast No 324Ladle No ----- Ladle lining life ----- Preheating temperature of ladle 800 °C Preheating of ladle terminated at 8.26Beginning of tapping at 8.35 Tapping time min 3 Furnace temp. °C -----Ladle temperature in melting shop °C ----- Ladle temperature in cc-plant °C 1650 Starting of casting at 8.45

Tundish Temperatures

Time from beginning of casting min	Tundish temperature °C	Casting speed		Steel level in tundish cm below max level	Remarks
		strand 1	strand 2		
5	1530		2.4	15	
15	1540		2.95	5	
25	1540		2.95	0	
35	1545		2.9	0	
45	1555		2.8	10	
55	1530	Breakout by starting	2.6	20	
65	1545		3.02	0	
75	1540		3.06	0	
85	1540		3.16	0	
95	1530		3.06	5	
105	1530		3.16	0	
115	1525		3.12	0	Casting time 123 min
125	1510	3.12	0		
135					







TYPE OF STEEL	DIN NORM		Corresponding SAE or AISI STANDARD	TYPE OF STEEL
	Material No	Symbol		
Structural Steels	1.0401	C15	1015	Constructional Steels
	1.0402	C22	1020	
	1.0501	C35	1035	
	1.0503	C45	1045	
	1.0601	C60	1060	
Free Cutting Steels	1.0715	9SMn28	1113	
	1.0718	9SMnPb28		
	1.0721	10S20	1115	
Spring Steels	1.0904	55Si7	9255	
	1.0906	65Si7		
	1.0908	60SiMn5		
	1.0909	60Si7	9260	
	1.0961	60SiCr7	9262	
Constructional Steels	1.1141	Ck15	1015	
	1.1151	Ck22	1620	
	1.1172	Cq35	1030	
	1.1181	Ck35	1035	
	1.1186	Ck40	1040	
	1.1191	Ck45	1045	
	1.1192	Cq45		
	1.1210	Ck53	1050	
	1.1213	Cf53		Ball Bearing Steels
	1.1221	Ck50	1060	Tool Steels

The above table gives an outline of steel grades produced by ASIL ÇELİK under its standard programme. However, other steel qualities can also be delivered on request according to customer specifications.

Material No.	DIN NORM	Corresponding SAE or AISI STANDARD
	Symbol	
1.5527	40MnB4	
1.5590	30MnB4	
1.5592	30MnB4Cr	
1.5710	36NiCr6	3130
1.5713	13NiCr6	3120
1.5752	14NiCr14	3310
1.6511	36CrNiMo4	9840
1.6523	21NiCrMo2	8620
1.6543	21NiCrMo22	8720
1.6546	40NiCrMo22	8640
1.6582	34CrNiMo6	
1.7033	34Cr4	
1.7034	37Cr4	5135
1.7035	41Cr4	5140
1.7103	67SiCr5	
1.7131	16MnCr5	5115
1.7147	20MnCr5	5120
1.7218	25CrMo4	
1.7220	34CrMo4	4130
1.7225	42CrMo4	4140
1.7228	50CrMo4	4150
1.8159	50CrV4	6150
1.8161	58CrV4	
1.3505	100Cr6	52100
1.1540	C100W1	W2
1.1740	C60W3	W1
1.2080	X210Cr12	D3
1.2208	31CrV3	
1.2344	X40CrMoV51	H13
1.2365	X32CrMoV33	H10
1.2550	60WCrV7	S1
1.2601	X165CrMoV12	D2
1.2714	56NiCrMoV7	L6
1.2842	90MnCrV8	O2

CONTINUOUS CASTING COURSE

This course is originally made in finish language but now there is available a little bit shortened version in Swedesh too. For Swedesh language there are several hundreds transperrency films available (over-head machine). A shortened english version is possible to make in near future if needed.

This course programme covers all important general aspects of continuous casting and many examples concerning solving of practical problems are presented.

PART 1.

a. Various types of continuous casting machines and the most important machine builders:

- the historial development of continuous casting machines.
- different types of machines (advantages and disadvantages)
- the most important builders of continuous casting machines.
- casting machines suitable for casting of tonnage steels and sp special steels.
- outlook to the future.

b. Steelmaking for continuous casting

- suitability of the different steelmaking methods for continuous casting.
- control of steel temperature in the ladle and tundish.
- gas stirring in the ladle.
- ladle metallurgy (influence on the continuous casting)
- examples from various continuous casting plants.

PART 2

a. Refractory materials for continuous casting

- ladles with the pouring equipment
- tundishes (lining and maintenance)
- tundish nozzles
- examples from various continuous casting plants
- regulation of steel flow from the tundish (stopper system, sliding gates system and the other methods)
- - pouring tube (type of tubes and tube material)
- examples concerning using of refractory materials in different continuous casting plants.

b. Metallurgical actions, which are possible to make in connection of continuous casting.

- protection of casting streams between ladle and tundish (immersion nozzles or gasprotection)
- protection of casting streams between the tundish and mould (examples from different plants)
- different kinds of addition of deoxidants in to the tundish and mould. (CaSi, lubricant, casting powder, AL-wire)

PART 3

Primary cooling (mould cooling)

- types of mould
- mould materials
- mould tapering
- mould length
- mould life
- lubrication of the mould
- solidification of steel in the mould
- heat extraction from the mould depending on the mould length, mould tapering, quality of the cooling water, temperature of the cooling water, deformation of the mould, wear of the mould, casting speed, super heat in the molten steel, carbon content and the other analytical factors
- mould oscillation
- differences between the right moulds and curved moulds
- examples from different continuous casting plants

PART 4

a. Secondary cooling

- general: history
- different cooling methods (radiation, gasflow, water stream, water nozzles, cooling plates)
- heat extraction in the secondary cooling zone depending on the water flow, water temperature, superheat, casting speed, scale formation
- planning of secondary cooling to correspond different casting conditions and quality demands
- examples from different plants
- water mist cooling

b. withdrawal and straightening machines, cutting stations, dummy cars, marking equipment.

- differences between various types of machines.

PART 5

Operation technics for continuous casting

- control actions before the casting.-
- preparation which must be made before starting of cast.
- start of casting and various starting methods.
- casting.
- ending of casting and the necessary control actions just after the end of casting.
- collection of casting data and reporting.
- sequence castings.
- synchronizing between steelmaking and continuous casting
- disturbances during casting (breakout, human errors, overflow, mould problems, breaking of pouring tube, electric and mechanical disturbances, problems with cooling water, disturbances with ladles and tundishes.
- yield of continuous casting (molten steel-blooms-billets-slabs)
- examples from different continuous casting plants.

PART 6

Steel qualities suitable for continuous casting and various defects in continuously casted products.

- steel grades which are possible to cast continuously
- different types of defects in CC-products
- cracks
- segregations and central porosities
- investigations of macro structure
- slag defects on billet surface
- overlappings(double skin)
- blowholes and pinholes
- oscillation marks
- slag inclusions in the steel

PART 7

a. Maintenance of continuous casting machines

- the principles of maintenance for continuous casting machines
- influence of maintenance on the production
- influence of maintenance on the product quality
- examples from various continuous casting plants

b. Inspection and conditioning of the continuously cast billets, blooms and slabs.

- general
- control methods suitable for continuously cast: billets, blooms and slabs
- methods suitable for conditioning of continuously cast billets, blooms and slabs
- examples from various continuous casting plants

2/12 1983

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