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EQUIPMENT FOR THE CONTINUOUS CASTING OF STEEL FOR THE NEEDS OF SMALL STEEL WORKS 1/

by

I. Mydlarz,
Poland

D01340

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SUMMARY

In 1967, the Polish iron and steel industry's output of steel exceeded 10 million tonnes per year for the first time.

Development plans call for an annual output of 23 million tonnes of steel to be reached in 1985.

In 1968 there were 19 steelworks in operation in Poland, with 88 open hearth furnaces of an average capacity of 96 tonnes, 15 electric arc furnaces with an average capacity of 20 tonnes, and 2 oxygen converters with a capacity of 100 tonnes.

Three continuous steel casting installations are in operation in steelworks in the Polish People's Republic. These installations are particulary advantageous for steelworks of small production capacity.

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* This is a summary of a paper issued under the same title as ID/WG.14/64.

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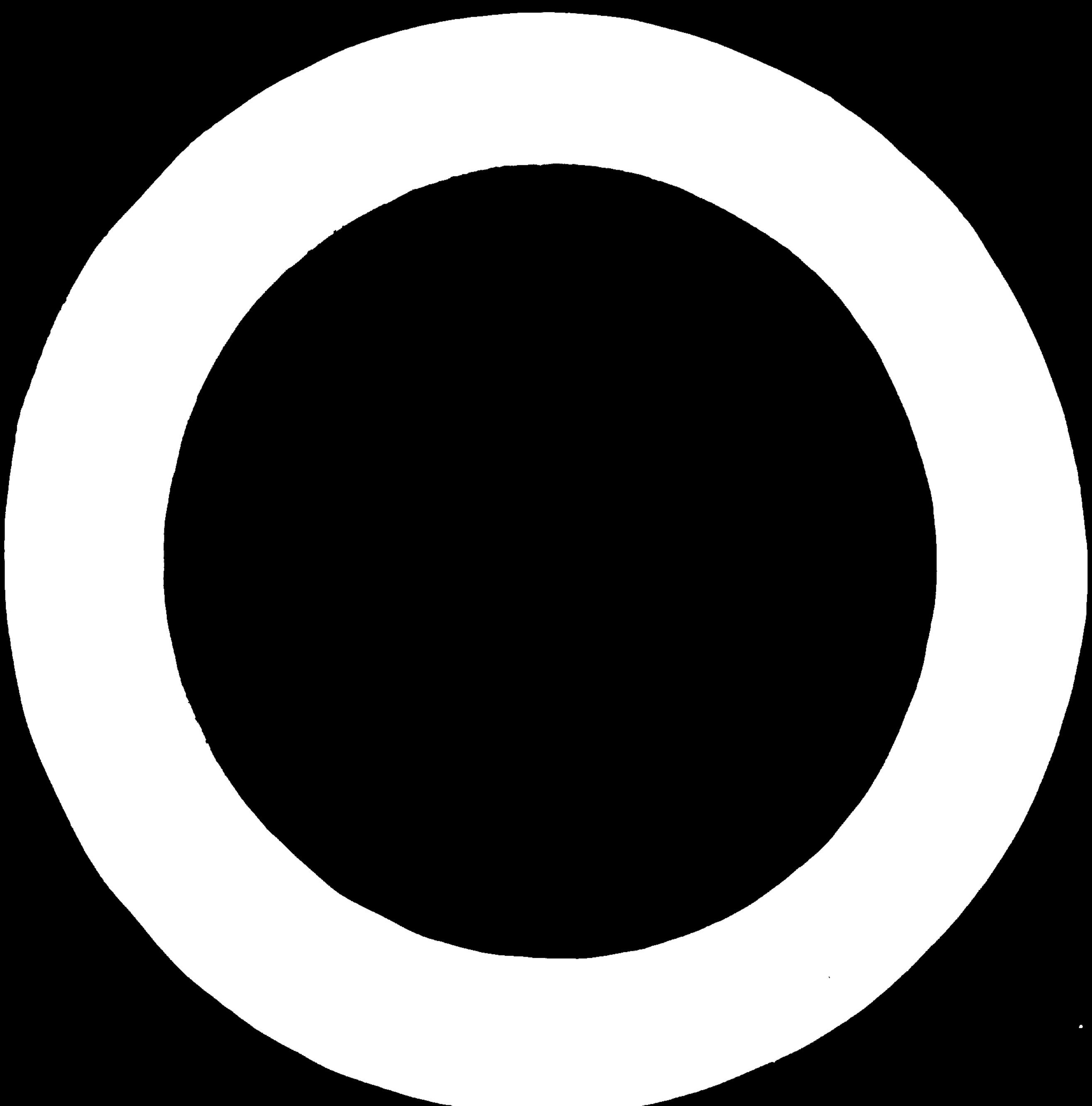

The continuous steel casting installation at the "Beldon" works, which was installed in 1962, is of an experimental/industrial character. It is used for the continuous casting into billets 100 mm square of high-alloy steel, high speed tool steel, and acid- and heat-resisting steels melted in an induction furnace of 1.5 tonne capacity.

This installation, which is of the single-strand vertical type, is partly housed in a well 5.0 metres in diameter and 7.0 metres deep.

The continuous steel casting installation at the "Ednost" works came into industrial operation in January 1963.

It is a vertical 4-strand installation equipped for the casting of melts of a rated weight of 50 tonnes into billets 140, 150 and 160 mm square.

This installation is housed in a well 18.0 metres in diameter and 23.0 metres deep.

A feature of this installation is the use of twin moulds.

The steel cast in this installation is killed carbon steel intended mainly for the production of tubes. There are about 6 melts a day, and the annual production capacity of the installation is 110,000 tonnes.

In practice, an increase in yield of about 11 per cent over conventional methods has been achieved for the complete process from liquid steel to finished tubes. The maximum monthly output which can be achieved is about 8,500 tonnes.

The continuous steel casting installation at the "Zavertse" works came into operation in December 1966. It is an 8-strand installation equipped for the casting of melts of a rated weight of 120 tonnes into continuous billets 160 mm square.

This installation, which is of the vertical type and has an annual production capacity of 280,000 tonnes, is partially housed in a well 24.0 metres in diameter and 20.0 metres deep.

From the point of view of technological layout, this installation consists basically of two 4-strand installations of the "Ednost" works type. It is used for casting killed carbon steel intended for the production of billets for jobbing mills.

The favourable technical and economic results obtained in the operation of these continuous steel casting installations have given grounds for planning the wider use of this method in the Polish steel industry, which is being extended and modernised.

The main reasons for envisaging the introduction of this process are that it makes possible:

- improvement of the yield of useful products by about 10-15 per cent;
- the establishment of direct technological and transport connexions between the steel production plant and the rolling shops, without the use of blooming mills;
- considerable improvement of the working conditions of casting floor operatives.

Poland is one of the small group of countries in whose steel industries research work is being carried out along these lines and continuous steel casting installations are being planned and installed.

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Continuous Steel Casting Installations in the Iron and Steel Industry of the Polish People's Republic

Introduction

This report sets out the present state and development prospects of the steel industry of the Polish People's Republic and describes the continuous steel casting installations operating at three plants in the Republic and the effects these have had on production and economic considerations.

On the basis of the experience gained, proposals are made for projects for small- and medium-capacity steelworks with installations for the continuous casting of square-section billets.

The concluding part of the report sets forth the possibilities for co-operation in the field of steel production between the Polish iron and steel industry and the iron and steel industries of other countries.

1. The present state of the steel industry of the Polish People's Republic and its development prospects

At the present time (1968) there are nineteen steelworks in operation in the Polish iron and steel industry, fourteen of them open-hearth plants, four electric open-hearth plants, and one an oxygen converter plant.

In 1967, the Polish iron and steel industry's output of steel exceeded 10 million tonnes per year for the first time; development plans call for an annual output of about 23 million tonnes of steel to be reached in 1985.

In the open-hearth steelworks, 88 furnaces with an average capacity of 96 tonnes are in operation. Eleven of these furnaces have a capacity of over 150 tonnes, 73 a capacity of between 50 and 150 tonnes, and four of them less than 50 tonnes. About two-thirds of the open-hearth steel produced in Poland is produced in furnaces with an average capacity of 65 tonnes.

All the basic open-hearth furnaces - that is to say, about 85 per cent of the total number - are heated with high-calorie fuels such as natural gas, producer gas or fuel oil.

In the majority of cases, the steel is cast in moulds into ingots weighing from 280 kilogrammes to 18 tonnes or forging blanks up to 54 tonnes. At present, the continuous casting of steel is carried on on an industrial scale at only two steelworks.

In seven steelworks ingots are cast on trollies, while in the remaining steelworks ingots are cast by the traditional method on a casting floor where the moulds are prepared, casting is carried out and the ingots are stripped.

The electric steel melting plants have a total of 15 electric arc furnaces with an average capacity of about 20 tonnes.

Of these 15 furnaces, three have a capacity of 50 tonnes, eight a capacity of between 10 and 30 tonnes, and four a capacity of less than 10 tonnes.

All furnaces over 10 tonnes in capacity are of the basic type.

Oxygen is used for refining in all the electric arc furnaces.

In five steelworks, vacuum degassing is carried out in order to improve the quality of the steel produced.

Development plans for the near future provide for measures aimed not only at the improvement of productivity, but also at improving economic considerations. These measures include the installation of continuous casting of steel.

2. Continuous steel casting installations in the Polish People's Republic

Three continuous steel casting installations are in operation in the Polish iron and steel industry.

The installation at the "Baldon" works, which was installed in 1962, is of an experimental/industrial character. In it, high alloy steel melted in a 1.5 tonne capacity induction furnace is cast into 100 x 100 mm square-section billets. This installation is of the single-strand vertical type and is partly housed in a well 5.0 metres in diameter and 7.0 metres deep.

A diagram of the installation is given in Figure 1.

The liquid steel is delivered to the installation in a tap ladle. The tundish has a metering orifice 7-10 mm in diameter.

The mould, which is 825 mm long, is made of copper tubing with walls 12 mm thick. Colza oil is used for lubricating its inner walls.

The mould is reciprocated over a travel of 15 mm by an electric motor through a system of eccentrics.

The secondary cooling system consists of rollers guiding the continuous billet and a set of nozzles by means of which the continuous billet is cooled either with water, a mixture of water and compressed air, or compressed air alone.

The withdrawal stand is provided with two pairs of drawing rollers pressed on the continuous billet by means of springs. The billet is cut into the required lengths by an oxygen/iron powder cutter. The pieces cut off the continuous billet, which are each about 1.2 metres long, are brought up to the level of the casting floor from the well by means of a hoist in a special container. The steels cast in this installation are mostly tool steels (1.7 per cent C, 0.4 per cent Mn, 0.4 per cent Si, 12 per cent Cr), high speed steels (0.8 per cent C, 18.0 per cent W, 1.3 per cent V, 5.0 per cent Cr) and also stainless and heat-resisting steels (0.14 per cent C, 2.0 per cent Mn, 1.2 per cent Si, 13.0 per cent Cr, 8.0 per cent Ni).

The installation at the "Ednost" works came into operation in 1963. It is a vertical 4-strand installation equipped for the casting of melts of a rated weight of 50 tonnes into billets 140, 150 and 160 mm square.

The carbon steel used is melted in an open-hearth furnace. The casting installation is located in an extension of the casting floor in a well 18.0 metres in diameter and 23.0 metres deep.

A vertical section of the installation is shown in Figure 2. Because of the relatively low casting floor, the casting deck of the installation is located at the same level as the main casting floor.

The liquid steel is delivered to the installation in tap ladles. The tundish, which has a capacity of 7 tonnes, is mounted on a rotating table and is heated before casting to a temperature of about 1000°C.

The four sockets of the tundish are provided with taps to regulate the amount of liquid steel admitted to the moulds. A feature of this type of installation is the use of twin moulds. Two copper tubes each 1,200 mm long and with walls 15 mm thick are housed in a single steel body to which they are fastened in such a way that they are free to expand longditudinally while at the same time their axes are kept constantly in correspondence with the technological axis of the installation.

Softened water is used to cool the moulds, which are reciprocated over a travel of 15 mm by a system of eccentrics driven by a direct current electric motor whose speed is synchronized with the driving motor of the withdrawal rollers. The inner walls of the moulds are lubricated with Colza oil. The secondary cooling unit, which is of the roller type, is 7.6 metres high and is provided with four sets of nozzles which spray water directly onto the continuous billets.

The withdrawal stand is provided with a pair of rollers for each billet. A view of the withdrawal stand is given in one of the accompanying slides (Figure 3).

The withdrawal rollers are pressed on the billet by means of springs. There is a single drive for the two continuous billets cast in the same pair of moulds. The speed of delivery of the continuous billets can be infinitely varied within the limits 0-2 metre/minute by adjusting the speed of the direct current electric moters driving the withdrawal rollers.

The continuous billets are cut into sections 3.0 - 4.0 metres long by oxygen cutters with a cutting speed of about 250 mm/minute. The two sections cut off simultaneously pass onto an inclined conveyor which delivers them to the lower roller conveyor.

From the lower roller conveyor the cut sections are transported by a hoist from the well to the level of the casting floor, after which they are transported by another conveyor to the billet store.

The cutting and transport of the billets are completely automated, the functioning of the main units of the installation being kept under observation from the central control cabin through television cameras.

The steel cast in this installation is killed carbon steel intended mainly for the production of seamless tubes. There are about six melts of this steel per day and the monthly output of the installation is about 8,500 tonnes.

The increase in yield, taken over the whole process from liquid steel to finished tubes, amounts on average to about 11 per cent compared with the conventional system of casting ingots in separate moulds.

The installation at the "Zavertse" works came into operation at the end of 1966. It is a vertical 8-strand installation equipped for the continuous casting of melts of a maximum weight of 140 tonnes into billets 160 mm square. The installation has an annual production capacity of 280,000 tonnes.

The installation is located in a separate bay next to the casting floor of the steelworks, and it is partly above the level of the casting floor and partly in a well. Its casting deck is at a height of + 7.75 metres, while the well is 24.0 metres in diameter and 20.8 metres deep. A vertical section of the installation is shown in Figure 4.

From the point of view of technological layout, this installation consists basically of two installations of the "Ednost" works type located in a mirror-image relationship to each other.

The double moulds are a feature of this type of installation. This layout has proved to be very advantageous in practice, as it considerably simplifies servicing of the installation and also reduces the number of driving mechanisms required. Fears that difficulties might be encountered in maintaining identical metal levels in the two moulds fed with molten steel through two tundish orifices for a given speed of delivery of the cast billet proved groundless in practice, and in fact the levels can readily be regulated by means of the taps in the tundish. The filling of the twin moulds with molten steel is shown in slide 5.

Modifications were made in the design of the installation as a result of differing technological conditions or of experience gained at the "Ednost" works. These modifications concern in particular the following parts of the installations:

- The 140-tonne-capacity casting ladle is provided with two sockets with tap mechanisms through which the two tundishes are supplied simultaneously.
- The tundishes are mounted on trolleys which can be moved out of the ladle heating area to the casting moulds and to the emergency mould for the pouring-off of steel residues and slag.
- As a result of extensive research work on different types of moulds, a tubular mould 900 millimetres long is used.
- Because of the relatively small section of the billet, observation with the naked eye of the level of metal in the mould was difficult and it appeared necessary to install an isotope apparatus to measure the metal level. This apparatus, which gives a continuous reading, consists of a metal level fluctuation sensor, an apparatus displaying the readings on the control panel, and signal lamps for the personnel operating the taps.
- The whole installation, which consists of four 2-strand units, is controlled from two cabins located on the casting floor. A view of the control panels and the control and measuring apparatus is given in slide 6.

Killed carbon steel intended for the production of billets for jobbing mills is cast in this installation. The average weight of the continuous billets cast from a single melt is of the order of about 120 tonnes.

The favourable technical and economic results obtained in the operation of continuous steel casting installations give grounds for foreseeing the wider use of this method in the Polish steel industry, which is being extended and modernized.

The introduction of such installations is envisaged both in steelworks which are to be modernised and in newly-built plants.

The main reasons for envisaging the introduction of this process are:

- to increase the yield of useful products with respect to the output of moulten steel;
- to link the steel melting sections directly with the rolling mills, without the need for blooming mills;
- to increase the throughput capacity of the casting floors of steelworks;
- to improve the working conditions of casting floor workers.

As far as the choice between vertical and curved-mould installations is concerned, the main factors to be taken into account are the section of the continuous billet, the geological conditions, and the space available, particularly in the case of already existing steelworks.

Where the continuous billet to be cast is of large section (over 220 mm), hydrogeological conditions are favourable, and the ground is solid and dry, a vertical system is indicated.

Where the continuous billet is of relatively small section, the geological conditions are unfavourable, and there is sufficient space available on the casting floor of the steelworks, a layout with a curved mould can be selected.

3. Utilization of the continuous steel casting process in small- and medium-capacity steelworks

The output capacity of a steelworks influences, basically, the selection of the technological process used for steel making and the type of furnace units used.

In considering what system to adopt for the steelworks, plants with an output of 100,000 tonnes per year were taken as being small-scale plants and plants with an output of up to 500,000 tonnes per year were taken as being medium-sized plants. In both types of plants, solid raw material is used in the majority of cases, usually in the form of scrap. This circumstance makes it necessary to use electric arc or open-hearth furnaces. In view of the magnitude of the capital costs involved and the output achieved, the most advantageous alternative is that using electric arc furnaces.

There may be grounds for not adopting this alternative, however, where electric power is not available but cheap fuel oil is.

The technical characteristics of the electric arc furnaces and open-hearth furnaces produced in Poland are given in Tables 1 and 2.

Output capacity of electric arc furnaces

Table 1

Rated capacity, tonnes	Transformer size, MVA	Output capacity, tonnes		Remarks
		per hour	per year	
3	2.0	1.0	7,800	1. Solid raw material
6	3.0	1.8	15,000	
10	5.0	3.0	25,000	2. Carbon steel
20	9.0	5.5	45,000	
30	15.0	7.9	65,000	
50	22.0	10.5	85,000	

In order to be able to compare both types of furnaces, identical conditions have been applied regarding both the raw material (1) and the quality of the steel (2) produced.

Output capacity of open-hearth furnaces

Table 2

Rated capacity, tonnes	Heat loading, gramme-calories/hour	Output capacity, tonnes		Remarks
		per hour	per year	
12	5.0	2.1	17,000	1. Fuel oil heating
15	5.6	2.5	20,000	2. Solid raw material
20	6.8	3.8	30,000	
40	10.5	6.0	48,000	
50	12.0	7.0	56,000	
75	16.0	9.8	78,000	

Electric furnaces enable a given output to be achieved with the use of considerably smaller production units, and this makes it possible to use cranes of smaller lifting capacity and hence to erect buildings of lighter construction.

The choice of continuous steel-casting machines is dictated basically by the size of the melt and the section of the continuous billet to be cast.

The section of the billet determines the casting speed and thus likewise dictates the output of the machinery.

On the other hand, the time taken to cast a melt cannot be very long because of the temperature drop which takes place in the steel.

As far as the choice of the equipment to be used for continuous steel-casting is concerned, it may be said that there are three basic types used on a large industrial scale, namely, the vertical system, the vertical system with bending of the billet, and the horizontal system with a curved mould. Diagrams of these systems are given in slide 7. According to data of the European Steel Commission of the United Nations, out of a total of 230 installations which are either in operation or in construction, 85 are of the vertical type, 50 of the vertical type with bending of the billet, and 75 of the horizontal type with a curved mould.

From the metallurgical point of view it can be assumed that all three of these types of installations are equally good.

From the point of view of capital costs, installations with a curved mould cost much the same as vertical installations.

An undoubted advantage of installations with a curved mould, however, is their modest height which makes it possible to avoid the construction of a well or of high bays.

On the other hand, an installation with a curved mould takes up about twice as much space on the casting floor as a vertical installation. In view of this, it is difficult to construct curved-mould installations in cramped, existing steelworks.

A vertical installation with bending of the billet is a compromise between the vertical and curved-mould systems.

A disadvantage of installations with a curved mould is that they require operating personnel of a very high order and also need extremely careful maintenance.

A very important factor which has a decisive influence on the actual output of continuous steel-casting installations is the need to syncronize the steel-melting cycles in the furnaces with the rate of operation of the casting installation.

The operation of the casting machine can be divided into the following phases:

- preparation of the continuous steel-casting installation;
- casting;
- clearing-up after casting;
- waiting for the next scheduled cast.

The installation must be so designed as to reduce to the minimum the time needed to prepare it for casting and the time needed to clear it up after casting. This can be achieved by equipping it with appropriate mechanical devices for changing the tundishes, the moulds and the secondary coolers, removing the end of the continuous billet, and so forth.

The waiting time depends mainly on the regularity of the cycle of delivery of metal to the continuous steel casting installation from the furnaces where the steel is melted.

The most inconvenient types of furnaces from this point of view are open-hearth furnaces, where the duration of the melting cycle varies over the furnace's life between overhauls.

More advantageous conditions are achieved with electric arc furnaces, where the length of the cycle is practically invariable.

If only the time when casting is actually taking place is considered as productive time for the installation and all the other phases are considered as unproductive (including the time spent on overhaul and servicing), it is possible to achieve in practice about 50 per cent utilization of an installation supplied from open-hearth furnaces and about 60 per cent utilization of one supplied from electric furnaces.

The characteristics of the three types of continuous steel casting installations produced by the Polish steel and engineering industries are given in Table 3.

Table 3

Characteristic	Unit of measurement	Type of installation: I	II	III
Output capacity	1,000 tonnes/year	40	100	280
Rated weight of melt	Tonnes	20	50	120
Section of continuous billet	mm x mm	140 x 140	140 x 140 160 x 160	160 x 160
Length of cut sections	mm	max. 6,000	max. 6,000	max. 6,000
Number of strands	-	2	4	8
Speed of casting	metres/minute	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Type of steel cast	-	Killed carbon, low-alloy, structural steels.		
Cooling water requirements	m^3/hour	300	600	1,000
Installed power	kW	550	1,000	2,100
Weight of casting installation	Tonnes	200	390	630
Weight of motors and electrical equipment	Tonnes	18	30	55

These continuous steel casting installations are particularly suitable for operation in conjunction with jobbing mills with an output of the order of 50,000 - 300,000 tonnes per year. This type of mill calls for billets with a square section of about 150/150 mm, and such billets can be produced by three means: by the casting of ordinary small-section billets, by the installation of blooming mills, or by the use of the continuous steel casting method.

The casting of ordinary small-section billets is uneconomic and extremely labour-consuming. On the other hand, the construction of a blooming mill for an output of the order of 300,000 tonnes per year is uneconomic also, as even the smallest mill of this type has an output capacity of the order of 1,000,000 tonnes per year.

The method of continuous steel casting completely overcomes these difficulties, gives the optimum billet of the required section, increases the yield of the finished product by about 10 per cent, and enables the large capital costs inseparable from the construction of a blooming mill to be avoided.

4. Scope for co-operation with the developing countries

On the basis of the experience which it has gained in the expansion and reconstruction of the Polish steel industry, the Polish steel and electrical engineering industries can provide co-operation in the construction of fully-equipped open-hearth and electric steelworks.

The steel industry's design offices can prepare the complete technological and professional documentation for the basic iron and steel plants.

The scientific research institutes of the iron and steel industry and of the refractories industry can work out the problems connected with the introduction of modern technology into industry.

Finally, the Polish iron and steelworks, which are equipped with up-to-date production facilities, can provide training for workers and engineering and technical staff.

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