Steelmaking based on inductive melting

by **Mohamed Chaabet, Erwin Dötsch**

Global production of steel has experienced rapid growth for a prolonged time. Over the last ten years alone, annual production rose from 851 Mt/a in 2001 to 1,417 Mt/a in 2010, much of this being attributable to growth in China. The percentage of electric steel produced with electric arc furnaces as the traditional melting unit around the world (without China, an exceptional case with 90 % oxygen steel) is around 45 %, and this percentage is growing. After the development of induction technology with inverter outputs of over 40 MW for crucible furnaces with capacities of more than 65 t, the induction furnace offers itself as an alternative electric melting unit for small mini-mills. Apart from saving the costs of electrodes and the low requirements on the electricity grid, the main benefits offered by induction furnaces are the high yield from the feed materials and low pollution of the environment and workplaces. The low metal losses becomes an economic factor, particularly when stainless steels are produced; although promising results have also been obtained in recent times for the inductive melting of carbon steels.

Steel is the most important industrial material for producing goods and plants by a long way, as can be seen from the quantities of the main materials produced across the world as depicted in **Fig. 1** [1]. **Fig. 2** shows the rapid, on-going development of world steel production since 1950 which, according to Ameling's estimates made in 2006, would reach some 1,500 Mt/a in 2010. The crude steel produced each year in the various regions during last 10 years is depicted in **Fig. 3**. This clearly shows that this annual tonnage - at 1,417 Mt/a - was almost achieved, despite the collapse in 2008/2009. The main reason for this is the astonishing growth in China, where the annual tonnage of 152 Mt in 2001 increased more than fourfold to 627 Mt in 2010 [2].

Steel production processes are characterized by a high recycling rate of steel scrap. This lies between 85 and 90 % in industry and for automobiles, and at 50 % in the private sector [3]. As the ratio of scrap used as the raw material for producing steel is 40 to 45 %, it is nowadays almost on equal terms with iron ore. **Fig. 4** shows the processes used to produce steel in diagrammatic form, the two main processes used to produce well over 90 % of all steel can be seen on the far left and far right. These are namely the lines "blast furnace/oxygen-converter" which primarily uses ore as the raw material, and the "electric arc furnace" with scrap as the main input basis [4]. Corresponding to these processes, a differentiation is made between oxygen steel and electric steel.

The electric steel process is characterized by its flexibility and, in the case of smaller steelmaking units (so-called mini-mills with 300 to 1,200 kt/a) its cost effectiveness. A further factor is the lower environmental pollution, in that less dust, CO_2, NO_x and slag is produced compared to the oxygen process [5]. The relative, absolute growth in electric steelmaking across the world, with the exception

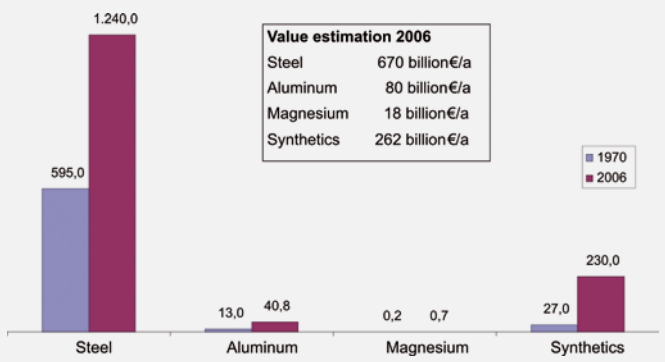

Fig. 1: Global production of the most important materials 1970/2006, in Mt/a [1]

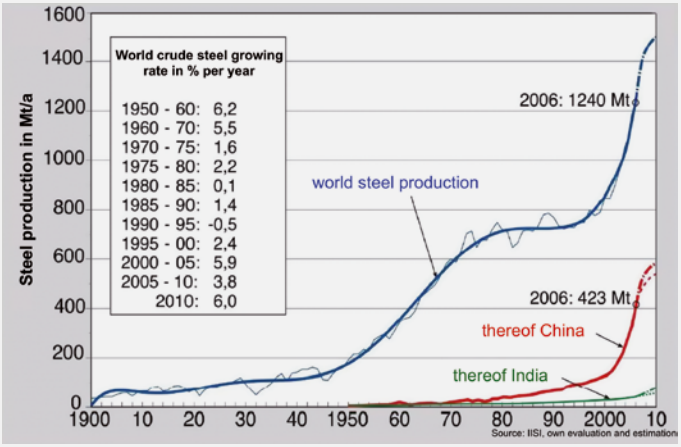

Fig. 2: The trend in global steel production, after Ameling [1]

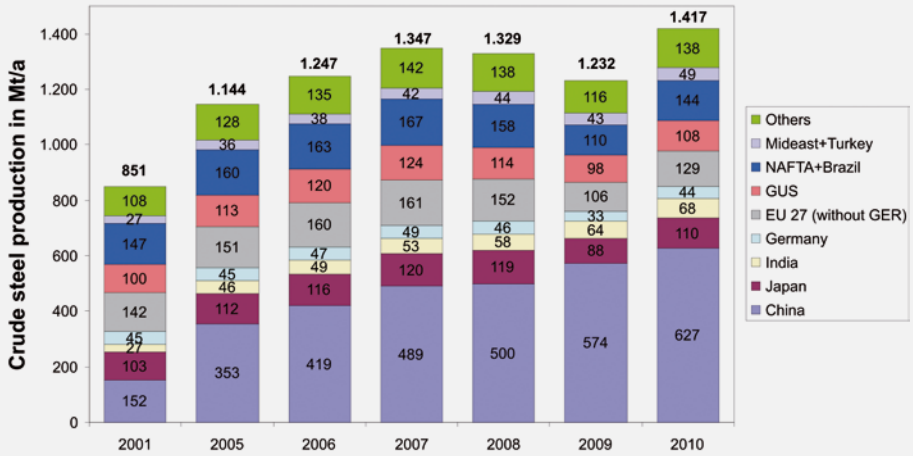

Fig. 3: Production of crude steel from 2005 to 2010 [2]

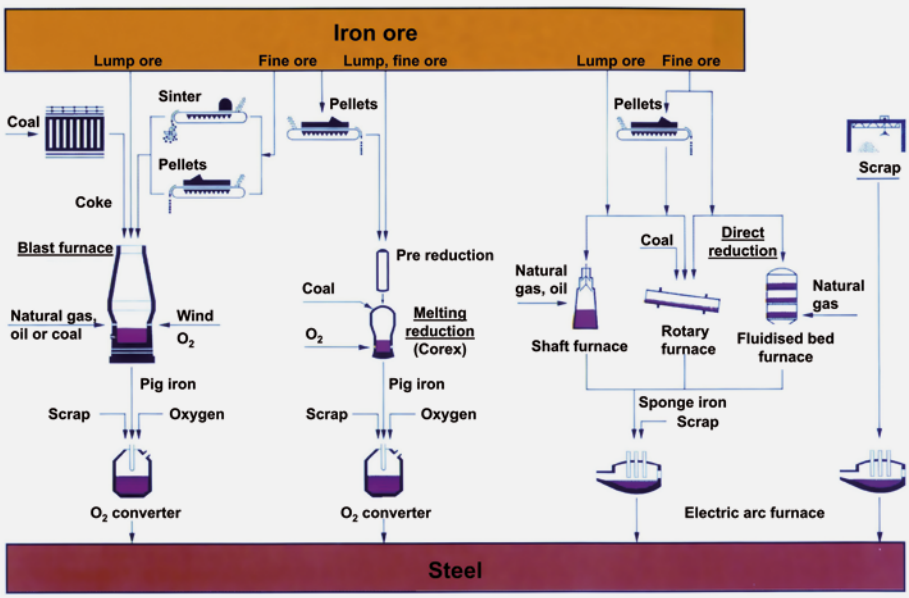

Fig. 4: Processing routes in steel production [4]

of China and Japan, is therefore not surprising. **Fig. 5** and **6** show that this trend is especially noticeable in the countries of the Near East, in Turkey and in India. Growth in China, in contrast, is mainly attributable to large-scale oxygen steel works, so that the comparatively moderate rise in the production of electric steel from 24 Mt in 2001 to 64 Mt in 2010 reflects the relatively low percentage of electric steelmaking at below 10 %. In the rest of the world production of electric steel rose from 323 Mt/a in 2001 to 350 Mt/a in 2010, thereby increasing its share of total steel production from 44 to 46 % [2].

As illustrated in Fig. 4, the melting stock used to produce electrical steel partly consists of so-called direct reduced iron (DRI). This is produced in the direct reduction process, in which prepared iron ore pellets are reduced from oxygen in their solid state by a heat and reduction gas, consisting of carbon monoxide and hydrogen, or even by coal [6]. The direct reduced iron which results is a porous product, so called sponge iron. It arises after reduction at a temperature of 600 to 900 °C and is often pressed while hot into HBI (Hot Briquetted Iron). The direct reduction process has economic significance in regions where natural gas is available as a resource for the reduction gas or gasifiable coal can substitute coke. The DRI tonnages depicted in **Fig. 7** show that these favorable conditions for direct reduction are particularly found in the Near East and in India. Consequently, of the 41 Mt/a of electric steel produced in India, 62 % (30 Mt/a) is made from direct reduced iron. The worldwide share of DRI is 15 % and growing.

As far as the continuous growth of global steel production is concerned, it can be expected that the recycling rate of steel scrap will at least remain at today's high level and that the importance of DRI as melting stock will rise. There will therefore be further growth in the production of electric steel. The most interesting component here from a technical and economic viewpoint is the "electric furnace" as the melting unit.

Apart from the established electric arc furnaces, it seems likely that induction furnaces will also be deployed in this context. In what follows, the characteristic properties of the induction furnace is first described before some example systems for steelmaking are discussed.

CHARACTERISTIC FEATURES OF INDUCTION FURNACES

There are two main types of induction furnaces used in industry, namely the induction channel furnace and the induction crucible furnace. Channel furnaces nowadays only have subordinate significance as equipment for melting ferrous materials, so that what follows refers to crucible furnaces. **Fig. 8** contains a diagram of such an induction melting system. Its main components are the power supply unit (with transformer, inverter and capacitor bank), the crucible furnace itself, the charging system, the cooling systems for the power supply and furnace coil, the fume extraction equipment and the process control system [7].

Power transmission without over temperature

The crucible furnace itself is a melting unit with a fairly simple construction. As shown in Figure 8, this basically consists of the refractory crucible and the surrounding coil borne by a steel frame. Alternating current flows through the coil, creating an electromagnetic field. This field induces eddy currents in the metallic melting stock which, in accordance with Joule's law, cause the feed materials to heat up and finally to melt.

The heat is thus generated directly in the melting stock itself, without over temperature, so that the emissions generated by furnaces heated by fuel or electric arc during power transmission do not occur in the induction furnace. Depending on the quality of the feed materials, the volume of dust produced is 0.5 to 1 kg/t of melt, the slag ratio is 10 to 15 kg/t. Further benefits of energy transmission without over temperature are that premature refractory wear does

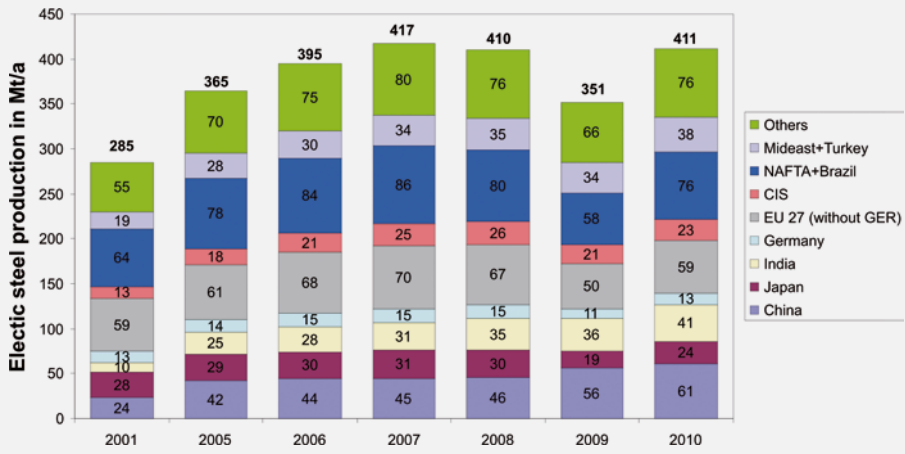

Fig. 5: Electric steel production from 2001 to 2010 [2]

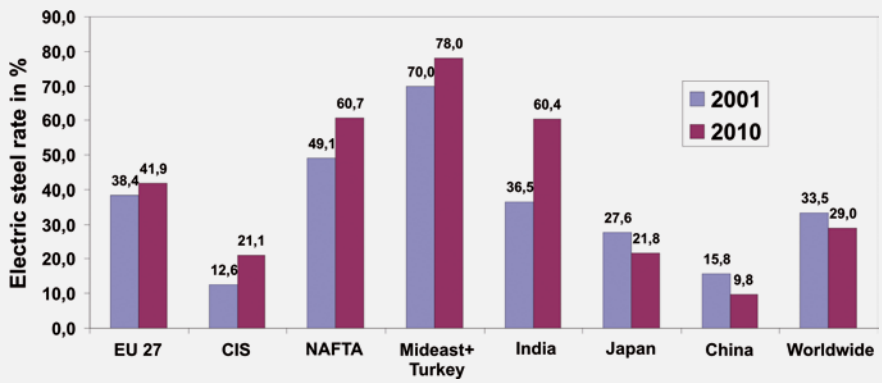

Fig. 6: Electric steel production as a percentage of total crude steel production, 2001 and 2010 [2]

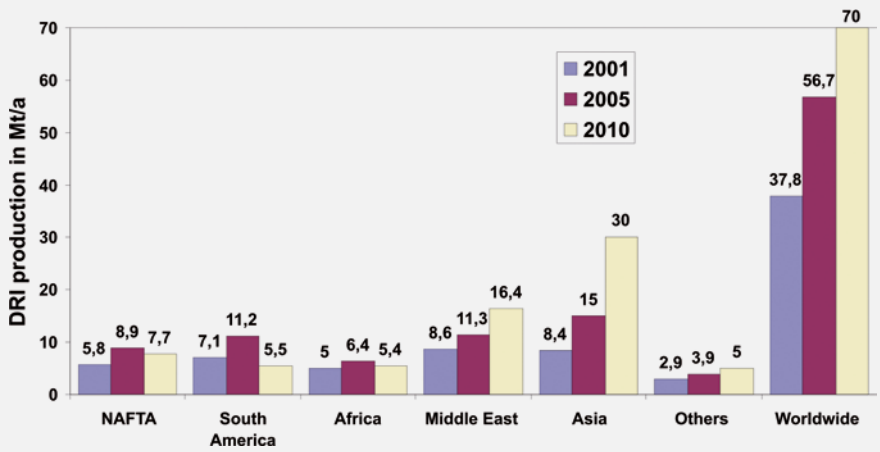

Fig. 7: DRI production in million t/a in 2001, 2005 and 2010 [2]

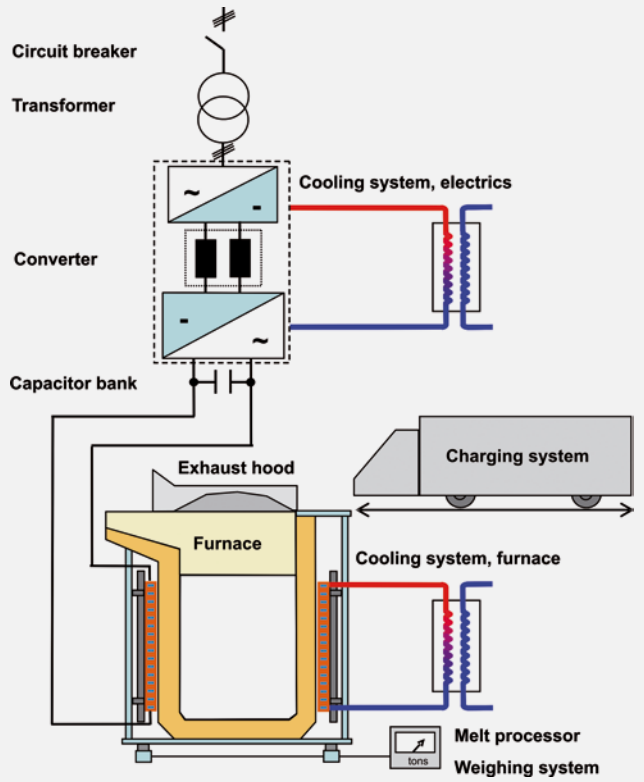

Fig. 8: Structure of an induction melting installation, ABP type

not occur as a result of excessive wall temperatures, gas take-up from the atmosphere is very low and, above all, that the burnout of the feed materials and alloying agents is minimal.

Inductive bath agitation

The diagram in **Fig. 9** (left) shows the magnetic flux generated by the coil current which partly runs through the melt [8]. The interplay between the eddy currents induced in the melt and the magnetic induction creates electromagnetic forces, which basically run in a radial direction to the crucible axis and thus press the melt inwards away from the crucible wall. Gravity works against these forces, so that a dome is formed on the bath surface. In addition, a bath flow is created in the form of two eddy toroids with opposite directions of turn. This is attributable to the fact that the radial pressure on the melt reaches a maximum around halfway up the coil due to the leakage of the field at the coil ends (Fig. 9 right).

The inductive bath agitation firstly leads to an ideal homogenization of the melt with regard to the chemical composition and temperature. It is furthermore beneficial for stirring in specific light materials, such as chips, stamping remnants, shredded scrap and sponge iron. Given a suitable method of charging, these materials are stirred spontaneously into the melt, so that optimum heat transmission conditions are created for melting the individual pieces of feed stock.

Inverter power supply

Power is supplied to the furnace coil via a transformer, a frequency inverter and a capacitor bank to compensate for the furnace reactive power, as depicted in Fig. 8. At a cos phi of some 0.95 in the range of 60 to 100 % of the nominal power, for the electrical supply grid the induction furnace thus represents a "pure" Ohm load. Moreover, this is constant in time, thus without short-term fluctuations. In addition, as the furnace is switched on via a time ramp, all types of flickers and grid loading through rush currents are prevented. Thanks to the 24-pulse design of the converter, the 5th, 7th, 11th and 13th harmonic caused by the inverter are largely reduced, so that just the 23rd harmonic becomes effective for the grid and thus adverse effects do not normally occur.

The current fed in by the inverter oscillates with a resonance frequency (between 60 % and 110 % of the nominal frequency) that adapts itself independently in the high power circuit between the furnace coil and capacitor bank, and thus enables a constant load regula-

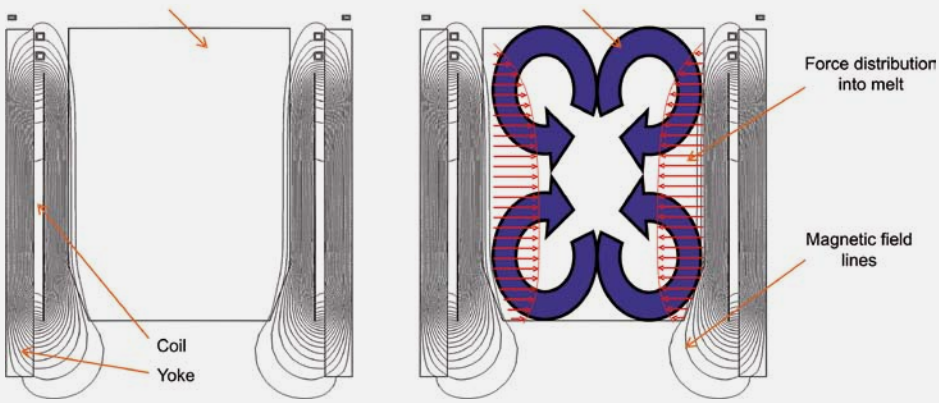

Fig. 9: Field image of a medium-frequency crucible furnace (left), Power distribution and flow pattern (right) [8]

tion in a simple manner. The available power can thus be fully used practically for every state of the melting stock in the crucible, i.e. over the complete melting period, by variable current, voltage and frequency. These demonstrate the main advantages of an inverter power supply compared to a conventional line frequency furnace, which only works economically in heel operation at a rigid line frequency. The variable and higher frequency of the coil current in the oscillation circuit with the variable current and voltage enables the MF furnace to be operated in charging mode, i.e. without heel with solid feed materials, without forfeiting anything in the melting performance, and it can be equipped with a power input many times as great, yet at the same capacity [9]. This, then, is the essential progress made compared to the situation in the 1970s, when efforts to deploy the line frequency induction furnace for steelmaking met with little or no success [10].

Operating behavior and environmental compatibility

The principle of direct energy transmission, as described above, produces a high yield from the feed materials with lower levels of dust emission. Noise levels are kept within admissible limits below 85 to 83 dB(A), firstly because the noisy power supply components (choke, inverter, capacitor bank) are installed in enclosed rooms and, secondly, the call for lower noise emissions is taken into account in the furnace construction with the furnace casing and platform being acoustically insulated [11]. The low levels of heat released into the surroundings also make the induction furnace a melting unit which is friendly to the workplace.

Refractory lining

As a rule, crucible furnaces are lined with powdery dry masses. These are sintered in the furnace into a monolithic, although elastic crucible. The induction process thereby places particular requirements on the refractory lining:

- Lowest possible wall thickness in order to keep the expenditure for the capacitor bank to compensate the reactive power low and electrical efficiency high.
- Metal may not be allowed to penetrate the refractory wall. This is because materials conducting electricity in the furnace refractory are inductively heated up, so that the penetrating metal melt does not stand still, but rather penetrates through to the coil, thereby causing a short circuit or even a molten metal break-through.
- High mechanical and chemical resistance in order to withstand the loading caused by the bath agitation.

These requirements are fulfilled for the inductive melting of cast iron by quartzite dry masses. Quartzite, however, is unsuitable for producing steel melts due to its inadequate thermal and chemical resistance. Spinel-forming dry masses on MgO and Al_2O_3 basis are the lining materials preferred for this purpose. They are characterized by a high temperature application limit of over 1,750 °C, whilst at the same time having a favorable thermal stability and a low infiltration tendency.

The latter named feature is based primarily on the formation of spinel whilst the applied mass is being sintered: The formation of the spinel ($MgO{\bullet}Al_2O_3$), consisting of magnesite and corundum, is associated with an increase in volume of 7.9 %. This not only compensates the shrinkage which occurs from around 1,200 °C during sintering without such reactions, but also leads to an additional densification in the sintered layer [12].

DEPLOYMENT OF INDUCTION FURNACES IN STEEL MILLS

Induction technology has now been developed to the extent that it is possible to generate connected loads of over 40 MW per inverter and specific power between 600 and 800 kW/t of furnace capacity. These developments fulfill the prerequisites for deploying induction crucible

Table 1: Characteristic features of electric arc and induction furnaces (source: ABP)

Feature	Electric Arc Furnace	Induction Furnace
Operation costs:		
• Electrical energy	500 kWh/t	540 kWh/t
• Refractory	4 kg/t	3.5 kg/t
• Electrodes	2.5 kg/t	none
• Oxygen	15 Nm^3/t	none
• Slag builder	25 kg/t	none
Melting:		
• Melt losses	• 7 to 10 %	• 1 to 2 %
• Alloying	• Not exact	• Simple and exact
Metallurgical work:		
• Decarburizing • Desulphurizing • Dephosphurizing	Possible by oxygen blowing and slag reaction	Restricted by refractory wear
Environment conditions:		
• Dust	5 to 10 kg/t	approx. 1 kg/t
• Noise	90 to 120 dB(A)	83 to 85 dB(A)
• Slag	60 to 70 kg/t	10 to 15 kg/t
Electrical supply net	• High load • Flicker disturbances	• Low load • No flicker disturbances

furnaces in steel works in two fields: Firstly, the induction furnace as the melting unit for mini-mills with an annual production of 100,000 to 900,000 t/a is now an alternative to the electric arc furnace. Secondly, it is suitable for melting the ferroalloys for adding to the ladle in liquid form when making stainless steel.

The induction furnace as an alternative melting unit to the electric arc furnace

Table 1 compares the main features of electric arc and induction furnaces for melting steel in mini-mills. According to this, an induction furnace has the following economic/technical benefits, these resulting from the interplays described in the foregoing section.

- Low requirements on the electricity grid; also suitable for power supplied by generators driven by diesel or gas
- Little expenditure for environmental compatibility and clean workplaces
- High yield from the metallic feed materials, above all the alloying agents
- No electrode costs
- Relatively low investment costs and small space requirement
- Largely automatic operation in a simple manner.

One drawback is the sensitivity of the refractory lining in an induction furnace, this being characterized by a minimal wall thickness and the risk of cracks forming leading to operational stoppages. Induction furnaces also place more stringent requirements on the quality of the scrap metal than electric arc furnaces. These firstly concern the geometric dimensions which need to be adjusted to the relatively small surface/volume ratio of the crucible furnace: the pieces of scrap metal should not be longer than half the crucible diameter. The non-metallic contents need to be kept in bounds to ensure that the ratio of slag does not become too great and that the refractory service life is not impaired. When considering the chemical composition of the metallic feed materials, it should be noted that the induction furnace is suitable for adding agents, i.e. alloys, at any time thanks to the characteristic bath agitation. However, it is not very good for removing components, such as carbon through oxygen treatment. This is to be discussed in more detail later.

The inductive bath agitation also represents a benefit for melting direct reduced iron. Melting performance is nevertheless limited by the boiling process to remove the residual oxygen (which is associated with the formation of flames and splashes of molten metal) and by severe slag formation which requires special action.

Design of an induction melting system for producing construction steel billets

In electric steelmaking, it has long since been regarded as making economic sense to perform metallurgical work not in the melting furnace itself, but rather in downstream equipment, such as a ladle furnace, oxygen converter or vacuum plant [13]. The process of producing the melt is thus characterized by the three stations "melting, treatment, casting", whereby it is assumed here that the molten metal is poured by continuous casting. The sequence is then determined by the requirements of the continuous casting plant which, as a rule, is fed continuously with liquid steel via a tundish from a ladle positioned above which is emptied through the base. After a pouring time of 40 to max 70 min, the ladle is exchanged in 3 to 5 min. During this time, there is sufficient melt available from the tundish, so that up to 30 sequential charges can be poured without interruption. The tundish is then exchanged and other maintenance work is performed, this generally taking around two hours per day. Melting operations thus face the task of providing a ready-to-pour, liquid charge in a 40 to 65 minute cycle for a period of up to 22 h/day. The design of an induction melting system suitable for this purpose is described in the following example [14]. 300,000 t of construction steel billets are to be produced per annum in the following composition:

0.15 - 0.3 % C; 0.6 - 1.6 % Mn; 0.15 - 0.5 % S; P and S < 0.04 %.

The feed material is shredded scrap with a low cast iron content. **Table 2** lists the benchmark data for designing the induction melting system. The system consists of three crucible furnaces, each with a useful capacity of 23 t, of which two produce the 46 t charge in melting mode whilst one is held on stand-by

Table 2: Design data for an induction melting installation for the production of construction steel billets [14]

Annual billet production		300.000 t/a
Working days per year	(22 days maintenance, 23 days standstill at 93.7 % availability)	310 d/a
Output of raw materials		95 %
Returns at 20 charges in sequential casting		3 %
Produced melt		310.000 t
Daily melt production 310.000/310		1,000 t/d
Amount of 46t charges (see below)		22 charges/day
Cycle time per charge 24/22 * 60		65 min

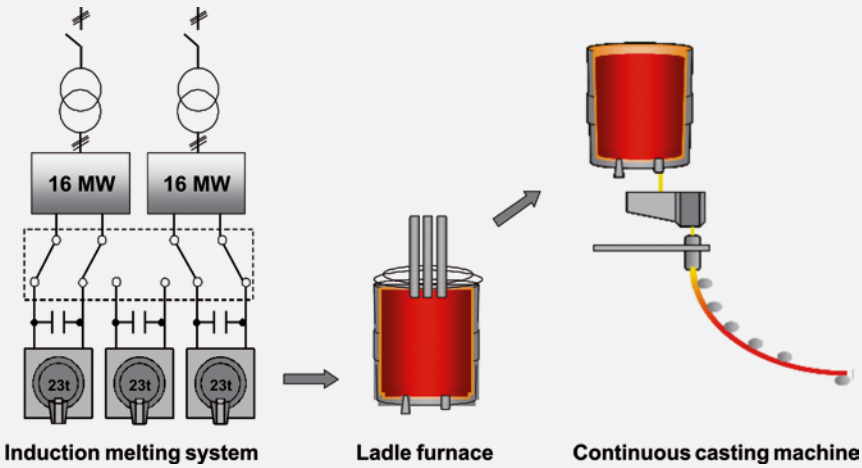

Fig. 10: Diagram of an induction melting facility and the process route for the production of 300 kt/a of structural steel billets; source: ABP

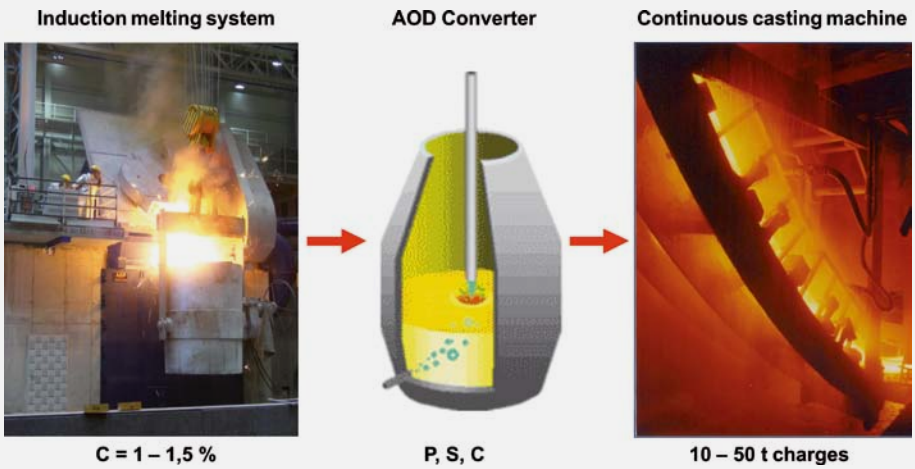

Fig. 11: Production in the induction furnace of alloyed steel heats for further processing in the AOD converter and continuous caster [14]

waiting for new refractory to be installed (Figure 10). The connected load per furnace is calculated from the aforesaid cycle time of 65 min; after subtracting 15 min for finishing, tapping and first charging, 50 min therefore remain as melting time. This results in the following equation for furnace power P:

$$P = 560\ \text{kWh/t} \cdot 23\ \text{t} \cdot 60\ \text{min/h} / 50\ \text{min} \approx 16{,}000\ \text{kW}.$$

The refractory service life is 70 to 100 charges, or 3.2 to 4.5 days given 22 charges per day of production. It takes around 1½ days to install new refractory, including sintering. So even if the refractory service life per furnace is only three days, two furnaces running in melting mode ensure that on-going melting operations continue with a reserve furnace on stand-by waiting for new refractory. The two parallel running 23 t melting furnaces then melt a 46 t charge in 65 min cycles. The melt is then taken for treatment in the ladle furnace and from there on to the continuous casting plant, as shown in **Fig. 10**.

Production of different types of steel

The induction furnace is suitable for producing different types of steel, from simple construction steel through to high-alloyed special steels. Differing requirements are thereby placed on both the treatment equipment and on the melting process, as the following examples show.

When smelting construction steel on the basis of scrap with a suitable chemical composition, the melt is finished in the induction furnace without subsequent treatment and is fed directly to the continuous casting plant [15]. In the majority of cases, however, the quality of the scrap metal available requires that a ladle furnace is placed in-between. This desulferizes and deoxidizes the melt, adjusts its composition and temperature, cleans it with argon bubbles and subsequently finishes it ready for casting (Fig. 10). In this respect, dephosphorizing and decarburizing are an additional task, one performed by the melting unit "electric arc furnace" by oxygen blowing during the melting process. It is recognized that this is not possible in an induction furnace due to the inadmissibly

Fig. 12: Type ABP IFM 30 t crucible furnace for 18 MW converter rating, installed at Viraj, Tarapur, India

high refractory wear which then occurs and the unsuitable surface/volume ratio of the furnace. If decarburizing and/or dephosphorizing are required due to the quality of the scrap metal, either a special ladle furnace is deployed or an electric arc furnace with low connected load is used as treatment equipment.

When producing alloyed steels, the induction melting system delivers together with an AOD converter (or a vacuum plant) as per **Fig. 11** the liquid charges for the continuous casting plant. In this context, the high yield of the ferroalloys used in the melting unit can be seen as the main economic advantage of induction furnaces compared to electric arc furnaces. A further advantage results from the relatively high carbon content of such premelting. In contrast to the cases described above, this enables a 100 K lower tapping temperature with a correspondingly longer refractory service life, whilst at the same time consuming less energy.

The particular benefits of melting stainless steels by induction have been reaped by the Indian steelmaker Viraj (one of the largest producers of long products made of stainless steel) for some time now. Due to the positive experiences made, an induction melting system is now being constructed for the works in Tarapur Maharashtra, near Mumbai, which will initially consist of three 30 t crucible furnaces each with a connected load of 18 MW. As can be seen from the plant diagram in Fig. 10, two of the 30 t furnaces (**Fig. 12**) run in melting mode and deliver a 50 t melt charge in hourly cycles. These melts are then finished in the AOD converter ready for subsequent continuous casting, as shown by the diagram in Fig. 11. The third furnace waits for the periodic installation of new refractory and sintering, as described above in the "Design" section. The next stage of the project foresees the installation of two further three-furnace-sets, each of these with a capacity of 47 t, likewise with 18 MW power supplies.

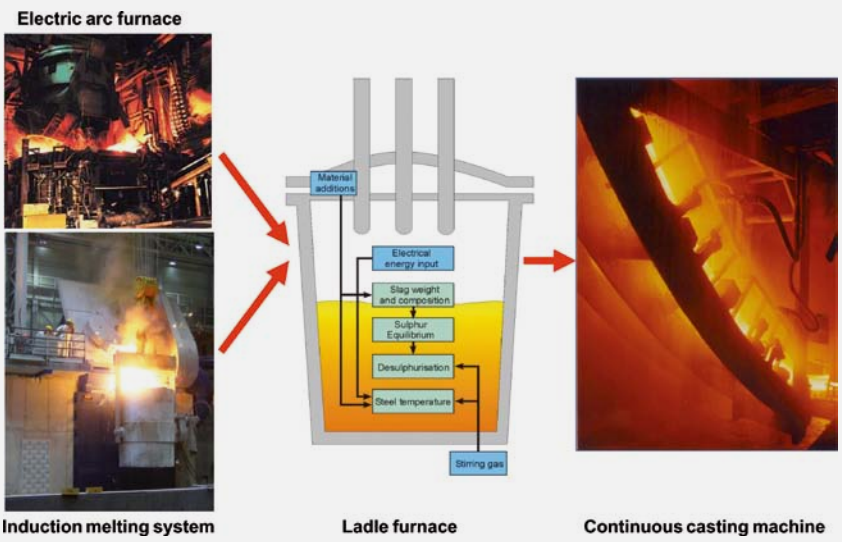

Fig. 13: Melting of structural steel in the electric arc and the induction furnace; treatment of the common charge in the ladle furnace, followed by continuous casting [14]

Combination of electric arc furnace and induction furnace

NASCO has operated an induction system in its electric steel works in Dammam, Saudi Arabia, since the end of 2008 as an additional melting unit to the electric arc furnace to produce over 900 kt/a of construction steel [16]. As shown in **Fig. 13**, 100 t liquid charges are produced in 55 min cycles. The electric arc furnace melts an 80 t charge (consisting mainly of direct reduced iron) which is supplemented with 20 t of melt from the induction furnace. The 100 t charge put together in this way is treated in the ladle furnace, as described in the foregoing section, and subsequently transported to the four-line continuous casting facility. The induction system consists of two 23 t crucible furnaces with a 16 MW/250 Hz-TWIN-POWER® energy supply fed from a diesel generator system. One furnace runs in melting mode whilst the other is kept on stand-by waiting for new refractory to be installed. Shredded scrap in differing quality is used as melting stock.

The photograph in **Fig. 14** shows the crucible furnace at the front being held in reserve whilst

skimming is performed in the second during a trial run. The charging vehicle can be seen in the foreground, this is driven backwards for loading with the shredded scrap depicted in **Fig. 15** b underneath one of the two supply containers (Fig. 15 c). The melting stock is transported from the scrap yard (Fig. 15 a) in baskets on carriages with weighing equipment and filled into the supply containers. Fig. 15 d shows the 12 t capacity charging vehicle from the rear.

The induction furnace being used for melting operations is run in charge mode in order to produce 16 to 23 t charges per hour (depending on the specifications of the electric arc furnace) at full output, around the clock, seven days per week. The service life of the refractory lining made from spinel-forming Al_2O_3-dry mass meanwhile averages 100 charges, which is a consumption of 3.25 kg mass per ton of melt. No repairs are needed except minor maintenance work on the pouring spout and in the upper section of the furnace. The evenly worn crucible is rather pressed out completely with the hydraulic press-out equipment after around four days in operation. Whilst the second furnace takes over melting operations for the next four days, there is then enough time to install new refractory, which can be accomplished in 1½ days in an emergency. The option of liquid sintering is particularly beneficial here, in that the sinter melt is poured from one furnace to the other from a stopper ladle.

The shredded scrap used provides the steel melt in the induction furnace with a composition suitable for producing construction steel:

0.233 C/ 0.026 S/ 0.021 P/ 0.613 Mn/ 0.087 Si/ 0.066 Ni/ 0.07 Cr/ 0.152 Cu/ 0.005 V/ 0.015 Sn/ 0.005 Al.

After reaching the tapping temperature of 1,650 °C, the melt is usually poured without skimming into the 100t ladle and, after filling the 80t EAF charge, fed to the ladle furnace.

After almost three years of trouble-free operation, NASCO's induction system has now proved its high availability and economic efficiency. This is shown in **Table 3** by the operating figures for the induction furnace updated by A. Phillips [16] in comparison to the electric arc furnace, which demonstrate a cost benefit of 15 US$ per ton of melt.

Melting ferroalloys in the most powerful induction furnace in the world

The Chinese steelmaker TISCO (Taiyuan Iron Steel Co. Ltd.) operates a steel works in Taiyuan with an output of 10 Mt/a, of which 3 Mt/a are stainless steels. It is planning to significantly expand its operations by 2015, this mainly involving the production of high-alloyed steels. As these are to be primarily produced via the route "blast furnace/ oxygen converter", it is necessary to add the ferroalloys to the melt in liquid form. The intention is to produce 180t liquid charges in hourly cycles, so that the alloy melts are required in quantities of up to 60 t/h. The induction melting system in question consists of three 65 t tandems, each equipped with an inverter output of 42 MW due to the high energy requirement of ferrochrome. In this case,

Fig. 14: Induction-furnace tandem installed at NASCO STEEL, showing a crucible furnace during slag tapping, charging car visible in the background [16]

Fig. 15: Supply of scrap to the NASCO STEEL induction-furnace installation: a) scrap storage, b) shredder scrap, c) scrap hopper in front of the furnace platform, d) charging car for conveyance of scrap to the furnace platform and continuous charging into one of the crucible furnaces [16]

Table 3: Consumption statistics for induction and electric-arc furnaces, in US $/t [16]

	Induction furnace	Electric arc furnace
Shredded scrap	313	310
Electrical energy (IO: 520 kWh/t)	18.7	16.1
Refractory (IO: 100 charges/lining)	6.0	1.6
Electrodes	0	9.7
Fluxing agent	0	4.7
Oxygen	0	2.3
Alloy materials	5.5	13.4
	343.2	**357.8**

too, one furnace in the tandem system will run melting mode, the other held on stand-by ready for installing new refractory and sintering, whereby separate power will be supplied by 2 MW-IGBT inverters. It is planned to commission the first 65 t 42 MW tandem by the end of 2012. The system represents an enormous leap in the development of induction furnace technology, breaking new ground for the deployment of such furnaces.

CONCLUSION

Global production of electric steel, in line with total steelmaking across the world, has more or less recovered from the collapse in 2008/2009, reaching 411 Mt/a in 2010. Further growth in electric steel is highly likely due to the continued rise of steel production in general and to the greater use of direct reduced iron. Whilst the electric arc furnace has been deployed in the past as the traditional melting unit, experiences made with induction furnaces for smelting carbon steels, although above all alloyed steels, lead one to expect that the induction furnace will become established as an alternative electrical melting machine in steel works. This is particularly attributable to the latest developments in induction technology, where electric energy supplies delivering over 40 MW are being built for crucible furnaces with capacities of over 65 t. Apart from the deployment of such high performance induction furnaces for melting steel from scrap or even from direct reduced iron in mini-mills, these are also suitable for melting the ferroalloys which are added into the unheated ladle in liquid form during the production of stainless steel. It can be forecast with great certainty that induction technology will build upon its established status in foundries and that a new area of application will open up with its deployment in steelmaking.

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