

Channel-type versus coreless induction furnaces

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The company Marx gives an overview of the different types of induction heating units for melting, holding and holding/casting furnaces. This paper focuses on coreless inductors and on their advantages over channel type inductors when it comes to holding/casting of special aluminium alloys. It illustrates and explains this comparison for the case of a holding/casting furnace in an aluminium semi-fabrication plant in Europe which was modified from a channel-type furnace to a furnace with coreless inductor

technology. The paper gives technical information comparing in detail the new benefits, such as an increased service life of the furnace of up to three years with the crucible inductor. Specifically, this revamp and upgrade of a 28 tonnes holding and casting furnace with a power of 200 kW converted it to 40 tonnes and 450 kW, as demonstrated by construction and field results.

Basically two different kinds of induction furnaces are used for melting, holding and cast-

ing of metals: the channel-type induction furnace and the coreless type induction furnace.

The channel-type induction furnace consists of a refractory lined furnace body made of steel to which one or several channel-type inductors are flanged for heating the metal. Due to effects like thermal conductivity and buoyancy of the hot melt, in most cases the channel-type inductor is flanged at the bottom of the channel type furnace body. This results in the typical design of a small to medium-sized channel-type melting furnace like that shown in Fig. 1.

Depending on the function of the furnace in the production line other furnace body designs may be appropriate, placing the channel inductor in other positions. Channel-type induction furnaces are used for copper and copper alloy melting, as the copper is sensitive to oxygen pick-up from the air at a turbulent surface. Channel-type furnaces offer a smooth bath surface, but still provide a sufficient turbulence inside the melt to mix it and ensure uniform chemical composition and temperature. These are also the preferred type of furnace for holding and casting of copper and copper alloys (Fig. 2).

Another application for the channel inductor is the holding of iron melts in huge storage furnaces or holding/casting furnaces with flanged forehearth, these being used in automatic high-speed sand mould casting lines.

Channel-type furnaces have a much higher electrical efficiency than coreless furnaces, but when it comes to iron and steel melting (high power density required) and frequent alloy change, or the need to empty the furnace regularly, the coreless furnace is the preferred choice as melting for holding/casting furnaces.

A third version of induction heating is a so called 'coreless inductor'. Coreless inductors were already being used at the beginning of the 1980s for heating holding furnaces in the aluminium and copper casting industries, typically for holding furnaces in continuous casting lines. Such inductors consume more energy than a channel-type inductor, but they offer much longer lifetime and they allow easy emptying the holding furnace on a regular basis (Fig. 3).

Marx has gained an extensive experience in modifying existing holding furnaces from being heated by channel-type inductors to being heated by coreless inductors. Such a refurbishment and modification can increase holding capacity, precision and power efficiency. Changing the old conventional tap switch power cabinet for a more economical IGBT transistor converter cabinet also allows a precise holding/casting temperature regulation of the melt.

Such a furnace refurbishment will be illustrated and explained using the example of a 28-tonne holding furnace at a prominent semi-fabricator plant in the European aluminium slab casting industry. This customer has been operating eleven units with 20- to 30-tonne holding furnaces, these being fed with liquid metal by gas heated melting furnaces, which supply the liquid metal by tilting into a semi-continuous vertical casting line (Fig. 4).

The holding furnaces had been equipped

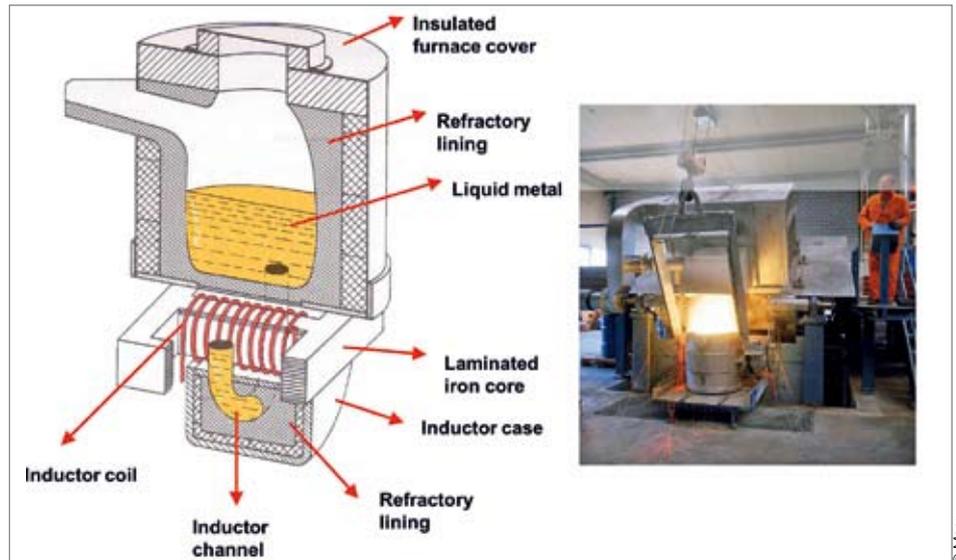


Fig. 1: Different types of induction furnaces – channel-type furnace

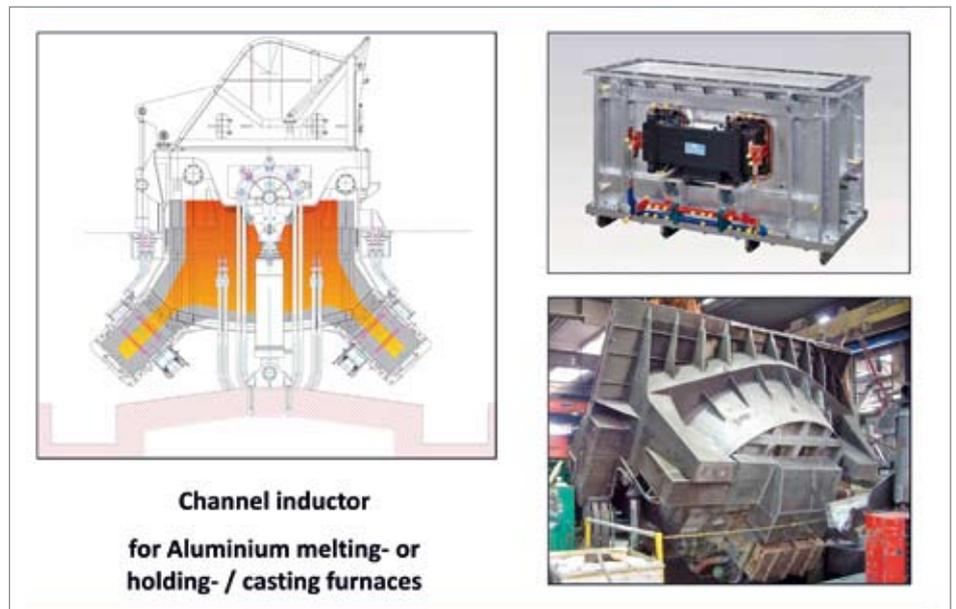


Fig. 2: Channel inductor – Aluminium

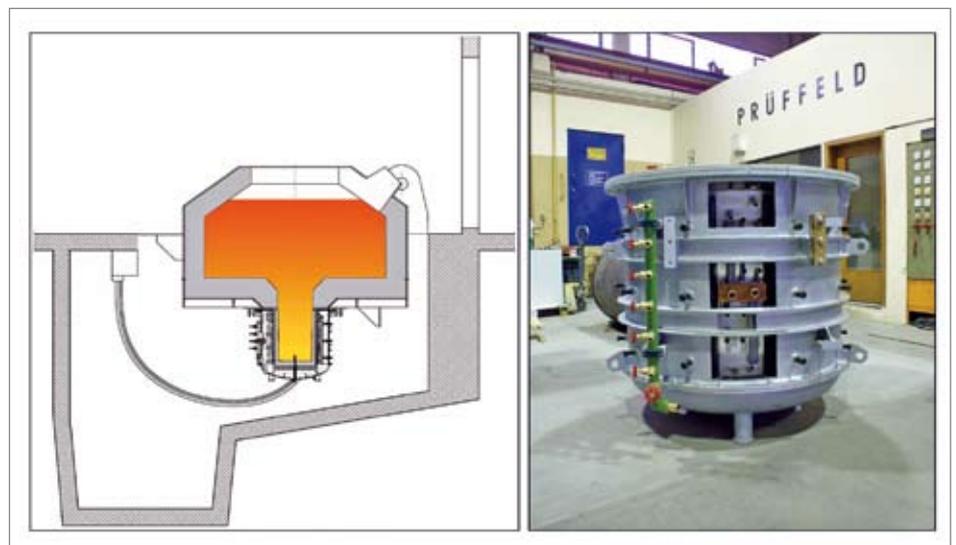


Fig. 3: Different types of induction furnaces – furnace heated by coreless inductor



Fig. 4: Channel inductor, 28-tonne capacity

Crucible inductor, 40-tonne capacity

with 200 kW channel-type inductors, but these required weekly cleaning due to clogging of the channels. Cleaning represents in significant production downtimes as well as difficult and time-consuming maintenance. In addition, the furnaces needed five to six inductor changes per year at one holding furnace, resulting in additional maintenance costs and production downtimes.

Converting an existing furnace involves first collecting the furnace's structural data. It is useful and recommendable to visualise this structure in a 3D image. Then we must decide whether the furnace volume will remain unchanged or whether the furnace casing should

be enlarged. For this purpose, we must subject the unit needs to static and dynamic functional testing and check the complete movement (tilting, driving) devices and power input. Calculations have to prove whether these components must be replaced by more powerful ones.

On the construction site itself, the disconnection of the old lower furnace body structure is prepared and carried out. The welding area is being mechanically and technically prepared and the new substructure is positioned on the contact surface and then welded onto the furnace (Figs 5 and 6).

The new furnace substructure supports the receiving structure for the crucible inductor that is installed later on. After successful welding and structural support, the furnace is ready to undergo welding analysis and, after approval, needs to be prepared for a new lining.



Fig. 7: 40-tonne holding and casting furnace, ready for production

Construational conditions, such as the furnace pit, are also checked in terms of spatial geometry. The necessary clearance spaces for more expansive tilting movements may require structural changes; this however is normally not the case (Fig. 7).

In terms of cost saving and production increase, such conversion is amortised in less than one year. For operating personnel, handling becomes much easier. So far, Gautschi has retrofitted or has prepared for retrofitting some 30 such furnace plants. It is nearly always possible to use the existing furnace ves-



Fig. 5: Separation of existing substructure



Fig. 6: Mounting prefabricated new substructure



For 50 years, the Marx group in Germany with its approximately 100 employees has been working in the furnace industry. The company's activities include planning and manufacturing of induction furnace plants, engineering, development, remanufacture, modernisation and retrofitting of induction furnace plants, service and customer support. The company has therefore gained extensive experience in working on almost all types of induction furnaces. Nearly every type of furnace has been serviced, repaired, retrofitted or modernised in its facilities. Its German sites in Iserlohn, Hennigsdorf, Donauwörth and in Youngstown, Ohio/USA provide well-aimed proximity to their customers in Europe and the United States.

Comparison over the year	
Furnace with channel inductor	Furnace with coreless inductor
Cleaning cycles	
52 cleaning cycles 3 man-days each (1,248 h)	no cleaning cycles
52 production downtimes due to cleaning 2 x 24 h each (2,496 h)	no production downtime due to cleaning
Inductor change	
At least 5 inductor changes / shutdowns for repair 10 man-days each (400 h)	1/3 – 1 vessel change / shutdowns for repair (1-3 man days → 8-24 h / 3 staff)
5 production downtimes 5 x 24h each (120 h)	1/3 – 1 production downtimes 10-30 h
At least 5 repair deployments €10,000/piece each → €50,000	1/3 – 1 repair deployment €10,000/piece each → €3,300-10,000
Refractories	
5 levelling processes and conditioning work on rectangular flange 5 x 3 h (15 h)	1/3 – 1 levelling process and conditioning work on round flange 1-3 h

Table: Comparison over the year

sels, to shorten them at the bottom and to fix a new substructure, thereby completing the refit within quite a short time, with good preparation in approximately four weeks. The coreless inductor is simply bolted on to the

lower furnace body. If it wears out, it can be changed within a time frame of 24 to 30 hours maximum from pouring the furnace vessel empty to its restart. The cost-benefit equation in relation to channel furnace versus crucible

furnace is surprisingly overwhelmingly clear in favour of the crucible furnace (see Table):

As already mentioned, the modification period can be used to change the old conventional-style power supply against a more efficient new converter power supply. Using an infinitely variable power supply via transistor converter in IGBT technology provides for automated and visualised control of the holding and casting process and, at the same time, allows for monitoring the condition of the crucible inductor itself.

It is clearly worthwhile to examine existing furnaces and to retrofit them with modern technology. This keeps melting and heating technology one step ahead of the market.

Authors

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