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The CONTIROD Furnace Concept at MKM
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Abstract
The MKM Contirod line has been equipped with three induction furnaces to assure excellent metal quality, precise temperature control and high process reliability. A deslagging furnace splits the line into an open and a closed part. The holding furnace primarily has a buffer function with metallurgically important features, and finally the casting furnace offers a safe and reliable metal dosing system for the Hazelett caster. The paper provides a description of the furnaces and their operational results since 1999.
Introduction
The furnace concept in a conventional rod line is based on a shaft melting furnace, a first transfer launder with an integrated deslagging box, a gas-fired holding furnace and a second transfer launder with stopper controlled outflow into the Hazelett tundish. This concept, shown in Fig. 1, has been proven for years and is successfully working and considered as a standard in more or less all rod lines all over the world.

Fig. 1: Furnace arrangement in a conventional Contirod-line

Although this furnace concept does its job, there are some natural limitations concerning its process capabilities:

- Deslagging is not 100% especially during startup or if a significant portion of return scrap is used.
- The superheating power of the holding furnace is relatively poor.
- Temperature control during startup is sometimes difficult.
- The holding furnace function is more or less limited to a buffer function for startup and stop. There are no metallurgical or thermal dwell time functions.
- Precise control of residual Oxygen is difficult.

When MKM started the Contirod project, it was the basic idea not only to eliminate the above disadvantages but also to go a step further in the direction of metal cleanliness and a possible OFC copper rod production in future. Accordingly, for their furnace concept the following considerations were most important:

- The line should clearly be separated into an open and a closed part.
- The copper temperature should be actively controlled along the whole line.
- Only „soft“ heating should happen and severe superheating being avoided.
- All furnaces should provide good mixing capabilities.
- The furnace atmosphere should be precisely controlled.
- The line should be automatized as much as possible.

Based on these expectations an induction furnace concept has been developed which in the meantime has been proven to fulfill all the above conditions.
The MKM Contirod concept

Fig. 2 shows an overview of the MKM Contirod line as it is in operation in Hettstedt since 1999. Besides the well known shaft melting furnace it is equipped with three induction heated furnaces: one deslagging furnace, a holding furnace and a casting furnace. The corresponding side view is shown in Fig. 3.

Fig. 2: Layout of the Contirod furnace arrangement at MKM

Fig. 3: Schematic side view of the MKM Contirod line. The (right hand sided) casting furnace is actually arranged 90 degrees backwards
At a first sight the line of course becomes more complicated by so many furnaces and it is therefore worth while to have a closer look to the individual furnaces and to discuss the expected benefits individually.

**The deslagging furnace**

Besides liquid copper just above the melting point, every shaft furnace also produces some unavoidable slag which has to be removed out of the line. Fig. 5 shows the design of a corresponding deslagging furnace with a capacity of 6 tons and an integrated inductor connecting the two furnace chambers by means of a syphon. The molten copper enters the furnace via a launder and flows continuously into the slag collecting chamber. This chamber can be opened by a hydraulically actuated cover for skimming which is easily done during operation from the backside of that furnace.

From the deslagging chamber the copper enters into a transfer chamber from which it flows through a tube into the holding furnace. On its way the copper has to pass three submerged inductor channels which totally have a heating capacity of 250kW. They are used to compensate heat losses and to allow a soft temperature increase from about 1100 to 1120 degrees C. For this, the furnace power is controlled by a submerged thermocouple.

Mechanically the furnace is composed of three parts which are flanged together. Therefore the inductor can be exchanged analogously to an attached conventional channel inductor type. All the lining material is dry ramming silica refractory.
Concerning its deslagging capability this furnace is superior to a conventional deslagging box because when entering the chamber the metal flow speed is slowed down significantly due to the relatively big volume. In addition the connecting channels position is deeply arranged under the melt level. Both features guarantee a 100% separation of the shaft furnace slag from the line under all operational conditions. Depending on cathode quality skimming is necessary about 2-3 times per shift for high and about 5 times per shift for lower grade cathodes.

On the other hand, the only opening of the transfer chamber is the overflow tube guiding the slag-free and slightly heated molten metal into the holding furnace. Therefore the atmosphere can be easily controlled and any contact to air is safely avoided. As a result this furnace clearly works as a separator between the more or less open melting part and the closed buffer and casting part.

**Holding furnace**
The overall shape of the MKM holding furnace is very much similar to the conventional Contirod dum-type holder, offering a continuous and controllable outflow independent of
the flow rate of the incoming metal amount. But instead of gas burners it is heated by
two channel type inductors and the syphon-type outflow picks up the metal well
underneath the bath level avoiding any open spout area. Both features are state-of-the
art in OFC production lines where practically the same furnace type is used as a melter
of preheated cathodes.
In Fig. 6 the arrangement of the MKM holding furnace is shown. The furnace is equipped
with 2 channel inductors. It has a total capacity of 47t of which 34t are useful. During
regular operation the useful metal content is kept at about 12t.
The heating power capacity is 500 kW controlling the holding temperature to about 1135
°C.

Fig. 6: Drum-type holding furnace

As a result, the following features can be attributed to this holding furnace concept:

- The inductors provide excellent mixing and efficient heating
- The metal temperature can be precisely controlled and refers to the complete
  furnace content
- The furnace offers a real mass and heat buffer
- Mixing results in partial degassing due to charcoal contact
- Width to height ratio is not critical
- Atmosphere control is easy
- Environmental improvements are obvious

In general, the furnace stabilizes the whole process a lot and assures a consistent and
stable metal quality.
Casting furnace with forehearth

Fig. 7 shows the MKM twin chamber casting furnace with an integrated 250 kW inductor and a holding capacity of 9 t, of which 3 t can be effectively used. The furnace has a forehearth which extends above the casting machine and from which the metal is poured into the Hazelett tundish. The flow rate is controlled by a stopper using the mould level signal of the caster. The bended shape of the forehearth has been chosen to provide an excellent view on the mould metal level inside the Hazelett caster.

Compared with a conventional casting launder, the forehearth flanged directly to the furnace has the advantage that it does not have to be additionally heated with gas burners during casting, as the heat losses are compensated by the direct contact with the metal heated by the inductor. The forehearth merely has to be heated up automatically approx. 15 minutes before the start of casting. Furthermore, the metal arrives at the stopper without the casting stream otherwise necessary, thus significantly reducing contact with the air.

At the end of casting, the furnace is tilted back to empty the forehearth into the furnace and to expose the nozzle. On the rear of the furnace is a deslagging opening through which the furnace can also be completely emptied.

The metal supply from the holding furnace enters the casting furnace directly through the tilting axis via a runner. This charging situation was chosen so that the furnace can be continuously charged with metal in both tilted positions, i.e. before the start of casting, and in working position as well.

In addition to the features known and proven for years in conjunction with forehearth furnaces, the MKM furnace is equipped with a weighing device. The cells are located
between the furnace vessel and bogey in order to allow the furnace weight to be monitored continuously during the whole casting process. This incorporation of weight monitoring into the furnace control concept prevents both overfilling and excessive discharging of the furnace, assures a continuous and determined metal flow to the caster, and so represents a further step towards a fully automated casting line.

Summary
Induction-heated holding furnaces have already become an integral part of upgraded continuous casting concepts. The combination of deslagging, holding and casting furnace for the MKM Contirod line, for instance, forms a recent and prominent example of such a milestone into future production lines. It features precise temperature control, high dosing precision and constant metal quality.