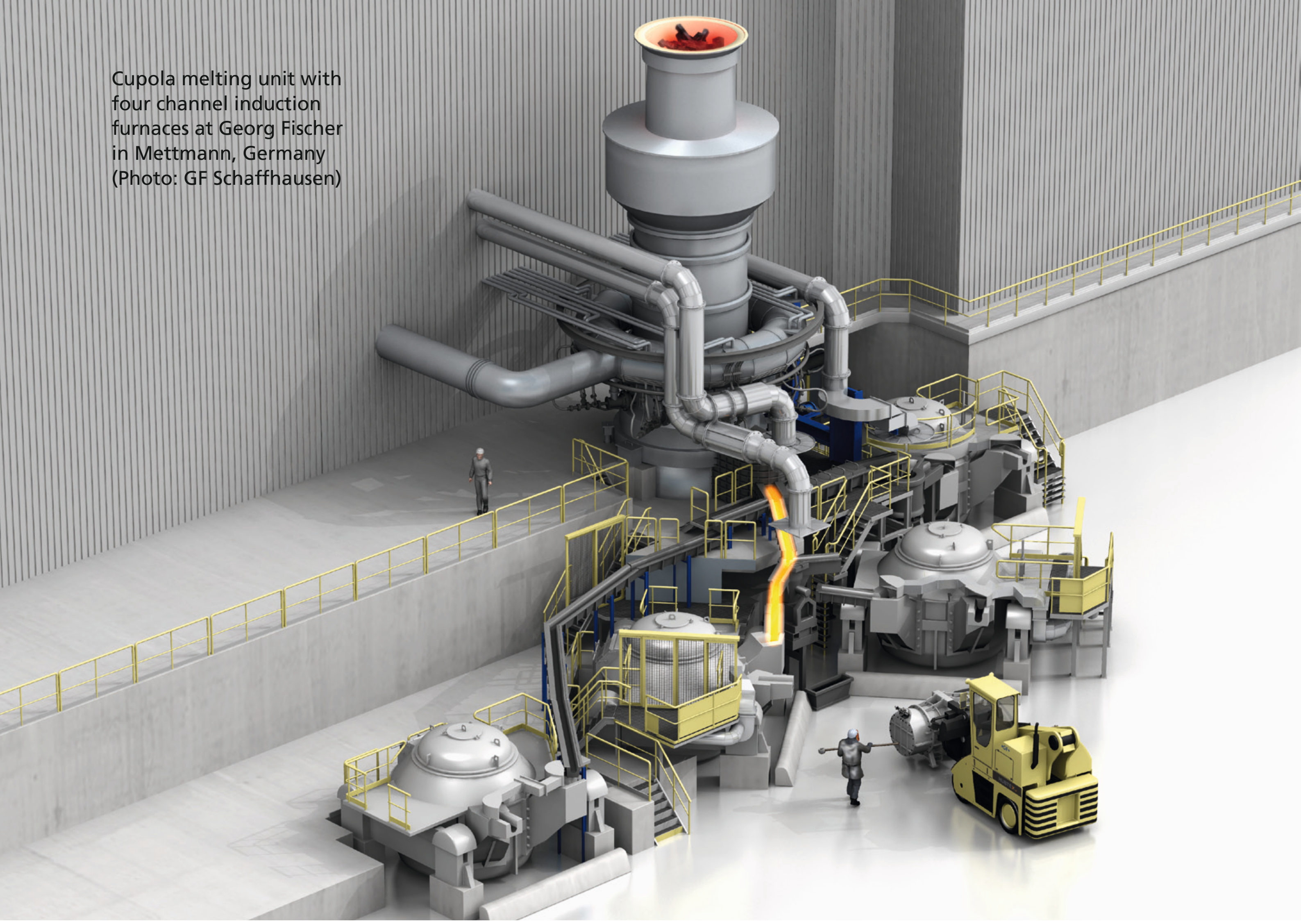

Cupola melting unit with four channel induction furnaces at Georg Fischer in Mettmann, Germany (Photo: GF Schaffhausen)

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High-capacity cupola feeds four channel induction furnaces

Georg Fischer (GF) has recently commissioned a new production line for light-weight iron castings at its Mettmann, Germany, location. Like in the existing manufacturing lines, the liquid iron is supplied by a hot blast cupola via downstream channel induction furnaces. To cover the extra peak demand and for risk considerations, it has become necessary to install a fourth channel induction furnace, which like the other three storage furnaces receives the metal from the cupola directly via open channels. Experience from the existing metal storage equipment gained by both the furnace operator and the furnace builder, ABP Induction Systems GmbH based in Dortmund, Germany, has been taken advantage of in the design and installation of the final arrangement of four channel induction furnaces. This applies not only to the furnace and inductor technology but also to the innovative water-hydraulics systems and the control system that monitors furnace and inductor operation

The GF Automotive business area of Georg Fischer AG develops and manufactures castings made of iron, aluminium and magnesium for chassis, drive train and structural components in passenger and utility vehicles with some 5,500 employees at twelve production sites in Germany, Austria and China as well as at two development centres in Switzerland and China. The biggest foundry within this business area is Georg Fischer GmbH & Co. KG in Mettmann, Germany. Here, about 1,000 employees produce ductile iron castings (GJS) of a total weight

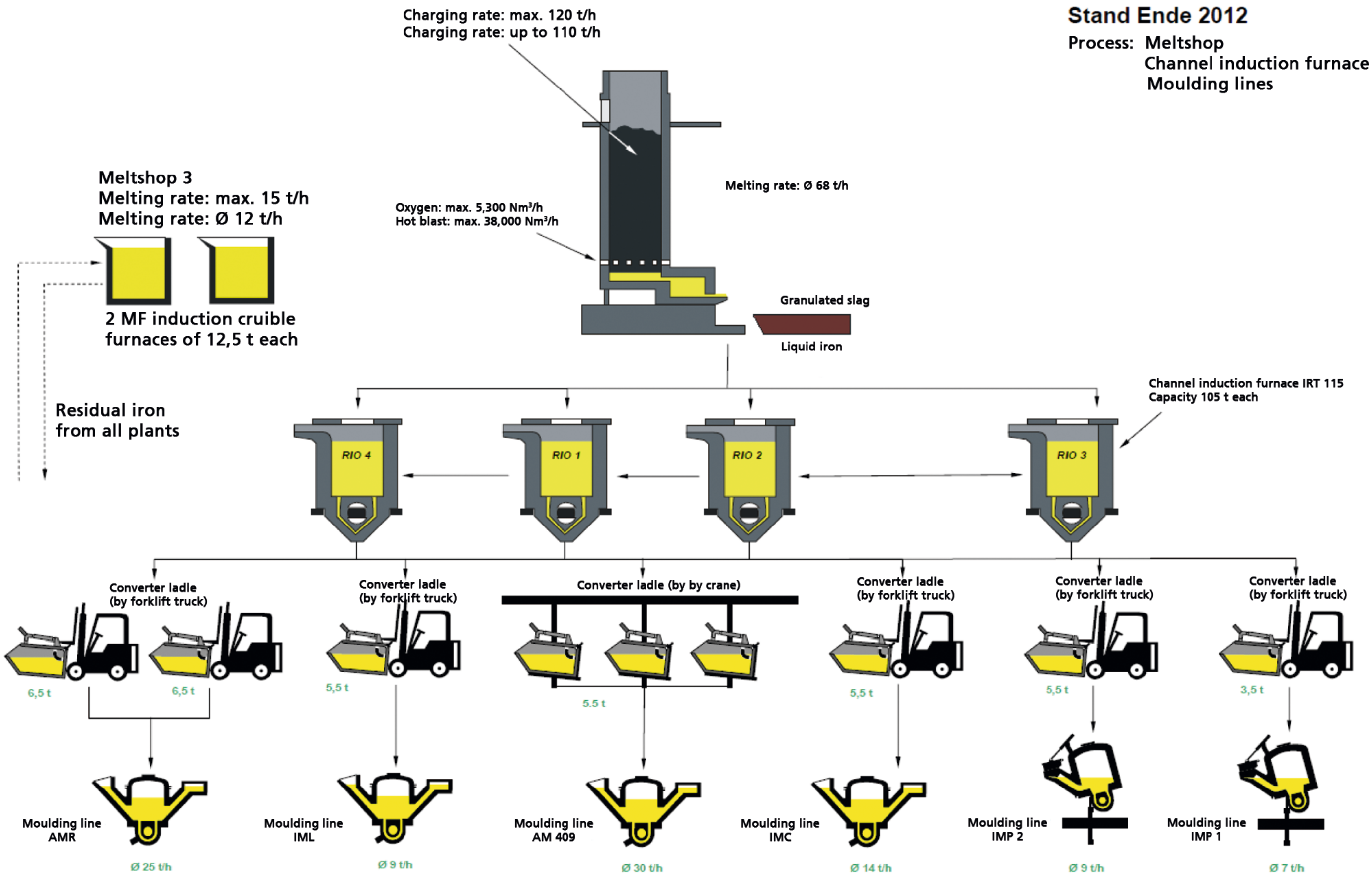

Figure 1: Supply of liquid iron to the six manufacturing lines at Georg Fischer Mettmann (Photo: Georg Fischer Mettmann)

of 200,000 t/year. Georg Fischer produces the wide range of ductile iron and SiboDur castings for world leading automotive producers on five production lines. A sixth line (AMR) for light-weight chassis components and crank shafts for passenger cars is currently being built (**Table 1**). The meltshop in Mettmann, which can produce approx. 400,000 t/year of liquid iron, mainly consists of a cupola with three downstream channel induction furnaces and of two induction crucible furnaces. The major share of the production is accounted for by the cupola/channel furnace route with a production rate of 70 t/h. The induction crucible furnaces are used as backups and for melting specialized batches.

Molding line	Installed in	Flask format (mm)	Capacity Max. (molds/h)	casting weight (kg)
AM 409	1974	930 x 705 x 320/320	330	180
IMC	1992	960 x 710 x 250/200	225	100
IMP 1	1996	960 x 710 x 200/200	134	100
IMP 2	1999	1020 x 760 x 200/200	134	100
IML	2002	1020 x 760 x 200/230	140	100
AMR	2012	1050 x 900 x 250/250	240	205

Table 1: Manufacturing line in the foundry of Georg Fischer in Mettmann

The base metal produced in the cupola, the central melting unit, is batchwised charged via a runner system in turn into one of the three channel furnaces. The magnesium treatment takes place in 5.5 t (or 3.5 t) GF converter ladles. The ladles are transferred by forklift trucks to the pouring furnaces of four molding lines and by crane to the pouring furnace of the fifth molding line. The base metal ready for casting for the grades GJS 400 through GJS 800 and SiboDur 450-17 through SiboDur 700-10 is stored in the three channel induction furnaces. The final analysis, especially the final carbon content, is set during converter filling.

The task

When the new AMR production line is up and running, the specific peak demand of liquid iron will rise by approx. 20 t/h. This extra demand will be covered by a cupola capacity increase to up to 90 t/h. Then, the three channel induction furnaces will for logistic reasons no longer suffice as storage and buffer units to ensure that the manufacturing lines are continuously supplied with the various alloys as required. This problem has been solved by the installation of a fourth channel furnace. Like the existing three storage furnaces, this new furnace will also be directly fed with molten metal via open runners connected to the cupola. The liquid iron will be discharged into 6.5 t GF converter ladles, in which also the magnesium treatment will take place. Forklift trucks will transfer the GF converter ladles to the pouring furnace of the AMR. **Figure 1** is a

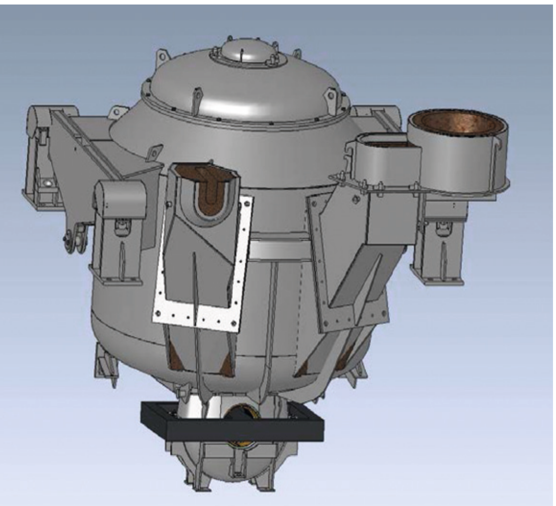

Figure 2: ABP channel induction furnace, type IRT 115 (Photos: ABP Dortmund)

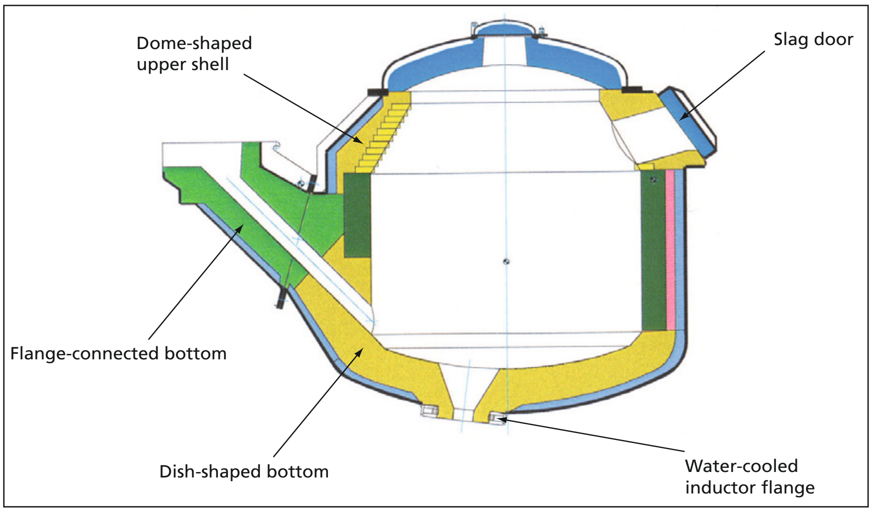

Figure 3: Section through the IRT furnace vessel

Figure 4: Water hydraulics system for tilting the channel furnaces (Photo: Georg Fischer Mettmann)

schematic illustration of how the metal supply of the six manufacturing lines will look like in the final expansion stage, including the new AMR. Design and installation of the fourth channel furnace as an integrated part of the multi-furnace storage unit is being provided by ABP, a leading manufacturer of channel-type induction furnaces. The design is based on technology of BBC and ASEA, from which ABP has emerged.

Induction furnace design

Like the previous three channel induction furnaces, also the fourth furnace will be an IRT 105 type furnace from ABP (**Figure 2**). It mainly consists of the furnace vessel, which has a total capacity of 105 t and a useful capacity of 90 t, the inductor with a design capacity of 1,200 kW fed by a mains-frequency switchboard and a water-hydraulics system for forwards and backwards tilting.

The furnace vessel (**Figure 3**) has a ball-type shape as a result of the dish-shaped bottom and the dome-shaped upper shell of the vessel. This design offers thermal benefits and favourable conditions for the life of the refractory lining. Feeding and tapping of the metal takes place via siphons, the upper ends of which are near the tilting axis of the furnace. This makes it possible to fill in and tap metal at the same time. A flange-connection provided to disconnect the upper part of the siphon facilitates mechanical removal of baked-on material from the siphon mouth.

The tilting system is made up of a hydraulic cylinder arranged in the middle of the furnace and a double bearing. This enables the furnace to be tilted forwards for tapping and backwards for deslagging. When the furnace needs to be tilted through 90° for an inductor change, the tilting movement can be made in either direction, depending on which is the most convenient position for fixing the flange connection. The three existing channel furnaces were retrofitted from oil to water hydraulics based on an own development by GF Mettmann (**Figure 4**). This solution is more favourable not only because it affords the benefit that it uses a lower-cost, non-inflammable medium but also because it is more environmentally friendly, insurance payments are lower and downtimes can be reduced. For these reasons, it was decided that the same technology was to be used with the new channel furnace.

The inductor is fixed to the vessel bottom by means of a water-cooled flange. This flange connection is designed in such a way that the surface of the inductor refractory lining is flush with the lining of the inductor neck, while a gap remains between the two flanges, as shown in **Figure 5**. This solution ensures not only that there is sufficiently tight form-fit contact between the refractory linings but also that the gap between the furnace flange and the inductor flange provides the possibility of monitoring the sensitive interface between the inductor and the furnace vessel by optical devices and measuring systems

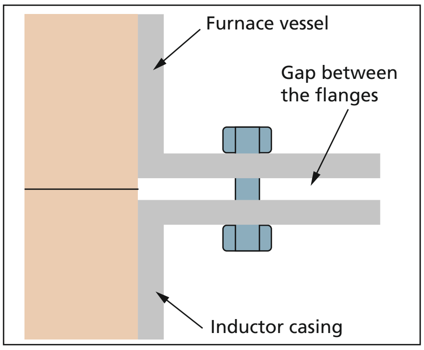

Figure 5: Gap between the inductor and furnace neck flanges (Photos: ABP Dortmund)

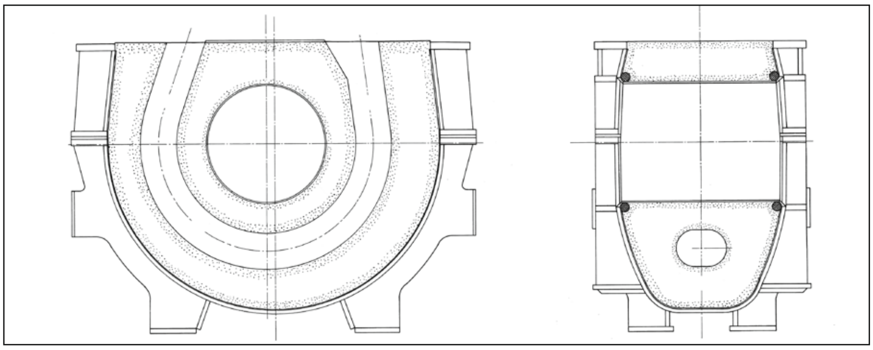

Figure 6: Longitudinal and cross-sectional drawings of the 1,200 kW ABP inductor

[1]. The inductor casing is also water-cooled and designed as illustrated in the longitudinal and cross-sectional drawings shown in **Figure 6**. The refractory lining surrounding the inductor channel has the same thickness throughout, without any corners. This provides optimal conditions for uniform sintering and prevents stress cracks in the refractory lining.

Power input is via a mains-frequency switchboard equipped with a step-voltage transformer and balancing device. This conventional solution was favoured to the solution with stepless voltage regulation by an IGBT converter in order to have on the new channel furnace the same proven equipment as on the three existing ones.

The refractory lining of the furnace vessel consists of insulating, safety and wear lining. On top of two layers of insulation bricks, which have a total thickness of 140 mm, there is a safety lining made of 30-mm-thick fireclay plates. The safety lining is covered by the wear lining which consists of a 270-mm-thick dry ramming mass on the basis of tabular alumina. The inductor is lined with a spinal-forming dry mass consisting mainly of 85 % MgO and 12 % Al_2O_3.

Control of furnace and inductor operation

Monitoring the proper functioning of the inductor plays a key role in ensuring reliable operation of the channel furnace. In addition to regular inspections, especially of the flange connection, the following measures are performed [2]:

» monitoring of heat losses via the separate cooling circuits for the furnace flange, upper and lower shell, inductor coil and particularly the cooling jacket;

» monitoring of the active and reactive power as well as the resistance

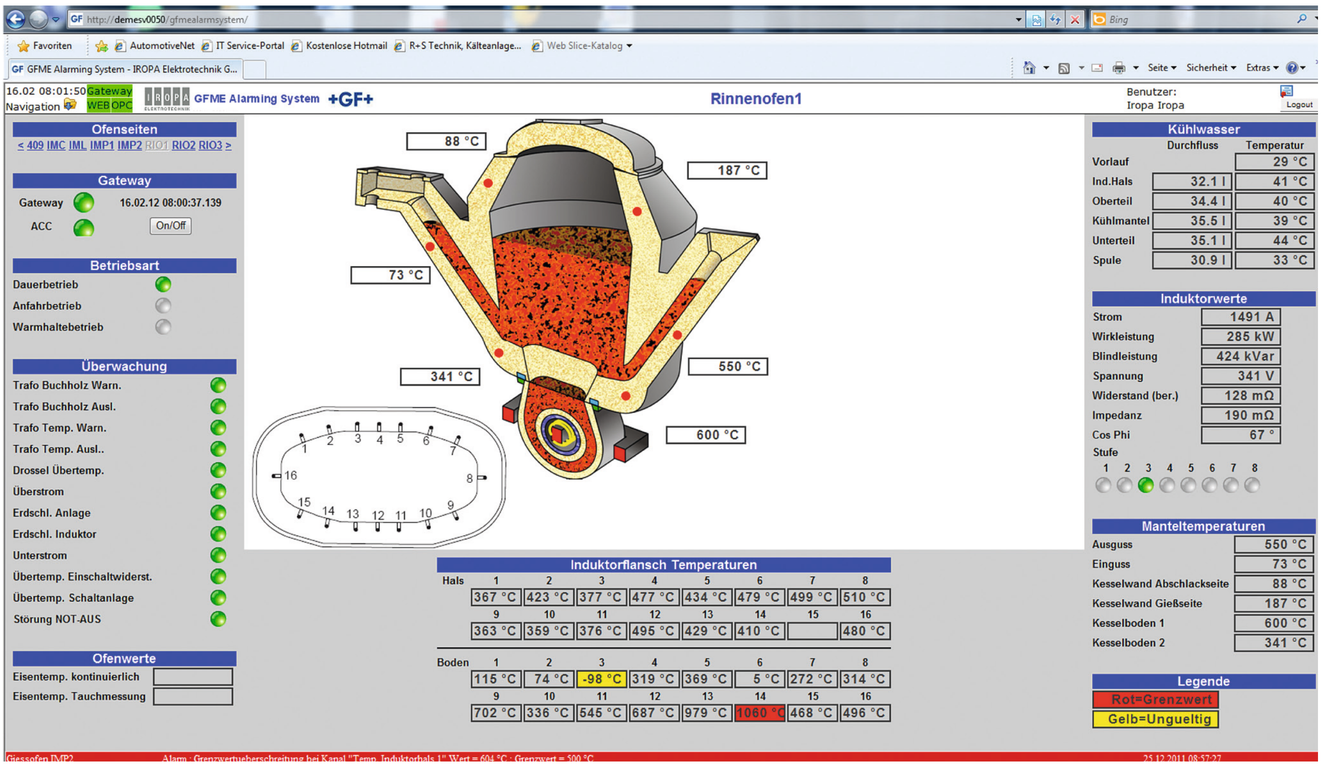

Figure 7: Control mask for monitoring furnace and inductor operation (Photos: Georg Fischer Mettmann)

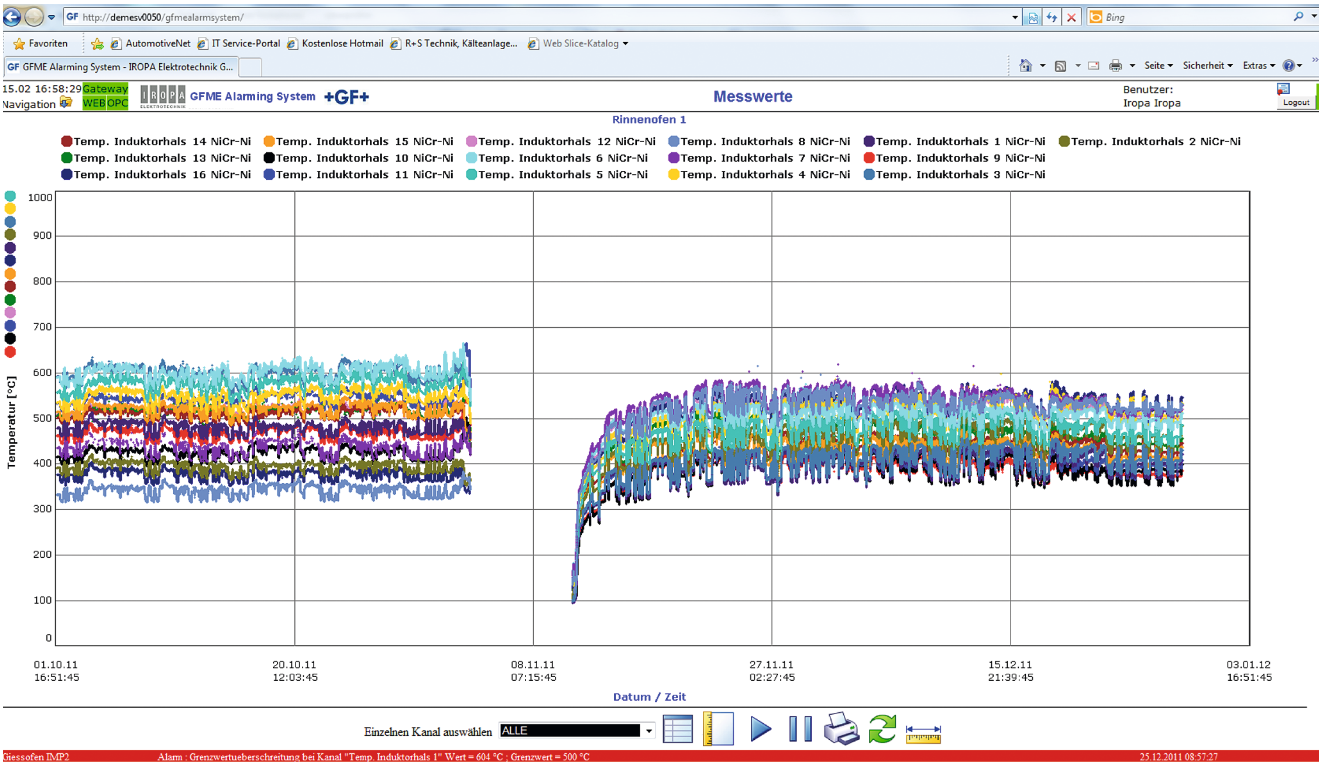

Figure 8: Time trend of the temperatures at the interface between the inductor and furnace neck lining

between the melt and the cooling jacket;

» continuous temperature measurement by thermocouples installed in the furnace bottom and other relevant positions of the vessel as well as between the flanges.

Figure 7 shows the control mask of the monitoring system. Here all relevant data are compiled. In the block on the left, the current operating modes and any malfunctions are displayed for the main furnace components. In the upper section of the block on the right, flow rates and temperatures of the cooling circuits for the inductor neck, the upper and lower shell as well as for the cooling jacket and the coil are shown. Below that block, the electrical parameters of the inductor are given, with the most important indicators of the wear status being the active and reactive power and the insulation resistance between the molten metal and the cooling jacket. The last block at the bottom lists the temperatures measured at significant positions of the jacket. These measurement points and temperatures are also shown in the drawing in the middle of the display. Below the drawing, the temperatures measured by the 16 thermocouples are given. These thermocouples are installed at a defined depth along the interface between the refractory linings of the inductor and the furnace neck. In the case shown, these temperatures range between 359 and 510 °C. Accordingly, there is no metal penetrating into the interface. All data characterizing the current state of the furnace and the inductor are visualized and documented. Based on these data, analyses of frequency of trouble and time-trend analyses can be performed. **Figure 8** shows as an example measurements by the 16 thermocouples in the inductor neck before and after an inductor change. For the assessment of the wear conditions of the inductor, the inductor diagram which gives the time trends of the reactive and active power is of special importance. In combination with the current trends of the insulation value and of the heat losses in the cooling jacket, a reliable assessment can be made as to when the inductor will have to be exchanged. The underlying criteria and their interpretation are explained in [1].

Installation of the fourth channel furnace

Retrofitting the third channel furnace (RIO 3) had been a challenging task at the time. An even greater challenge was the installation of the fourth furnace (RIO 4), which on the one hand had to ensure that the metal could be directly fed from the cupola and on the other hand had to provide for the convenient tapping of the base metal into the 6.5 t GF converter ladles carried by fork lift trucks. The adopted solution is shown schematically, though true to scale, in **Figure 9**. The tapping siphon of RIO 4 is easily accessible from the maneuvering area in the meltshop. The feeding channels have been arranged around RIO 1 at a distance that will not hinder the backwards tilting of RIO 1 for deslagging. The channel system for RIO 4 is almost 20 m long, with a 3.3 % slope. At a feeding rate of up to 90 t/h, this results in a cross-sectional area in the channel of about 200 cm².

The inlet of the channel system into the furnace siphon is of special importance. **Figure 10** shows the design of this L-shaped channel flanged to the inlet siphon. This design has proved

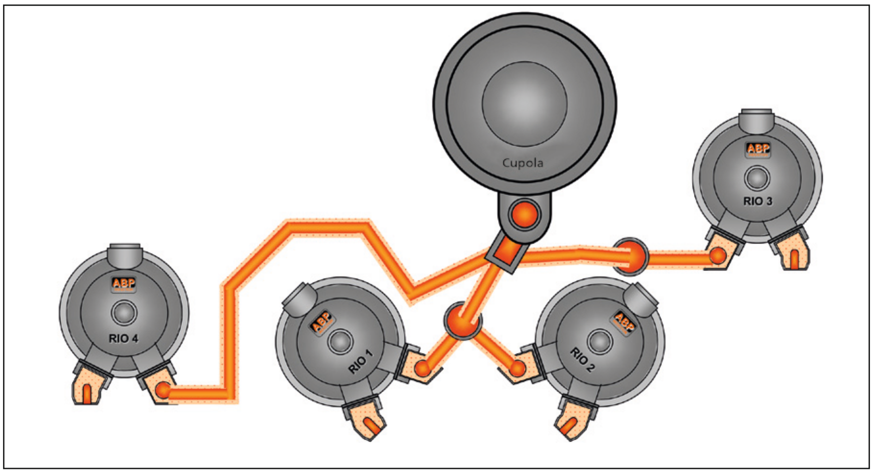

Figure 9: Arrangement of the metal storage system behind the cupola, consisting of several induction furnace (Photos: ABP Dortmund)

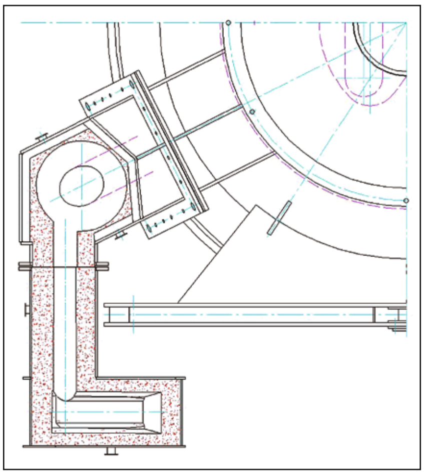

Figure 10: L-shaped channel for continuously feeding the melt into the induction furnace siphon

very successful on the existing channel furnaces. On the one hand, it has the task to divert the metal flow coming from behind RIO 1 through 90° into the siphon inlet, as shown in Figure 9, on the other hand, it compensates the movement of the siphon inlet taking place as the furnace is being tilted by providing the possibility of lengthwise varying the impingement point of the pouring stream released by the feeding channel.

Summary

The cupola in the foundry of Georg Fischer GmbH & Co. KG in Mettmann, Germany, produces approx. 400,000 t/year of liquid iron in ductile iron and SiboDur grades for the supply of up to now five molding lines via three channel induction furnaces. The investment in a new manufacturing line required the installation of a fourth channel furnace, which would also receive the molten metal directly via open channels from the cupola. All four channel furnaces, built by ABP Induction Systems GmbH in Dortmund, are of the same design (type IRT 115). Each one has a capacity of 105/90 t and is equipped with 1,200 kW inductors. The tilting systems of the furnaces have been retrofitted from oil to water hydraulics. The inductors have a lifetime between five and nine months. The length of the lifetime is decisively influenced by the amount of baked-on oxides in the area of the inductor neck. Furnace and inductor control is via a monitoring system which continuously measures, visualizes and documents the temperatures at significant points of the furnace and inductor, the heat loss from the various cooling circuits as well as the electrical parameters of the inductor.

www.abpinduction.com
www.automotive.georgfischer.com

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