We understand Metals
Process optimization by numerical simulation

- Hot gas flow regime
- Electromagnetic field effects
- Solidification of metal melts
Dear Customers and Business Partners,

Crucial sectors of the industry – like metalworking industry, machinery & equipment manufacturing and the automotive industry – are currently experiencing the impacts of a severe crisis all around the globe.

Above and beyond the need to cope with the downturn in business financially, structurally and economically at present, setting the right strategic course for the future is a matter of great consequence as well.

Apart from setting up our business processes to efficiently match an appropriate level of business volume, it is the development of new technology that forms the basis and the driving force for a long-term success of our company. This has been true for more than 85 years – ever since our company was founded – and will hold true in the time to come. It is indeed part of our company philosophy to shape competition by offering outstanding technology at reasonable prices.

An important tool we are using today is numerical simulation: With suitable formulation of boundary conditions, numerical models form the basis for the design of concrete industrial solutions – theory forms the basis of professional practice.

Have a look at some interesting examples in the present Junker News.

Sincerely,

Hans Rinnhofer

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Uwe Zulehner – new Managing Director of INDUGA

Dipl.-HTL-Ing. Uwe Zulehner has been appointed Managing Director of INDUGA Industrieöfen und Giesserei-Anlagen GmbH & Co. KG in Cologne with effect from 1st July 2009. He is responsible for Sales and Engineering of the company that has been associated with OTTO JUNKER GmbH since early 2006. In this capacity he will run the business of INDUGA together with Markus Schmidt, Chief Commercial Officer of the company.

Uwe Zulehner studied engineering at the Höhere Technische Lehranstalt für Bergbau und Metallurgie in Leoben/Austria. He started his industrial career in 1997 as a technical assistant in the melting operation of Breitenfeld Edelstahl in Mitterdorf/Austria. From 1998 till 2001 he was Marketing and Product Manager for functional refractories with the focus on steel converters at RHI Refractories AG in Vienna/Austria. Another milestone in his professional life was his engagement in the copper melting plant division of MAERZ-Gautschi Industrieöfenanlagen GmbH with its headquarters in Düsseldorf/Germany from 2001 till 2007, where he started as Sales Manager and then advanced to the General Manager of the copper business unit. It was in this period that he published papers dealing with industrial furnace manufacture for secondary copper refinement and two patents were granted. During his time with MAERZ-Gautschi Mr. Zulehner spent three years together with his family in Brisbane/Australia running the international business.

Before joining us, Mr. Zulehner was working with the Küttner Group as Director of Küttner Non Ferrous GmbH in Essen, Germany.

‘I look forward to joining Induga and despite the currently difficult overall market situation...’
This article describes the development of a new type of strip flotation furnace realized in close cooperation with the Technical University of Aachen (RWTH). The aim of this development was to design a furnace capable of handling higher temperatures and thicker strip material than its predecessors.

Maintaining the strip afloat in the furnace requires a specific total outlet pressure from the nozzle system. This outlet pressure is generated by means of fans. Evidently, thicker strip needs higher pressures to build up an adequate supporting gas cushion. Moreover, the gas flow velocity and dynamic pressure essentially determine the system's power consumption. Since the high pressure needed to convey more heavy-gauge strip will tax the fans to the limits of technical feasibility, a different solution had to be found. The basic idea was to arrange two fans in series in the manner known, e.g., from pump technology.

For the application on hand, a configuration was selected with two fans for the bottom nozzle array and one fan for the top nozzle array, cf. Fig. 1. The advantage of this design lies in the fact that the top and bottom sections of the furnace – i.e., the nozzle systems – are mutually independent. This creates more leeway for ensuring strip stability, etc.

The upper fan draws protective atmosphere from the furnace chamber and blows it towards the second fan. With the pressure upstream of the second fan thus increased, the second fan merely needs to boost this pressure marginally to achieve the pressure level required at the nozzle array. In order to examine
The new furnace generation is aimed at applications in the medium power range. Its development was based on the expertise gained with many successful OTTO JUNKER medium-frequency melting systems. The entire furnace design has been reviewed and optimized with the aid of advanced computing and numerical simulation methods.

One main characteristic of this new-generation equipment is its power saving and cost-efficient design. Capacities range from 2 to 6 tonnes (relating to cast iron). The electrical power input ranges from 1 to 4.8 MW. Along with many improvements in detail, a special melt processor with touch screen operation (M2F Touch Screen) has been incorporated.

With design now complete, sales of the new furnaces have commenced as of now.

If you have any questions regarding the new furnace generation, please do not hesitate to get in touch. Your contact is Mr. Donsbach (+49 2473 601 207).

Hansjörg Hoppe (+49 2473 601 284)
Günter Valder (+49 2473 601 328)
On high-powered medium-frequency furnaces (approx. 1,000 kW per tonne of furnace capacity) used for melting cast iron, metal spatter from the bath surface will occasionally be observed in the melt superheating phase. This phenomenon has been found to occur mainly when the furnace is full, i.e., at bath levels significantly above the top edge of the induction coil. One cause of such metal splatter is the boiling reaction that is a function of temperature and carbon and silicon concentrations of the melt.

\[
\text{C} + \text{O} \rightarrow \{\text{CO}\} \\
2\text{C} + (\text{SiO}_2) \rightarrow \text{Si} + 2\{\text{CO}\}
\]

This CO gas formation may set in quite vigorously as soon as the boiling temperature is reached, particularly with thin-walled or rusty charge material which drives up melt oxygen levels.

To gain a more accurate understanding of this process that will help in devising countermeasures, the energy, heat and material transfer phenomena taking place inside a medium-frequency furnace were studied in greater detail with the aid of coupled numeric flow and temperature field computing. It was found that high flow velocities in the upper part of the crucible and the presence of a pronounced meniscus can prevent the occurrence of metal splatter. Presumably, under normal conditions, the CO bubbles formed in the melt are dragged away by the strong bath flow, escaping into the atmosphere via the pronounced meniscus. Permanent melt degassing will thus take place without any interference by metal splatter.

If, on the other hand, the melt is prevented from continuously degassing in this manner, larger gas bubbles will form and will ultimately develop enough buoyancy to rise abruptly to the surface which they will then penetrate with force, causing the melt to splatter.

The correctness of this description is confirmed by tests and observations made on coreless induction furnaces in several foundries.

The study has laid the groundwork for the creation of designs and operating regimes for coreless induction furnaces whereby metal splatter from high-oxygen melts can be reduced.

In planning new installations, the furnace rating, operating frequency and coil arrangement can thus be optimized accordingly. It is also possible to run the furnace at a lower frequency in the superheating phase through the use of a frequency changeover feature (multi-frequency technology). This will result in a more pronounced meniscus and more vigorous surface flow, thus preventing molten metal splatter.

Coreless induction furnace with pronounced meniscus and high melt flow velocity (Left: Calculation of the flow velocity in m/sec Right: Calculation of the temperature field in °C)

A similar challenge is encountered in melting down galvanized steel scrap, where the problem lies in the associated formation of zinc vapour bubbles in the melt. Here, too, a "custom" control of the bath movement can help in the management of outgassing phenomena.

Wilfried Schmitz (+49 2473 601 441)

News

Another OTTO JUNKER channel furnace for an Italian foundry

Fonderia Corrà, a renowned foundry based in Thiene/Italy, has ordered an 85-tonne channel-type induction furnace system from OTTO JUNKER for use in the company's existing cupola melting operation. Molten iron is to be continuously transferred from the cupola to the holding furnace via a system of launders. The channel-type furnace has an overall capacity of around 100 tonnes and is powered via a 1000 kW IGBT converter system. This is enough to superheat 21.2 tonnes of liquid iron by 100 K per hour. A JOKS melt processor, acting in conjunction with a precise weight sensing system, ensures an accurate temperature and process management. Work is currently proceeding at full speed to complete the system. Its delivery is scheduled for July of this year.
Newly founded Zeitzer Guss GmbH uses OTTO JUNKER melting equipment

The successful company Silbitz Guss GmbH established a new foundry for the production of large hand-moulded castings of up to 30 metric tonnes unit weight in Zeitz, Germany. These castings are primarily used in the energy field (power stations/wind power plants). Only 20 km from the company’s headquarters, an all-new foundry was erected on the premises of ZEMAG Zeitz, a former company with a very long tradition.

The melting plant was ordered from OTTO JUNKER mid-2008 and successfully commissioned in April this year.

The formal inauguration ceremony for the new foundry was solemnly conducted by the two managing directors, Dr. Wolfgang Maruschky and Dr. Frank Göttert, on June 25, 2009. Saxony-Anhalt’s Minister-President, Professor Dr. Wolfgang Böhmer, pushed the starting button of the new furnace plant after the first pour had been initiated by Dr. Göttert following the tradition.

The foundry is equipped with a 25-tonne medium-frequency melting furnace plant. With its electrical power rating of 6,000 kW, the unit provides a melt output of 11.5 tonnes/hour. The furnace itself has a power consumption of 505 kWh/t at a melt temperature of 1,500 °C.

The furnace features a back-tilting system and a deslagging spout to facilitate the slag removal operation.

Our scope of delivery further comprised a longitudinally movable charging chute plus the entire water re-cooling system. The latter is equipped with separate systems for the furnace circuit and the switchgear circuit. The furnace circuit has a glycol-free air-to-water cooler developed by OTTO JUNKER.

Jörg Andrejewski
(Tel. +49 2473 601 208)
One more OTTO JUNKER system for ELVAL

At the Inofita rolling mill operated by ELVAL, the Greek aluminium producer, several OTTO JUNKER furnace systems have been successfully in service for years. The company’s equipment pool comprises two chamber furnace systems for annealing strip coils, a cooling chamber and charging machine as well as two pusher furnaces for preheating and homogenizing rolling ingots. In the spring of 2009, OTTO JUNKER was awarded the contract for supply of an additional chamber furnace for the heat-treatment of strip coils.

As the new chamber furnace will supplement the existing production environment, it is designed to be loaded and discharged via the present charging machine. In the same way, the existing cooling chamber will also serve the new furnace.

As the new unit is intended to heat-treat strip of varying aluminium alloy compositions and thicknesses in the 0.2 to 12.7 mm gauge range, it must provide the associated flexibility. Thus, annealing temperatures may range from 150 to 580 °C at furnace throughputs of between 2.4 and 4.4 tonnes/hr.

The furnace can be charged with 3 jumbo coils (of up to 2.6 m in diameter), or 4 standard coils, up to a maximum charge weight of 90 tonnes. As an indirect natural gas-fired chamber-type furnace it is designed to operate both under protective nitrogen atmosphere or under air. It is divided into three fan sections, with two recuperative radiant tube burners per section. The fans are arranged in the furnace roof; heating ducts with integrated double-P shaped radiant tubes are mounted to the side of the useful chamber.

The furnaces are equipped with the proven nozzle array to produce short heat-up times and a uniform temperature distribution. The swirl nozzle system with its star-shaped configuration of slot nozzles plus an array of three frequency-controlled recirculation fans ensure a rapid and uniform heating process with minimized energy input. As a result, the furnace can be run in higher temperature regimes without risking local overheating of the coils. The coil face temperature is monitored by press-on thermocouples of a new design, so that even a charge comprising differently sized coils can be uniformly heated.

Temperatures are controlled separately for the right- and left-hand side of each fan section, so that a total of 6 independent control zones is available.

In conjunction with the high-convection heating principle, this design provides a ± 5 K control accuracy in the 150 - 580 °C load temperature range.

Work on the detailed engineering of this furnace is currently proceeding at full speed. Its delivery to the customer is scheduled for the end of this year. Higher productivity despite lower energy consumption were the key arguments in favour of OTTO JUNKER.

Bernd Deimann (Tel. +49 2473 601 241)
Lambda control – active fuel control for billet heaters
saves energy and the environment

The first air/gas control for gas-fired industrial furnaces has stood the test under real operating conditions. After several months of commercial multi-shift operation on a gas-fired rapid heater for aluminium extrusion billets operated by Hydro company in Uphusen, Germany, the system has delivered very positive results. Gas savings in the order of more than 10 % were achieved easily. Of course, these savings could also be translated into increased throughput capacity.

This innovative development takes into account the ever-changing variables of gas/air mixing, which have so far been neglected. Ambient conditions, air temperature and pressure, humidity, gas quality, and actual output requirements are parameters measured and evaluated for furnace control.

HIGH-TEC Engineering GmbH has focused its development efforts in the field of gas-fired industrial furnaces on gas mixers, burner nozzles and this lambda control, which has already been patented.

OTTO JUNKER GmbH is the exclusive contracting partner for application, sales and service. Joint trials and projects have paved the way to the leading market position we hold.

It is only through the newly developed applications in ‘open’ gas-firing systems that lambda control, which is known from car engines, can now be used in this field. Comparative measurements prior to and after installing the lambda control have confirmed improvements, or energy savings, amounting to more than 10 % on average.

The only modification required (for each furnace control zone) is the installation of the pilot burner with integrated lambda probe for measurement of the current values, a motor-controlled gas valve and the integration into the furnace control system.

We have achieved the said improvement by installing the lambda control system, new burner nozzles and mixers, of course perfectly tailored to suit the overall concept.

Key improvements through use of the lambda control:

- stable and uniform combustion quality
- optimum adjustment of furnace control to partial and full load conditions
- reduction of energy consumption or increase of furnace throughput
- improved and constant exhaust gas quality through optimum combustion

There is a proper economic relationship between the cost of this modification and the result thereof – not even taking into consideration the emission reductions achieved.

Oliver Flamm (+49 2473 601 211)
Assuring the safety of controlled atmospheres – continuous strip annealing lines with controlled atmospheres containing up to 25 % H₂

OTTO JUNKER GmbH is the leading manufacturer of continuous strip processing lines for copper and its alloys.

A broad spectrum of complete OTTO JUNKER furnaces and equipment designs matching diverse customer needs is available for the continuous processing of ultra-thin to heavy-gauge copper and copper-alloy strip in applications ranging from recrystallization and solution annealing to surface treatment.

Strip in the 0.05 to 2.0 mm thickness range is annealed in strip flotation furnaces at temperatures up to 850 °C (within limits up to 900 °C).

The continuous passage of the strip through the flotation furnace makes for a defined short annealing cycle capable of providing a homogeneous strip temperature distribution and hence, uniform material properties.

In order to meet today's increased production technology and quality demands on specific product types, OTTO JUNKER also supplies strip flotation furnaces operating under a controlled hydrogen/nitrogen atmosphere of up to 25 % H₂ in N₂.

Major benefits of a 25 % H₂ in N₂ atmosphere over conventional equipment running with max. 5 % of hydrogen, are the superior convective heat transfer, markedly increased reduction (i.e., anti-oxidation) performance, and the much cleaner material surface obtained.

Aside from these production engineering benefits, however, the combustion and explosion characteristics of a 25 % H₂ atmosphere pose exacting requirements on furnace design, mainly in terms of explosion prevention technology.

In close cooperation of OTTO JUNKER and TÜV Nord, a hazard assessment has been developed and refined over a number of years. This hazard assessment takes into account the various furnace conditions as well as the substance characteristics of the protective gas, inert gas and air atmospheres across all possible concentration and temperature ranges. The result is an explosion protection concept incorporating indispensable explosion-protection measures as part of the fundamental design of the strip flotation furnace.

This explosion protection concept is basically achieved through effective sealing of the furnace from the ambient atmosphere, the general prevention of potentially explosive areas, and the separation between air and the 25 % H₂ in N₂ atmosphere (inertising concept). The approach is pursued further at the level of the control and analytical system design (equipment concept). Here, key aspects include the configuration and evaluation of the systems monitoring the oxygen and furnace chamber pressures. All equipment is selected and configured in line with the safety category stipulated in the explosion protection concept.

The latter is rounded out by an on-site acceptance process in which the system's protective features are checked on site by TÜV Nord.

Consequently, a fully tested and safe installation will be handed over to the customer. Most recently, the furnace control configuration and interfacing with peripheral equipment have been based on the use of a fail-safe Siemens automation system. The advantages of this control technology lie in the fact that programmed protective functions can be simulated prior to commissioning, so that start-up times will be markedly reduced. Less hardwired programming of the type known from conventional safety technology will further accelerate the commissioning process.

System diagnosis features and an online remote access capability enable rapid fault identification and troubleshooting. The ability to adapt software and control systems flexibly to individual process conditions and furnace designs, bearing in mind the requirements of the hazard assessment, is likewise highly beneficial.
Thanks to the concept outlined above, OTTO JUNKER equipment embodies a high degree of automation, meets exacting process safety standards, and is noted for greatly reduced failure probabilities.

Two strip flotation furnaces for operation with a protective atmosphere of up to 25 % H₂ in N₂ – both embodying the new control system – are currently being commissioned.

OTTO JUNKER has sold 6 lines using a high-hydrogen protective atmosphere technology at the global level since 2000, and all are operating successfully.

Jörg Neuhaus (+49 2473 601 364)

INDUGA to supply brass pouring furnace

As part of an extensive upgrade of its vertical-type continuous caster, DIEHL Metall placed an order with INDUGA in late January 2009 for a channel-type induction furnace for holding and pouring of brass.

The new forehearth-type pouring furnace replaces the existing furnace having reached the end of its life. The new installation will have an overall capacity of 20 tonnes and is to be heated by a channel inductor with a rated output of 500 kW. The order also comprises a new electrical powerpack and advanced furnace control equipment.

The furnace can be hydraulically tilted and rolled back on a bogie to perform setup or maintenance work on the continuous caster.

Molten metal is provided by three coreless-type chip melting furnaces arranged one three sides of the pouring furnace. The pouring furnace is filled through three filling gates.

The commissioning of the pouring furnace will be in the 4th quarter of 2009.

Alejandro Hauck (+49 221 95757 24)
Numerical simulation – the modern tool of foundry operators

About 30 years ago Prof. Dr. Dr. h.c. Peter Sahm laid the foundations for numerical simulation at the Foundry Institute of the Technical University RWTH Aachen. In these early days, however, operators smiled at this condescendingly with statements like “Look at these computer casters”.

Very soon, however, the tremendous benefits of this technology were realized in foundry circles. Expensive trials for optimum design of castings could be replaced with numerical simulation.

Time savings also were significant, since pattern changes and optimization steps no longer needed to be done on the pattern or mould itself but directly on the computer.

The high-grade steel foundry of OTTO JUNKER GmbH recognized this great potential at a very early stage and supported the development of this technology by way of research projects financed by the OTTO JUNKER Trust.

Since as early as 1992 numerical simulation has been used successfully in our special-steel foundry. This tool is of paramount importance, especially for jobbing foundries operating on a contract basis. In the jobbing business, the numbers of castings to be produced are typically small and casting defects or expensive practical tests for casting design would render the job unviable economically.

This is why numerical simulation is used to optimize intricate parts with high quality requirements prior to any real casting operation. The objective of numerical simulation is to translate theoretically determined casting and gating parameters into real life.

A machine bed of approx. 2,300 kg casting weight is a typical example. We have optimized the mould filling (Fig. 1) and solidification behaviour (Fig. 2) of this casting by numerical simulation on the computer. Quality check of the prototype (Fig. 3) impressively confirmed the results of simulation.

Numerical simulation offers a wide range of features in the preparation and design stages to ensure cost-efficient manufacture and high castings quality.

Elmar Westhoff (Tel. +49 2473 601 400)
Many years of experience plus advanced simulation methods ensure success

The dynamic behaviour of liquid metal flows and hot gases, as well as the solidification of metals and the flux pattern of electromagnetic fields, have one thing in common – they are too complex to be theoretically described and captured with the aid of physical formulae alone.

While a steady-state process may still be calculable, individual parameter changes in time may influence the overall system in ways which elude adequate and precise mapping.

By developing a model which represents a mathematical abstraction of the system under investigation, the influence of individual parameters can be examined. In a simulation, this theoretical model is studied to gain insights into the real-life system.

However, it should be borne in mind here that any mathematical model employed can only depict reality with more or less precision. A model necessarily involves simplification, and its results need to be interpreted accordingly. The findings derived from it must therefore be verified through investigations or measurements on scale models or in laboratory-level trials (so-called physical simulation) before they can be deemed valid.

Through numeric simulation followed by validation of the computed results, one can progress from the more or less "empirical" fundamentals of furnace design and advance towards precise, optimized design solutions.

At the same time, this approach creates the basis for designing high levels of safety and reliability into new applications, technical innovations and new developments, and into tomorrow’s larger and more powerful furnace systems.

Many time-consuming, expensive experiments on real-life equipment can thus be largely avoided. The same holds true for the technological preparation of product casting processes.

Without simulation of the solidification cycle it used to be necessary to conduct multiple trial castings with different pouring system configurations and unfinished product designs before a reliable casting process was achieved. By simulating the solidification of the melt, it has become possible to optimize technological processes quickly and cost-efficiently.

In the future, simulation will play an increasing role in industrial equipment planning and process optimization, as well as in training and instruction environments. Real-life applications also exist, e.g., for training operators and maintenance personnel.

The experience, knowledge and skills accumulated by our staff over many years, combined with the benefits of numeric simulation and advanced computing techniques, guarantee the continuing optimization of OTTO JUNKER equipment and technology.

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