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Fachausschuss
Geschichte

4. Gießereihistorisches Colloquium 2019
4th Colloquium of Foundry History 2019

Saturday/Samstag, 29.06.2019
in German only

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Föhlan – Innovative corrosion protection for zinc die casting

T. Herper, Adolf Föhl GmbH + Co KG, Rudersberg-Necklinsberg/Germany

The presentation is divided into four parts:

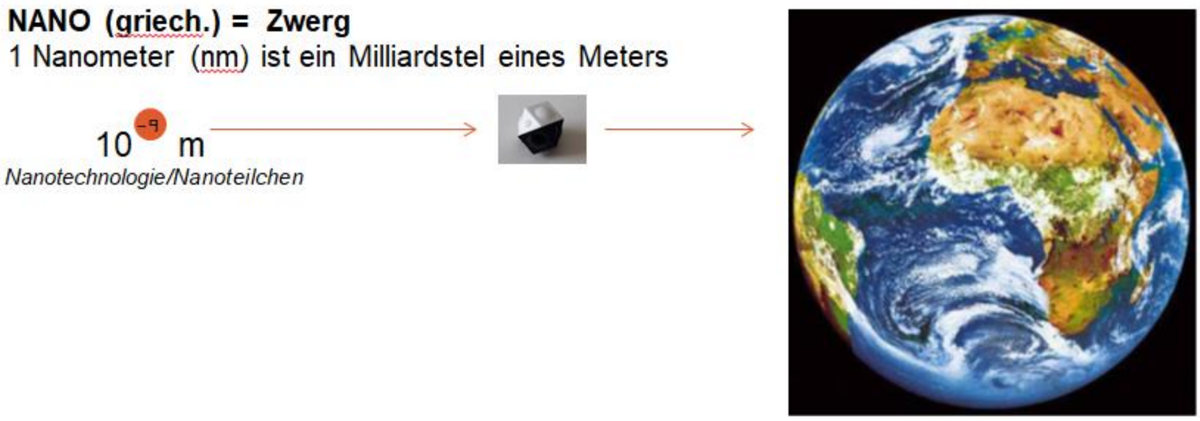
In the first part, the layer structure and the mode of action of the new process will be described and compared with the galvanic process. Especially addressed are the advantages of the process and the associated system technology. The significantly better environmental sustainability of the new process is highlighted.

The second part describes the actual coating line and previous findings and results with specific regard to corrosion protection and abrasion resistance. The results are sometimes significantly better compared to the galvanic process.

In the third and fourth part, we present the economic benefits of this process, the difficulties of the series introduction in Germany and Europe as well as the first results of the line produced and launched in China.

FÖHLAN

Dünnschichtpassivierung von Bauteilen



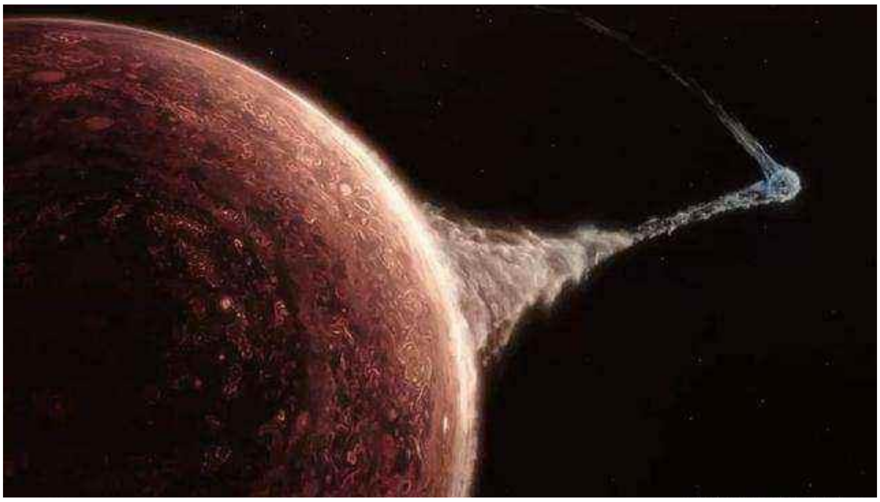
Ein Nanometer zu einem Meter entspricht dem Größenverhältnis eines Tipp-Kick- Balles zu unserer Erde.

FÖHLAN

Neue Anlage Foehl China – seit März 2019

Zukunftstechnologie

FÖHLAN!



“Let’s help to save our earth.”

Advances in Coating Technology: INNER CLEANLINESS

Dipl.-Ing. Ch. Genzler, Vesuvius GmbH, Hengelo/Netherlands;
Dipl.-Ing. T. Nilsson, Volvo Powertrain, Skövde/Sweden

The trend to convert from combustion engines to either hybrid or even full electric powered engines will continue over the coming years, however in many applications the transition will be slow as neither the technology or the infrastructure to support the developments are immediately available. There is therefore a requirement to reduce the polluting emissions of current diesel internal combustion engine technology so that the environmental impact from trucks and other heavy-duty engines used in marine applications is minimised.

The article is the result of a long-lasting cooperation between two companies, whose goal has always been to progressively improve casting integrity by enhancing the properties, application and consistency of the products used in their production.

The influence of a coating manufacturer on the final engine seems to be very limited in this context and even more if we think about an impact on the life and performance of the engine itself. In the past all a coating could do was to ensure a defect free component. However, today the influence of a coating applied at a thickness of about 3 human hairs goes way beyond the actual cast component; it can beneficially modify the metal matrix, resulting in an improvement of the performance of the final engine.

This paper focuses on a specially developed coating that shows a quantifiable improvement in the inner cleanliness in very complex engine component castings and will help the automotive industry to achieve even more stringent emission demands than the currently applied Euro 6 standard. Moreover, the improved cleanliness also extends the required service intervals, reducing downtime and increasing overall productivity.

“… The greatest opportunity for efficiency gains, fuel savings, lower greenhouse gas emissions and cleaner air – now – is to get more truckers into the newest generation of more fuel efficient and near-zero emissions clean diesel technology, as rapidly as possible.” *Allen Schaeffer, executive director of the Diesel Technology Forum.*

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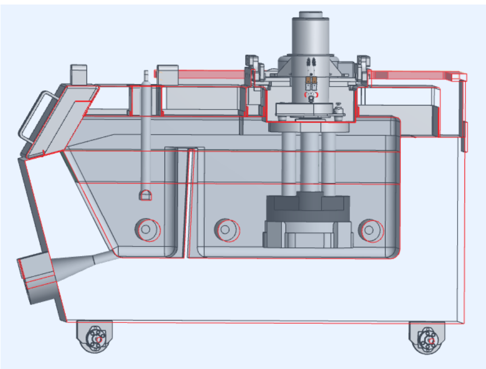
Use of a Precision Casting Pump to Replace the Low Pressure Casting Process

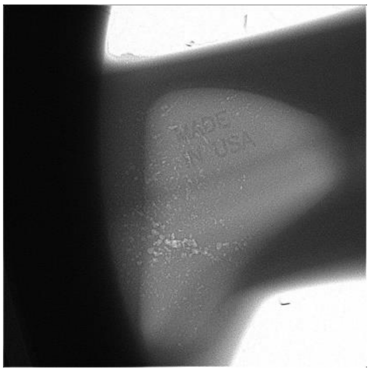
J. Fritzke, J. Tipton, Pyrotek Inc., Columbia City/ USA

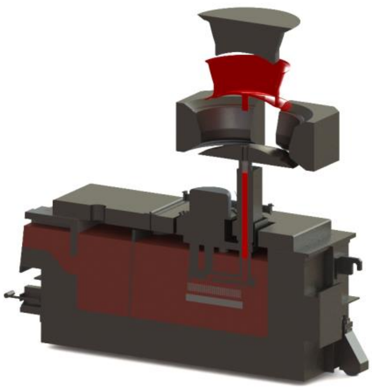
This paper describes the experiences with a new casting technology that has been designed to replace traditional low pressure casting systems. The paper addresses the filling of various low pressure molds using a Pyrotek Precision Casting Pump (PCP). Traditional low pressure (LP) systems have a few inherent issues. These issues are described in this paper and how they are resolved using a Precision Casting Pump. The PCP also brings process improvements that are not available with low pressure casting systems. These improvements include better thermal profile of the metal entering the mold and the ability to avoid washing oxides from the stalk tube after every casting. The elimination of these inherent issues result in significantly better casting quality.

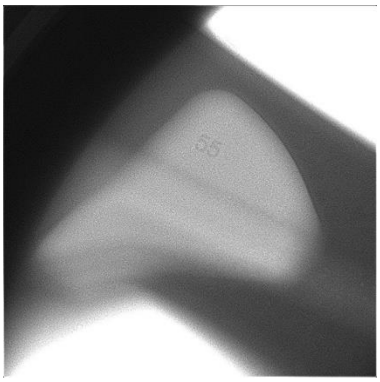
The mold filling process with PCP is considerably more controlled and repeatable than with current low pressure technology. The ability to accurately predict the metal output of the precision casting pump allows for a fill profile that can optimize casting quality.

The filling of the mold with the PCP is not impacted by metal level in the furnace. The elimination of compressed air in the furnace allows for improvements in metal quality and the ability to fill the furnace at any time during the casting process. This can reduce casting scrap by as much as 8 percent for a typical casting.









Vacuum Die Casting: Quality Controlling and Data Collection

J. Emmenegger, Ing. D. Baumgartner, Ing. Ch. Bertholet, FONDAREX SA, St. Légier/ Switzerland; Ing. R. Gschwandtner, Arbeitsgruppe Druckguss, Österreichisches Gießerei-Institut (ÖGI), Leoben/Austria

The adequate controls and measurements of the vacuum die casting process are the key for efficient production improvements.

Introduction

Today, vacuum technology plays a major role in the production of complex, high-quality casted parts, as well as for structural components.

In order to guarantee an efficient vacuum process, Fondarex has to consider the complete die casting process.
The quality of the casted part depends on the mold tightness and precision, the alloy quality, the lubrication and thermoregulation technologies, the tightness between piston and shot sleeve, the die casting machine parameters and efficiency, as well as an adequate vacuum system (figure 1)

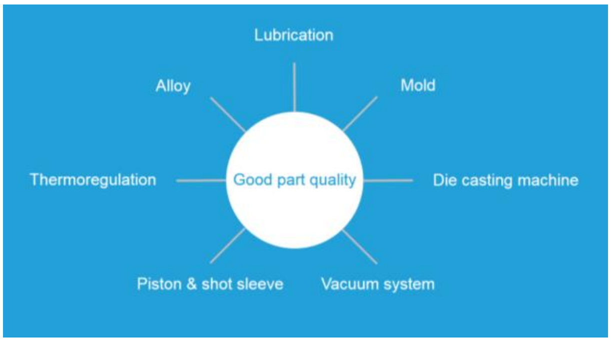


Figure 1: Dependency of the casted part quality

Vacuum die casting requires complete mastery of both the pressure die casting process and the vacuum technology. Any variation such as leakage, incorrect parameter settings, or even inappropriate dimensioning or integration of the vacuum system can have major effects on the quality of the casted part.

Therefore, each project starts with the analysis of the mold. Fondarex as the specialist in vacuum application studies do provide recommendations on:
- The gating system layout
- The vacuum channels layout
- The vacuum devices, such as vacuum valves or chill blocks, according to the project and the customer needs.
- The vacuum system according to the casted part and the technical requirements

From the investment point of view it is important to consider what the most adequate type of strategy is. Both, the mobile vacuum system (figure 2) or the cell vacuum system (figure 3) might be the right solution, but depending on the factory layout, the die casting machine size range and the casted part range, Fondarex can recommend the most cost-efficient solution.

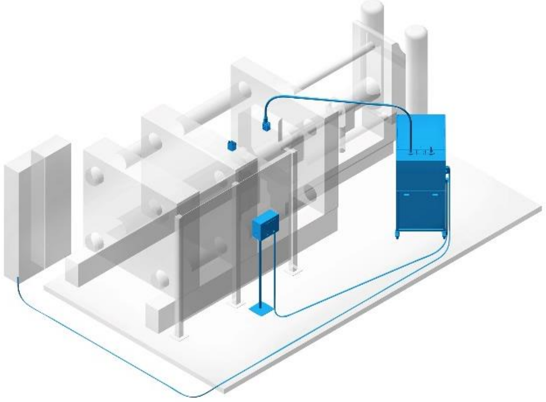


Figure 2: Fondarex Mobile vacuum system

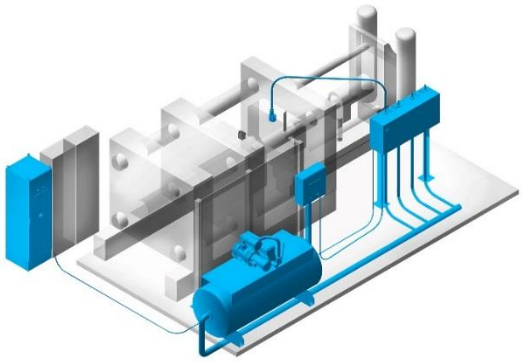


Figure 3: Fondarex Cell vacuum system

Advantages of Vacuum

The vacuum technology has demonstrated over the years on many high end productions the need to achieve efficient production. It is no longer a new technology, but it is still one of the technology which is continuously improving and able to influence in a positive way the casting process and the casted part quality at the same time.

The largest pores are eliminated (figure 4) through the help of the vacuum technology, which is leading to a better heat treatability without blistering of the casted parts, even at high treatment temperatures.

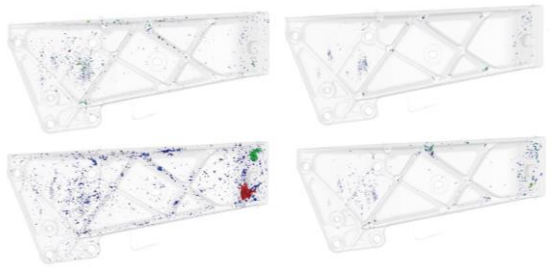


Figure 4: Top left: without vacuum, without heat treatment; top right: with vacuum, without heat treatment; bottom left: without vacuum, with heat treatment; bottom right: with vacuum, with heat treatment. Researches of the Austrian Foundry Institute (ÖGI)

Vacuum Process Control

Fondarex grants high importance on enhanced and reliable control in measures of the vacuum process (figure 5). The aim is to provide adequate control of the vacuum die casting process by offering the following main process controls parameters:
- Continuous measurement of the vacuum in the mold (inside the vacuum valve or on the top of the chill block) (figure 6)
- Real-time vacuum set-up in order to reach the optimal vacuum curve in relation to each specific project
- Continuous measurement of the vacuum in the tank
- Continuous measurement of the filter pollution
- Continuous measurement of the profile of the chill block
- Continuous measurement of the air flow per vacuum channel
- Measurement of the evacuated air volume per shot
- Continuous measurement of the evacuated air quality
- Control of the evacuated air humidity
- Control of the mold tightness
- Control of the compressed air consumption
- Control of the electrical power consumption
- Control of the vacuum pump performance

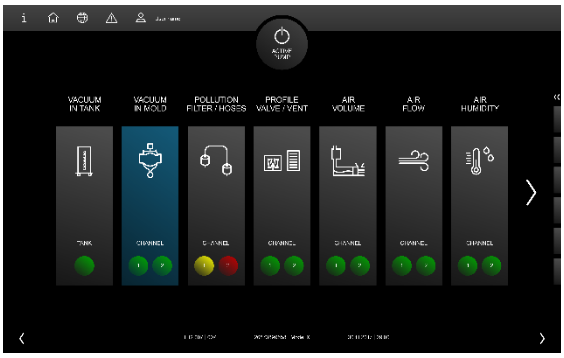


Figure 5: Overview of the future Fondarex control panel showing the main controls of the vacuum process

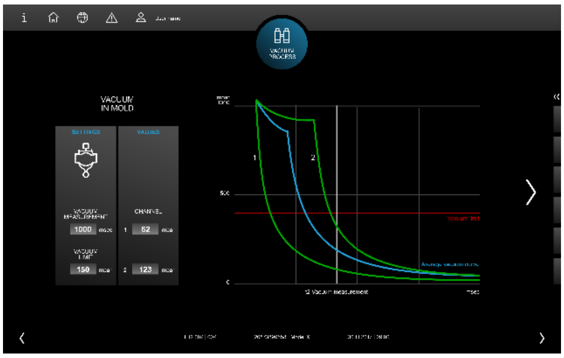


Figure 6: Continuous vacuum measurement, independently for each channel, incl. real time vacuum regulation

Data Collection of the vacuum process

Fondarex does manage the data of the vacuum process on different levels. First of all, the data and measurement curves are registered in the Siemens automation system of the vacuum system (figure 7).

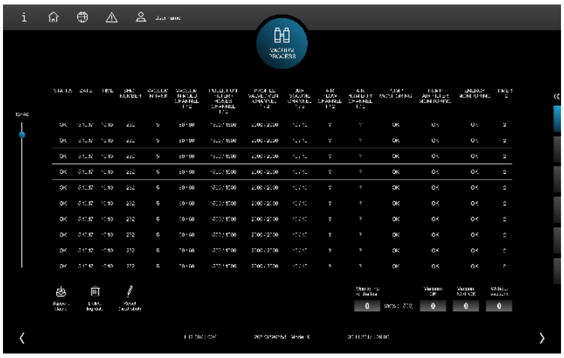


Figure 7: Log data of the vacuum process

From there, Fondarex provides the possibility to transfer the data and measurement curves to a computer or to the die casting machine through Profinet, Profibus or Ethernet communication interfaces.

To simplify the usage of the vacuum system, Fondarex has integrated the control of the vacuum process on several die casting machine brands (figure 8 and 9).

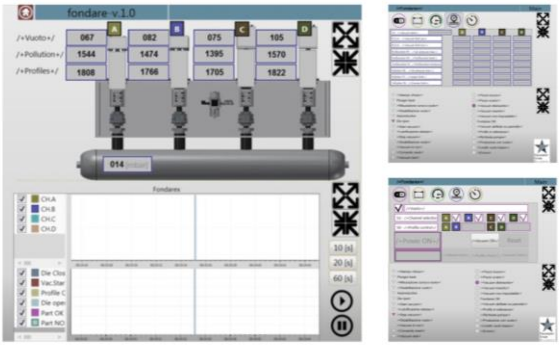


Figure 8: Integration of the Fondarex vacuum system in the Idra die casting machine control panel

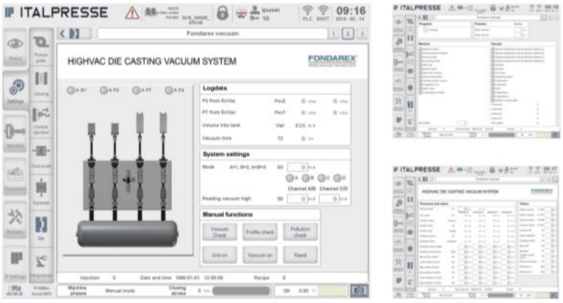


Figure 9: Integration of the Fondarex vacuum system in the Norican - Italpresse die casting machine control panel

Those technical options, in combination with Fondarex staff experience, lead to a continuous improvement in the control and the analysis of the vacuum die casting process (Figure 10). Fondarex equipment provides the means to evaluate the stability and the performance of the vacuum die casting process up to the qualification of the casted part. Fondarex gives high importance on the collection of the data, but actually even more emphasis on the right analysis of the collected information in order to provide in future a condensed report of the vacuum die casting production, including the data of the quality of the casted part.

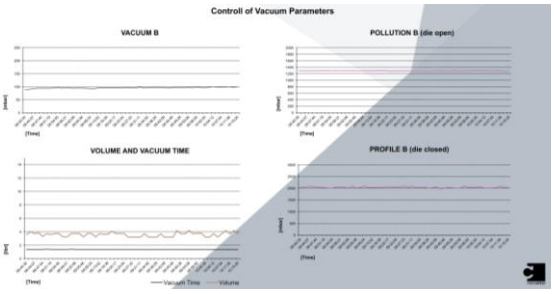


Figure 10: Analysis of the vacuum process and its variations. Analysis at Costampress, Italy

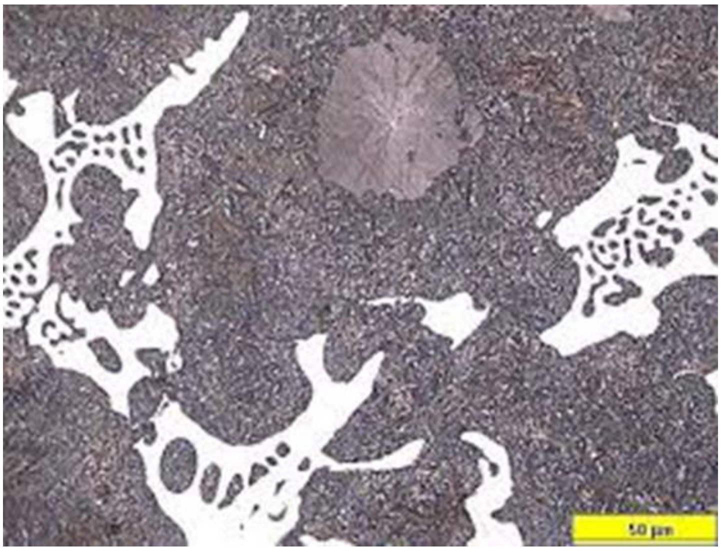
Conclusion

The Fondarex vacuum technology has the ability to achieve high flexibility within its integration in the die casting cell. Furthermore the Fondarex units are compatible with all die casting machines and adaptable to each project, providing a complete analysis of the vacuum process and lastly proposing modern data transfer options. The correct analysis of the collected data in the vacuum die casting process is Fondarex' specialty.

Current Applications of Carbidic Austempered Ductile Iron (CADI) in Europe

Dr. A. Rimmer, S. Day, ADI Treatments Limited, West Bromwich, West Midlands/United Kingdom

Carbidic Austempered Ductile Iron (CADI) has been used as a material option in the UK for almost two decades. One of the first applications was to an agricultural machine manufacturer. CADI was successfully developed for wear shins and is still in production. Since then, CADI applications have expanded from traditional agricultural applications to those used in cement systems; waste-to-energy furnaces; coal crushing; slurry mixers and pumps; material handling for sand and caustic soda and also metal grading machinery. Although the applications are predominantly related to wear, both carbide volume and austempering parameters have been modified to suit specific markets and applications.


50 µm


2016/03/23

Hybrid IoT Services for the Foundry Industry –“ Please press #ENTER”

Dr.-Ing. M. Rische, Dr.-Ing. M. Spichartz, M. Fournell, ABP Induction Systems GmbH, Dortmund/Germany

There is a huge potential in the foundry industry to increase productivity and quality while reducing environmental impact and costs. As the global economic environment changes it becomes crucial for foundries to pursue continuous improvement. Apart from addressing the challenge with lean tools and commercial efforts, the opportunity to interconnect equipment and process offers a significant potential to raise efficiency to a level never dreamt of. The article identifies opportunities for optimizing melting and pouring processes by using Web-based technologies (IoT) in combination with ABP domain knowledge.

1. Hybrid IoT services

ABP will present innovative hybrid services solutions to its customers at the GIFA 2019 trade fair in Düsseldorf under #EnterABP. The focal point is on the analysis of machine and process data to provide value add insights. The new customer portal my.ABP.com opens the doors to new digital services for foundry owners. my.ABP.com is the information hub and assistant for melting, holding and pouring from ABP. The manufacturer, broad domain knowledge, meets forefront technologies. All information on the status of furnaces is available in real time at any given moment by linking the furnace sensors to the portal. This supports foundries to focus on their core expertise, while ABP takes care of optimize availability of the furnace systems.

In the past, furnace operators and maintenance personnel were sent to the manufacturer for training courses. Today training is brought directly to employees with the new **“Virtual Training”** modules. Based on virtual reality, ABP created a 3D production environment. Training in the operation of furnace systems and the associated peripherals are as realistic as in a flight simulator.

In order to further increase the availability of furnace systems, ABP has developed a perfect digital solution for identification, analyzes, and rectification of errors as quickly as possible with the **“ABP Expert on Demand”**. Using smart glasses, smartphones or tablets, ABP service experts enables foundry workers to receive important information, regardless of their location in the production plant. The multimedia features of smart glasses additionally open new dimensions of documentation and a rapid investigation of errors.

2. Platform and security

There is the highest level of data protection. The **my.ABP.com** digital solutions are cloud-based as standard, in which all servers are located in Germany and certified by European authorities. Customer data are therefore secure at all times. However, on-premise solutions can naturally also be implemented.

The aims of raising the productivity and quality of the foundry to a new level and of constantly increasing competitiveness are achieved much more easily with these new solutions.

Hybrid Resins - A great advantage for quality, ecology and costs

Dr. A. Mazzon, Eng. M. Moretto, F.lli Mazzon S.p.A., Schio (Vi)/Italy

After a sudden increase in furfuryl alcohol costs, F.lli Mazzon immediately found an alternative, thus developing a new generation of furan resins. Such resins, besides granting excellent quality and avoiding price increase for customers, also improved working conditions - being harmful and not toxic - and reduced emissions and smells. F.lli Mazzon succeeded in transforming a problem into an opportunity.

Due to the huge increase in the price of furfuryl alcohol, furan resins almost doubled their prices. Such an increase cyclically happens every 5 -7 years for a number of reasons. As a consequence, foundries found an immediate increase in estimated costs of around 2-3 cents per kg of casting, which final customers didn't want to pay. So the market, i.e. hand-molding foundries, asked for new products with good technical characteristics and more competitive prices.

For a long time F.lli Mazzon has been producing furan-phenolic resins, i.e. mixtures of phenolic resins and furfuryl alcohol to grant more reactivity and mechanical strength. But also these formulations were not competitive because even a low percentage of furfuryl alcohol caused prices to go sky-high.
Our R&D laboratory started to process different synthesis and chemical reactions in order to obtain a resin with a behavior similar to furan resins, but whose costs are similar to phenolic resins.
We found that by making phenolic resins reacting with furfuryl alcohol and other molecules in the reactor for rather long times at given pressure and temperature conditions, we obtain some effective polymers with the following characteristics.

Furan resins are characterized by a long bench life. Phenolic resins seem to have a bench life, but they actually begin to react immediately with longer stripping times. Our new polymers have similar characteristics to classic furan resins, i.e. good bench life that allows to work within the required times.

Furan resins have a very good long bench life / short stripping time rate. For example 10 minutes bench life and 40 minutes stripping time. On the contrary the rate for phenolic resins will be 10 minutes bench life and some hours of stripping time. Our new polymers of Hybrid Resins have good stripping times and enough bench life.

The mechanical strengths as well as the thermal resistances of the new polymers of Hybrid Resins are up to the performance of the well-known furan resins. In most cases foundries keep the same percentage of use or sometimes specific catalysts are used to accelerate or slow down the reaction or to obtain maximum resistance.

This is definitely the most critical parameter, since hybrid resins are naturally more viscous than pure furan resins. In any way foundries can manage viscosity even at low temperatures. There is no problem if the mixers are equipped with systems that keep the resins e.g. at around 20 ° C. There is no problem too with geared pumps. But it is essential that the mixing system must work efficiently to homogeneously mix the resin with the sand.

As for the emissions and smells of Hybrid Resins, the working environment is improved. Hybrid Resins are in fact condensed polymers, i.e. high weight molecular chains or interlocked molecules, therefore they can not evaporate in the environment. The content of free molecules is limited so that also smells are fewer. This is definitely an advantage for the working environment.

Hybrid Resins are made up of molecules linked to each other and so there is a very low percentage of single free components. The share of free furfuryl alcohol is less than 40% and therefore the labelling symbol is only "harmful" and not "toxic".
In addition, interlocked molecules of furfuryl alcohol do not evaporate and do not increase TLV value that is the allowed concentration in the working environment. That's why Hybrid Resins are eco-and worker-friendly.

These resins are produced using a formaldehyde content lower than 0,1%, as required by law. Often by using specific reagents we manage to lower its content below this threshold, benefiting the workers and the working environment.

Last but not least let's focus on the price. All the tailor-made formulations of these hybrid resins have anyway a cost of raw materials lower than those of traditional resins. For sure the long synthesis process for the polymerization of the resins in the reactor and energy used to remove condensed water are increasing the costs.However these hybrid resins give value for money.

In conclusion, a problem has turned into an opportunity for both F.lli Mazzon and his customers. Surely these resins must meet the needs of each foundry but Hybrid Resins are having an unexpected success both in Italy and abroad.

Crucible Coatings on Performance

Dr. D. Heumannskämper, Morgan Advanced Materials – MMS GmbH, Berkatal/Germany

Functional coatings have been developed to increase the performance of Graphite or SiC-Crucibles in specific applications. Typical areas of applications of such clay or carbon-bonded crucibles are in the melting, refining, among others, of non-ferrous metals such as aluminium, copper, precious metals, zinc and related alloys. The benefits of the coatings on the crucibles are increased purity of the molten metal, reduce dross adhesion and increased erosion resistance. These advantages were highlighted through case studies in this report.

1. Introduction

Graphite and SiC-Crucibles are used in a variety of furnaces ranging from electric resistance, induction furnaces to fuel-fired furnaces for melting and/or holding non-ferrous metal like aluminium, copper, zinc, precious metal and their alloys.
The typical dimensions of the crucibles are between 500 – 2000 mm in height and 400 – 1000 mm in outer diameter. The raw materials are clay or other organic compounds as binder, and graphite, silicon carbide and silicon metal as filling materials.
The required properties of the crucibles are good thermal conductivity, high erosion resistance and little or no impurity seepage in the molten metal. To achieve and improve on these properties, a range of functional coatings has been developed for use on Morgan Advanced Materials' crucibles.

2. Crucible Production Procedure

Crucibles are produced via the following procedures:

Mixing → Pressing → Drying/Curing → Glazing → Firing. (1)

Mixing:	The main raw materials: graphite, SiC and Si metal, are mixed with clay or an organic compound binder.
Pressing:	After mixing, the material is shaped through one of the 3 different forming methods: rib-forming, isostatic-pressing and roller-forming.
Drying/Curing:	The next step is drying at 120°C of clay-bonded crucibles and the curing of crucibles with an organic binder to create the crosslinked phenolic bonds.
Glazing and Firing:	The final steps are glazing and subsequent firing to achieve high strength and refractoriness of the crucible body.

The glaze on the crucible protects the graphite and the SiC in the body against oxidation at temperatures greater than 700°C. During firing the clay sinters into a ceramic matrix and the cross-linkages in the SiC-crucibles convert into a vitreous carbon matrix.

Figure 1. Glazed and fired Crucibles

3. STAR Coating – Nano Boron Nitride Coating

Physical and Technical Properties

- Ceramic bond: Nano ZrO_2 or Phosphate
- BN-Particles: Very good distribution in Bond Matrix
- Particle Size: 0,2 µm – 5 µm
- Colour: White
- Max. application temperature: Up to 1000°C

Figure 2. Crucible with STAR Coating

Prime Features

- Excellent non-wettability due to nano Particles and well distribution of BN in Bond Matrix.
- Less dross adhesion due to non-wettability of coating.
- Low impurity leak into melt (Table I).
- Low coating thickness (Figure 3).
- Low porosity, high density coat due to nano-scaled ingredients.
- Protection of crucible material against aggressive components (chlorine or metal alloys).

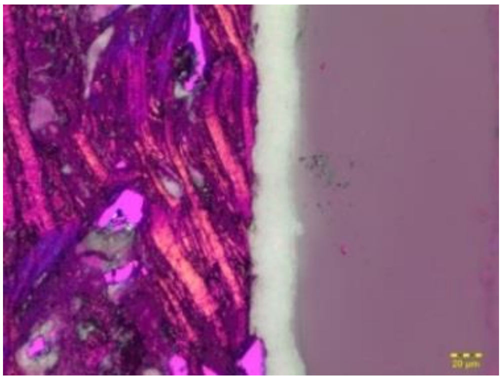


Figure 3. STAR Coating (white) on crucible Material (see left) under microscope

Typical Application

- High purity aluminium metal (99.999%).
- High purity aluminium alloy melting.
- Precious metal melting.

Case Study: Laboratory Trial with Aluminium (99.999%)

Small crucibles with STAR Coating (Figure 4) were filled with pure Al5N, which was melted and hold at 710°C for 48 hours. The melt was tested before and after the holding for the amount of silicon and boron and it was found that the increase in impurity was very insignificant (Table I). The melt still has a pureness of 99.999%.

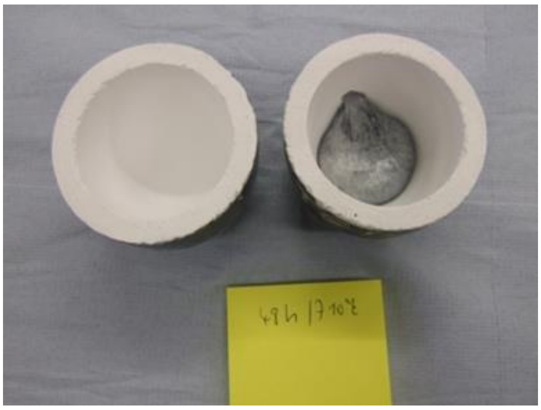


Figure 4. Small crucibles with STAR Coating

Table I. Amount of impurity elements in aluminium metal (99.999%) before and after melting at 710°C for 48 hours using STAR coated crucibles.

Impurity Element	Before Melting	After Melting
Silicon [ppm]	0.8	4.4
Boron [ppm]	0.09	0.24

Additionally to the pureness of the molten metal the adhesion of the metal in liquid and solid state is really less. According this excellent non-wettability of the coating the molten metal could be casted easy out of the crucible without sticking of a lot of remaining metal on the surface of the STAR coating. The same is with a solidified metal inside the crucible with STAR coating.

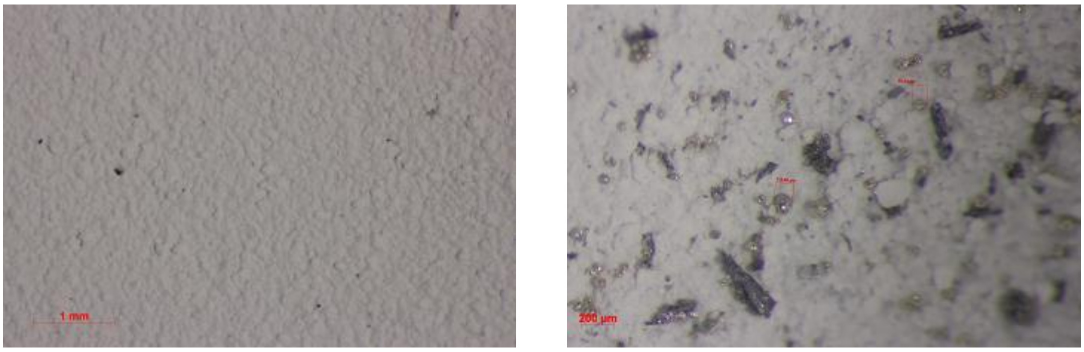


Figure 5: Microscope pictures with 20-times and 40-times magnification before and after holding Aluminium 5N in crucible with STAR coating.

Case Study: Induction Furnace with Aluminium 5N Melting

A cylindrical crucible ZYLS 1300 x 760 with STAR coating (Figure 6) was used to melt Al5N in an induction furnace with a frequency of 300 Hz and power of 300 kW. The molten Al5N was taken to cast products for the electronic industry.

Figure 6: Cylindric Crucible ZYLS 1300 x 760 with STAR Coating

During melting it was necessary to prevent any contamination of the molten Al5N out of the crucible material. And this should happen not only during the first melt, the coating on the inside surface should protect the pure liquid aluminium also to the end of the lifetime of the crucible.

The lifetime of the used crucible was 80 – 90 charges and during all charges the impurities were less enough to cast ultra-high-purity sputtering targets for the electronic industry.

Table II. Comparison of Morgan Syncarb with STAR coating to standard crucible for melting Aluminium 5N

	Si ppm	Fe ppm	C ppm[1]	P ppm	Total Metallics ppm[2]
Charge Material	1.92	0.80	<4	0.70	4.56
Standard Crucible					
Average	3.84	1.04	<4	1.05	6.86
Std Dev	1.07	0.87	na	0.20	1.87
Morgan Syncarb with STAR					
Average	2.02	0.83	<4	0.73	4.68
Std Dev	0.14	0.15	na	0.10	0.28

[1] Si, Fe, and P (GDMS);
C (LECO)
[2] Calculated from GDMS

The advantages for the customer was **no molten metal contamination due to the STAR coating** during all 80 – 90 charges. Additionally exceptional less dross adhesion on the inside wall of the crucible surface which results into easier cleaning of the crucible and also to inspect the crucibles on cracks in between the different charges.

<u>Case Study: Gas Fired Furnace for Melting and Holding Aluminium Alloy</u>

An isostatic pressed crucible TPS 587 TopAl with STAR Coating was used in aluminium alloy melting and holding, the furnace was gas fired. The casting temperature of the molten metal was 720 – 730°C.

Figure 7. TopAl Crucibles with STAR Coating

The actual crucible was also an isostatic pressed crucible but without any coating. This crucible was difficult to clean after every day and so the dross thickness increased until a thickness of around 50 mm.
The dross adhesion on the inside wall of the crucible reduced the capacity of the crucible during the lifetime step by step and additionally the speed of the melting time increased due to the isolating property of the dross.
The dross has a much higher thermal expansion than the isostatic pressed crucible and due to cooling down and heating up of the crucible during melting of the aluminium alloy the crucible got more and more cracks at the crucible wall and the crucible could not been used any longer. The average lifetime of this isopressed crucible was due to the expansion cracks 42 days.

Figure 8. Crucible with 50 mm dross adhesion on inside surface after 42 days

The **TopAl crucible with STAR Coating** on the inside wall was much more easier to clean after every day (**more than 50 % decrease of cleaning time**) and therefore the dross adhesion increased over the lifetime to a maximum thickness of only 5 mm. The capacity of the crucible is nearly the same the whole lifetime and the speed of the melting time, too. The final average **lifetime** of this **crucible with STAR Coating** is **154 days** which is **3 - 4 times longer** comparing with the standard isostatic pressed crucible without any coating.

4. ResCoat Coating – Nanoscaled SiC Coating

<u>Physical and Technical Properties</u>

- Double bond: Carbon + SiC
- Colour: Grey
- Max. application temperature: Up to 1600°C

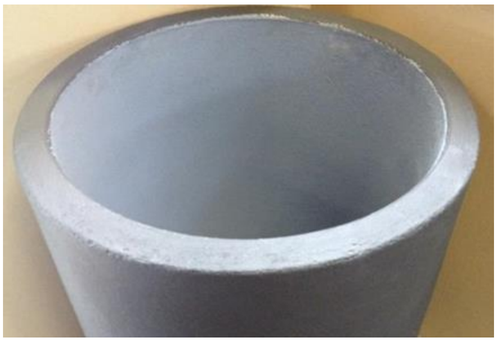


Figure 9. Crucible with ResCoat Coating

Prime Features

- Exceptional erosion resistance.
- High non-wettability leading to low dross adhesion.
- Low porosity, high density coat due to nano-scaled ingredients.

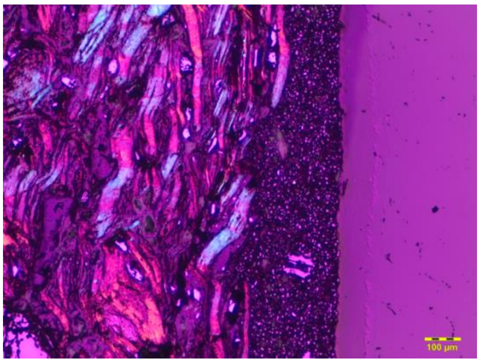


Figure 10. ResCoat Coating (middle part of pic – finer particles) on crucible material (left side) under microscope

Typical Application

- Copper and copper alloys melting, also using fluxes
- Precious metal refining
- Zinc distillation

Case Study: SnPbZn Copper Melting

A cylindrical clay-bonded isostatically pressed crucible (height 815 mm/outer diameter 610 mm) with ResCoat Coating for SnPbZn copper alloy melting was placed in an induction furnace set at 180 Hz. This creates a significant amount of metal movement during melting which wears off the crucible, leading to a thinner wall and finally failure by erosion. **With the ResCoat Coating**, the erosion rate was lower than in a crucible without the coating. This **led to a 20% increase in melt output** (90000 lbs as compared to 75022 lbs) over the crucible lifetime.

Figure 11. Melting of SnPbZn Copper Alloy

Case Study: Gold Refining in Crucible with ResCoat Coating (Induction Furnace)

With the crucible E323 VO ResCoat Coating the number of charges to refine gold (flux: borax) were 24 compared with the E323 VO without coating which lasts only 18 – 19 charges. The erosion of the crucible wall was postponed due to the nanoscaled ResCoat Coating which sticks very well on the crucible inside surface and resist better against the flux than the crucible material.

In another application with a crucible E329 R4 + ResCoat the amount of melting and refining of gold dust was 33 charges compared with a non-coated E329 R4 crucible which lasts only 22 – 25 charges. The used flux was a combination of borax – soda – potassium nitrate. The reason for increasing the lifetime was the postponed erosion of the crucible wall because of the nanoscaled SiC coating (ResCoat).

In the application of precious metal refining the **increasing of the lifetime of a crucible due to the ResCoat Coating is 25 – 40 %!**

Case Study: Copper and Copper Alloys melting with fluxes in fuel fired furnaces

A rollerformed SiC crucible (TPC 587) was used to melt bronze in a gas fired furnace. The crucible eroded due to the copper alloy including the used fluxes step by step and the normal lifetime was around 60 charges. The same crucible but with a ResCoat coating on the inside surface achieved in the same furnace 111 charges. The erosion was postponed due to the nano-scaled ResCoat coating on the inside surface of the crucible.

In another application a rollerformed AC 610 R4 crucible was used in an oil fired furnace to melt copper (charging material: scrap). Without coating the lifetime achieved 17 charges, the same crucible with ResCoat coating lasts 24 charges. The nanoscaled SiC coating protects the inside surface of the crucible against erosion at the beginning of the use of the crucible and so the lifetime increased to 24 charges. The used flux was a phosphorous borax.

In a third different application a clay bonded isostatic pressed crucible AI 601 was used in an oil fired furnace. The molten alloy was brass charged by scrap. The used flux was borax. The number of charges increased from 42 to 51 with a coated crucible.

In melting copper and copper alloys with using fluxes the **lifetime of the crucible increase 20 – 80 % because of a ResCoat coating** on the inside surface of the crucible!

5. PureCoat Coating - Nanoscaled Si_3N_4 Coating

Physical and Technical Properties

- Colour: White
- Max. application temperature: Up to 1500°C

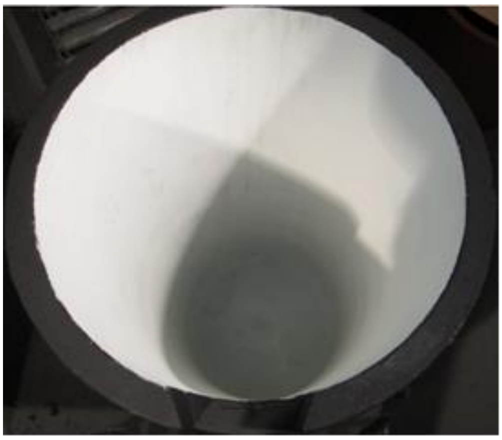


Figure 12. Crucible with PureCoat Coating

Prime Features

- Low coating thickness (Figure 13)
- Excellent non-wettability leading to low dross adhesion.
- Low porosity, high density coat due to nano-scaled ingredients.

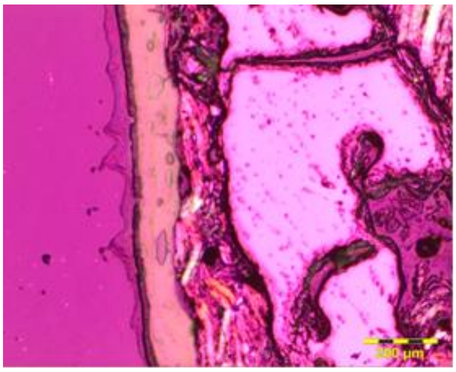


Figure 13. PureCoat Coating (middle of the pic – light red line) on crucible material (right side) under Microscope

Typical Application

- Zinc distillation
- Copper melting

Case Study: FUS 750 Z2 with PureCoat Coating in Zinc Distillation

A customer in Peru is using the isostatic pressed crucible FUS 750 Z2 since years in zinc distillation. The charging material includes a some higher ratio of iron which increase the dross adhesion on the inside crucible wall a lot. It is also very difficult to clean the crucible well from the dross and after around 70 charges the volume of the crucible for the molten metal decreased so much due to the thick layer of dross (Figure 14).

Figure 14. FUS 750 Z2 after using in Zinc distillation with a thick layer of dross

The same type of crucible FUS 750 Z2 was used with the PureCoat coating and after the same number of charges there was much less dross on the inside surface of the crucible (Figure 15). **The lifetime of the crucible with PureCoat coating increased by 30 %.**

Figure 15. FUS 750 Z2 with PureCoat Coating with no dross adhesion

6. Conclusion

Coatings are able to improve the specific performance characteristics of the crucibles through a number of ways:

- **Decreased impurities leakage from the crucible material** into the molten metal (e.g. STAR Coating with reduced silicon impurities in aluminium or precious metal melt).
- **Increased erosion resistance of crucibles** (e.g. ResCoat Coating in induction or fuel fired furnaces with high flux usage applications such as in copper alloys or precious metal refining). **The better erosion resistance of the crucible increases the amount of molten metal for 20 – 40 % and in some case more than 50 %**.

Coatings can also confer onto crucibles new functional characteristics such as:

- **Less or no dross adhesion** onto the crucible inside wall in aluminium application (e.g. STAR Coating) or zinc distillation (e.g. PureCoat Coating). **Reduction of cleaning time of crucibles more than 50 %** and **increasing lifetime of the crucible** - in special application more than double.

Calciner-Free Green Sand Reclamation by Using Advanced Mechanical Reclamation System

T. Oba, J. Iwasaki, A. Abe, T. Aoki, Sintokogio Ltd., CASTEC COMPANY, Toyakawa Aichi/Japan

In most green sand / core sand systems, unused sand is usually added as cores, and waste sand is discharged as dust or separated from castings at shotblasts. If their amounts are completely equal, they must be balanced. However, in most cases, amount of entered sand is much larger than lost after shakeouts. This unbalance makes overflowed sand. Unfortunately, overflowed sand has insufficient properties for replacing unused sand. Consequently, overflowed sand must be recycled or wasted. Some large foundries reclaim thermally their waste sand as core sand, and other large foundries recycle it for steel making material or concrete material. Both methods have various difficulties for small to medium foundries. Therefore, they must waste their overflowed sand for landfill. Moreover, landfill cost is unbelievably more expensive compared to purchase unused sand. Authors developed the cutting-edge mechanical reclamation system that is effective for green sand reclamation with eliminating use of calciners. This presentation describes the principle of the system and results of some case studies. The results shows sand reclaimed by this system is usable as alternative to sand reclaimed by thermal system and unused sand. These advantages contribute not only waste reduction but also defect elimination caused by poor quality cores.

1. Principle and Mechanism

This reclamation system, *Roller Squeezing Type Mechanical Reclaimer*, consists of a pair of ceramic rollers and a rotating drum. Combination of attrition and squeeze works on removal of oolitics and fines effectively. At first, this system had developed for tough chemically bonded sand processes such as Phenol Nobake or Sodium Silicate processes [1-3]. However, after numerous experiments, authors established the mechanical green sand reclamation system without calciners.

Fig. 1 shows the schematic diagram of standard reclamation system for overflowed green sand.

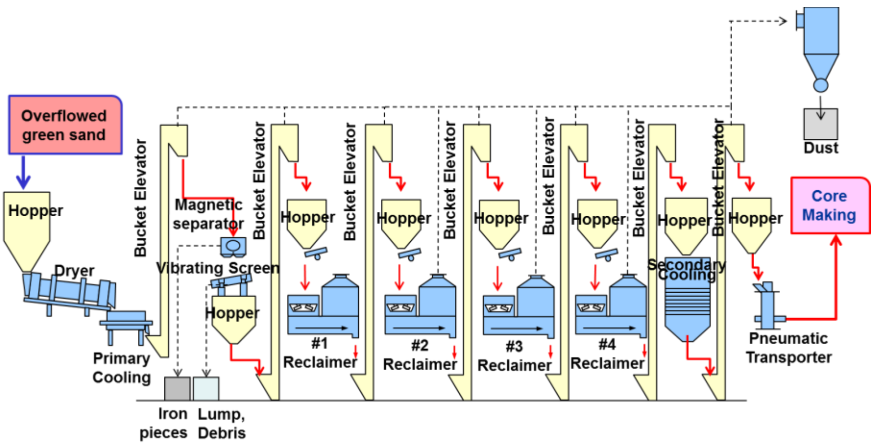


Fig. 1: Schematic Diagram of a Standard Plant

2. Case Studies

2.1 Reclamation for Resin Coated Sand (RCS)

RCS, used for shell cores, is one of the most popular applications of green sand reclamation in Japan. Authors conducted one comparison test between Roller Squeezing Type Mechanical Reclaimer and conventional reclaimer for a customer. Conventional method is to combust the sand by a calciner and then to scrub it by a numerous passes of attrition type reclaimers. On the other hand, developed system possesses four or six cell Roller Squeezing Type Mechanical Reclaimers. Test conditions are shown in Table 1, and test result for transverse strength is shown in Fig.1, and that for SiO2 purity is shown in Fig. 2.

Table 1: Test Conditions from Green Sand to RCS

Throughput	Motor Power	Pass
4.0 MTPH	30kW/Pass (1st to 4th) 22kW/Pass (5th, 6th)	6 Passes

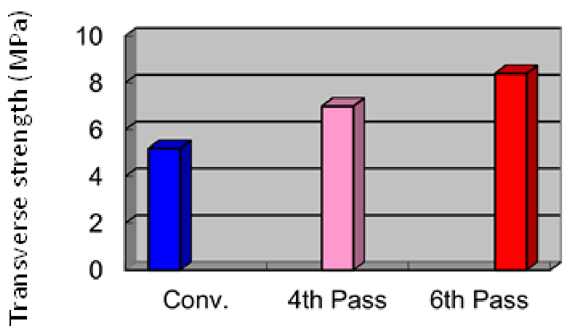


Fig. 2: Transverse Strength Comparison

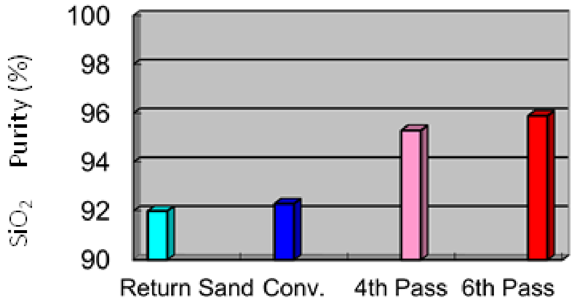


Fig. 3: SiO_2 Purity Comparison

Table 2: Test conditions from Mold Sand Mixture to PUCB

Throughput	Motor Power	Pass
5.0 MTPH	30kW/Pass	4Passes
Sand Mixture		
Overflowed sand	Core Sand	Sand from Shotblast
50%	30%	20%

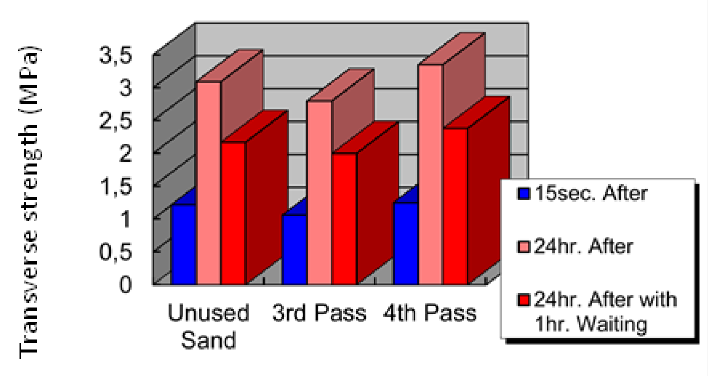


Fig. 4 Transverse Strength Comparison

Fig. 2 and Fig. 3 clearly show that Roller Squeezing Type Mechanical Reclaimer achieves superior transverse strength and SiO2 purity compared to conventional method using the calciner.
These results mean Roller Squeezing Type Mechanical Reclaimer enables to remove adhered oolitics as well as fines more efficiently than conventional method. Oolitics is very hard to remove and conventional combination of combustion and attrition does not enable to remove it enough.
Consequently, combination of attrition and squeezing shows much more effective performance compared to conventional method.

2.2 Reclamation to Phenol Urethane Cold Box (PUCB) Sand
PUCB is popular core molding process for green sand mold all over the world. Authors conducted another reclamation test from waste green sand, core sand, and sand discharged from the shotblast ixture to PUCB cores for a customer. Test conditions are shown in Table 2, and Fig. 4 shows the transverse strength comparison between unused sand and reclaimed sand.

From the result shown in Fig. 4, Roller Squeezing Type Mechanical Reclaimer achieves superior values at 4 Passes in each condition compared to unused sand. This result means that Roller Squeezing Type Mechanical Reclaimer does not remove oolitics and fines but also polish sand grain surface and improves its shape to be rounded.

3. Conclusion

Authors conducted numerous tests from green sand or sand mixture contains much green sand to core sand or mold sand. From the results mentioned above, Roller Squeezing Type Mechanical Reclaimer enables to eliminate calciners for reclaiming green sand. This system achieves to manufacture superior quality reclaimed sand only by mechanical reclamation. Case study results clearly show the sand reclaimed by this system superior core strength and SiO_2 purity compared to the sand reclaimed by calciners and unused sand. These results mean sand reclaimed by this system enables to make more quality cores than that reclaimed by calciners. More quality cores must improve casting quality as well by eliminating casting defects caused by poor quality cores.
Authors expect this system to improve casting quality as well as to reduce waste sand.

[1] Oba, Iyoda, Iwasaki and Aoki: AFS Transactions 107 (1999) 89-93.
[2] Oba, Hagata and Nakayama: Development of Mechanical Sand Reclamation Technology Using Roller Squeezing Method, (159th Japan Foundry Society Meeting, Matsue Japan, 2011) pp12.
[3] Oba, Hagata and Nakayama: Journal of Japan Foundry Society 84 (2012) 533-538.

Use of Additives in ExOne 3D Core and Mold Printing

T. Tuffentsammer, ExOne GmbH, Gersthofen/ Germany

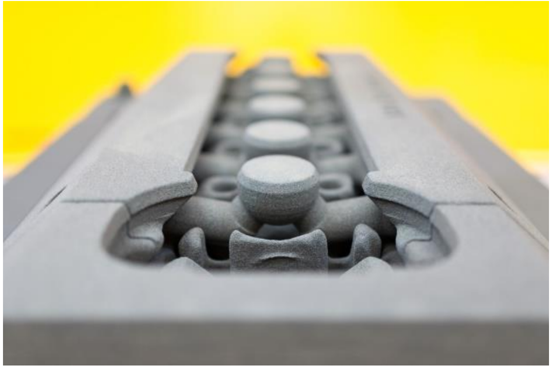
The ever-increasing requirements on the production of cast parts pose great requirements on foundries and foundry suppliers. High-quality cast parts with the lowest possible reject rates are the aim of the industry.

The well-known advantages of 3D core and mold printing, speed, precision and the possibility to produce highly complex components, have now been complemented with another component. ExOne, the world's leading manufacturer of 3D sand printing machines, has declared war on the known casting defects, such as veinings, etc.

In response to the prevailing market demands, especially in high-temperature casting, the ExOne development department has focused on the dosage of foundry additives. The task was an automated solution to lead additives easy and reproducible in the printing process. The result is an automated dosing unit that can be attached or retrofitted to all 3D production printers.

Generally all additives can be added to the printing process. So far first experiences in the house of ExOne were made with magnesium inhibitor, iron oxides and hybrid additives. Here, the addition of these helpers has throughout shown better results.

The practical example of a pump manufacturer and the associated cast part - an impeller casted in stainless steel - proves the positive results.



Alloy, Vacuum, Heat Treatment – Potentials of HPDC-alloys based on a case study

Dr. P. Hofer-Hauser, Ing. R. Gschwandtner,
Dipl.-Ing. G. Schindelbacher, Österreichisches Gießerei-Institut,
Leoben/Austria

Today the HPDC-alloy Alsi10MnMg is one of the most common alloys for the production of high ductile and corrosion resistant castings for automotive components. By the variation of the Mg-content the mechanical properties of this alloy can be excellently modified. However, in order to use the full potential of AlSi10MnMg a good casting quality with respect to gas and air inclusions is mandatory to prevent blistering during the heat treatment. In the presented work the influences of vacuum and heat treatment on the mechanical properties were investigated.

Today's most commonly used HPDC-alloy is AlSi9Cu3(Fe). With regard to the standard (EN 1706:2010) a great band width of the main alloy elements silicon, copper and iron is allowed. This leads to a wide spread of the resulting material properties, if the contents of these elements are not restricted by further specifications of delivery. The aim of the presented investigations was the quantitative evaluation of the variability in the properties of the castings due to variations in the alloy composition.

Based on the case study of an engine torsion support three different alloy compositions (low, medium and high Si, Cu, and Fe contents) were investigated. The varieties subject to these investigations were compared to the results obtained from trials with three different AlSi10MnMg-alloys with varying Mg-content. The castings from AlSi9Cu3(Fe) were tested by means of tensile testing and component testing. Besides from the as fabricated state (F) one heat treated state (T5) was analysed.

The investigation results show that the high strength level of highly alloyed AlSi9Cu3(Fe) is able to compensate for the lower fracture elongation compared to AlSi10MnMg on the component level which resulted in similar energy consumption until failure in the component tests. This is especially applicable for the non heat treated state. The components from the low alloyed AlSi9Cu3(Fe)-alloy reached similar fracture elongations as AlSi10MnMg.

The material data obtained in tensile testing were used for the numerical modelling of the component test. The simulation aimed at the analysis of the influence of casting defects on the component strength. Furthermore the results were used to give an estimation from which point on the influence of quality parameters exceeds the influence of the material properties on the mechanical properties in real castings. The numerical models and calculation results are presented.

The Future of Structural Components in HPDC - Costs competiveness into the high volume car manufacturing

H.J. Roos, Bühler AG, Uzwil/Switzerland

Structural components are increasingly popular for the automotive industry. Currently, they are proving their strengths above all with premium cars such as the new Jaguar I-Pace, the BMW series 8 Coupé or the Mercedes C class. The market for structural components has already multiplied over the past five years. At the same time, manufacturing costs were reduced by approximately 20 percent; however, an additional savings of 20-30 percent is needed to achieve economic viability in high volume automobile platforms. Every percent of saving helps the HPDC industry to tap into high volume automotive segments. Cooperation across the industry is essential for further development of structural processes that will move us toward large series production. Bühler Die Casting considers the opportunities to reduce cost throughout the entire process chain.

Great Potential for reducing costs

The presentation highlights the potential cost savings by increasing productivity through tool design and proper alloy selection. Proper tool design offers shorter cycle times because the thermal energy is intelligently managed. Special alloys are now available that can deliver the proper mechanical properties without costly heat treatment. This study of costs shows possible savings of up to 15-20 percent through: 1. Increasing the lifetime of tools, 2. Shorter cycle times, 3. Better availability of the cell and 4. Excluding the need of heat treatment. Target is to increase the competitiveness to other technologies and materials. The Bühler Team is ready to support customer all over the world with their expertise and ongoing new developments.

Analysis of the Potential of a Shock Tower in Newly Developed Aluminium HP-DC Alloys in Comparison to a Magnesium and a Steel Construction

Dr.-Ing. St. Wiesner, Dipl.-Ing. F. Niklas, Rheinfelden Alloys GmbH & Co. KG, Rheinfelden/Germany; Dr.-Ing. E. Beeh, Dipl.-Ing. G. Piazza, Deutsches Zentrum für Luft- und Raumfahrt e.V., Stuttgart/Germany

A capability analysis of crash-relevant vehicle structures in different materials is shown with the help of the FEM calculation of a shock tower. The component design using recently developed aluminum HP-DC alloys AlMg4Fe2 (Castaduct-42) and AlMg6Si2MnZr (Magsimal-plus) is compared with a construction in magnesium and in steel.

Test profiles and plates were produced in both aluminum alloys in order to determine static and dynamic material properties as well as fatigue strength. These characteristics were used for a strength calculation to determine the required geometry optimisation using the new materials.

Dynamic 3 point bending trials and strength calculation of the Institute for Vehicle Concepts (DLR Stuttgart) are presented. Consequences for the component geometry were compared with each other; in particular the calculated total weight.

smartfoundry.solutions

Dr.-Ing. K. Kerber, Oskar Frech GmbH + Co. KG, Schorndorf/Germany

Industry 4.0, the Internet of Things, have become strategic development goals in many industries. Digitalization projects are being promoted worldwide. In many foundries, single projects are already being realized, and the digitization is also finding its way into the production of small and medium-sized companies.

Industry 4.0 projects require a close cooperation or partnership between foundries, their customers, suppliers, machine manufacturers and IT service providers. At present, there are only few plug & produce or industry specific solutions for foundries and especially high pressure die casting foundries. Oskar Frech GmbH + Co. KG maintains a close partnership with its customers and suppliers, which has now enabled in deep collaborative projects in this pioneering phase of industrial digitization.

Over the past two years, Oskar Frech GmbH + Co. KG, in cooperation with various die casting companies, has carried out first projects for this purpose. In the context of the lecture results of the pilot and exploratory projects and the first resulting products will be presented.

As a part of the smartfoundry.network numerous foundry approved components for data acquisition transfer machine, process and production data from the sensor, to the machine and into the cloud data storage. In addition smartfoundry.applications allow an efficient and robust digitalization of offline data from production and logistics with Entry Point applications. Visuals and Analytics components allow role-specific data visualization on the shop floor and in the management of the foundry. The smartfoundry.community connects foundries, machine manufacturers and suppliers to master today's and tomorrow's challenges together.

CGI 500Si5: A new material for heavy duty ICE´s?

Dipl.-Ing. M. Walz, Fritz Winter Eisengießerei GmbH & Co. KG, Stadtallendorf/Germany

Kurzfassung
Bisheriger Standardwerkstoff für hochbelastete Nfz-Zylinderkurbelgehäuse und -Zylinderköpfe war in den vergangenen 10 Jahren der seit 2006 international genormte GJV 450. Grund dafür ist die günstige Kombination aus thermischen und mechanischen Eigenschaften und der Bearbeitbarkeit. Bei der Entwicklung neuer Motorengenerationen zeigen sich jedoch zunehmend Probleme, die oft nur noch mit entsprechenden Designkompromissen gelöst werden können. FW beschäftigt sich seit 2010 mit der Entwicklung einer neuen mischkristallverfestigten GJV-Sorte, mit dem Ziel die mechanischen Eigenschaften, insbesondere das thermomechanische Ermüdungsverhalten, zu verbessern. Als Ausgleich zu einer geringfügigen Steigerung der Herstellkosten gegenüber dem GJV 450 zeigt sich als positiver Nebeneffekt eine Verbesserung der Bearbeitbarkeit und eine Reduzierung des Werkzeugverschleißes um bis zu 15%. So dürfte sich unterm Strich ein zusätzlicher kostenseitiger Kundennutzen ergeben.

Today’s standard material for high performance heavy duty crankcases and cylinder heads is CGI 450 that has been normated internationally since 2006. The reason for that is a beneficial combination between thermal and mechanical properties and machinability. Developing new IC engines more and more problems show up that only can be solved by compromises in the design. Since 2010 FW is developing a new semi solution strengthened CGI material, with better mechanical and especially thermo-mechanical properties. Potential for compensation of slightly higher cost for that material, could be the improvement of machinability with a reduction of up to 15% in tool wear that has been achieved. The result is a material for higher loads with improved cost for machining.

1. Motivation und Zielstellung
Anfang der 1990er Jahre wurde unter anderem auch bei FW damit begonnen, sich intensiver mit GJV (Gußeisen mit Vermikulargraphit) zu beschäftigen. Der Werkstoff ist zwar schon seit Mitte des 20. Jahrhunderts bekannt, die Serienanwendung scheiterte aber an dem komplizierten Herstellprozeß und der schlechten Reproduzierbarkeit. Nach 3 Jahren Entwicklung waren diese Probleme gelöst und es wurde begonnen, Bauteile, zunächst Kleinserien für den Rennsport, aus GJV 500 herzustellen. Ende der 1990er Jahre wurden erste Nutzfahrzeug-Zylinderkurbelgehäuse aus GJV 450 in Großserie produziert. Das besondere Interesse an GJV resultiert aus der günstigen Kombination der thermischen und mechanischen Eigenschaften und es entstand eine richtige Werkstofffamilie, beginnend mit dem vollferritischen GJV 300, der teilferritischen Sorte GJV 400 und der vollperlitischen Sorte GJV 450. GJV 500, bei dem die Steigerung der mechanischen Eigenschaften durch eine Erhöhung des max. zulässigen Kugelanteils auf Kosten der Bearbeitbarkeit erreicht wurde, kam bis auf ein kurzes Intermezzo für ein ab 1998 produziertes PKW V8-Zylinderkurbelgehäuse nie zur Serienanwendung.
Mit dem VDG-Merkblatt W50 erfolgte im März 2002 ein erster Schritt zur Vereinheitlichung der Werkstoffcharakterisierung der einzelnen Werkstoffgüten. Seit August 2006 existiert eine

entsprechende ISO-Norm (16112) und seit Februar 2012 die entsprechende DIN-Norm (16079).
Im Laufe der Zeit stellte sich heraus, daß GJV 450 den idealen Kompromiss aus mechanischer und thermischer Beanspruchbarkeit für die Anwendung bei Zylinderköpfen und Zylinderblöcken darstellt, so dass bei FW seit einigen Jahren 70.000 to/ anno dieser Bauteile ausschließlich in diesem Werkstoff hergestellt werden.
Mit der Entwicklung von Motoren, die die Abgasvorschrift Euro 6 zu erfüllen hatten, gab es erste Hinweise seitens Kunden, daß es mit GJV 450 zunehmend schwieriger werde, die thermischen und mechanischen Anforderungen an Zylinderköpfen zu erreichen, ohne daß Risse entstehen bzw. ausreichender Restwandstärken nach Anrissen noch vorhanden sind. Grund dafür seien die steigenden Zünddrücke und steigenden Abgastemperaturen. Steigende Temperaturen verlangen nach einer Verbesserung der Wärmeabfuhr, z.B. durch Reduzierung der Flammbodendicke, während höhere Zünddrücke nach mehr Festigkeit bzw. einer Erhöhung der Wandstärke am Kompressionsboden verlangen, um eventuelle Durchrisse zu vermeiden. Ideal wäre also ein neuer Werkstoff, der beiden Anforderungen gerecht würde: Höhere Festigkeit bei besserer Wärmeleitfähigkeit!

2. Versuchsplanung und Materialqualifizierung

Abgeleitet aus den Erfahrungen mit den mischkristallverfestigten GJS-Sorten wurden Legierungen mit Kohlenstoffgehalten zwischen 2,5 und 3,5% und Siliziumgehalte zwischen 3,5 und 5,5% untersucht. Um eine Datenbasis für die üblichen FEM-Berechnungen bei potentiellen Kunden zu generieren, wurde beschlossen, mit der vielversprechendsten Variante reale Bauteile (NFZ-Zylinderköpfe) herzustellen. In Abstimmung mit dem Kunden wurden aus den funktionsrelevanten bzw. kritischsten Bereichen Materialproben entnommen und zur Bestimmung der Wärmekapazität, Dichte, und Temperaturleitfähigkeit bzw. Zugfestigkeit, Streckgrenze, Dehnung, Zug-Druck-Wechselfestigkeit und thermischen Ermüdung herangezogen. Es ergaben sich deutliche Verbesserungen beim statischen und dynamischen Festigkeitsverhalten. Die thermischen Eigenschaften zeigten eine geringfügige Verschlechterung. Außerordentliche Verbesserungen konnten hingegen beim TMF-Verhalten festgestellt werden.

3. Motorische Erprobung und Bewertung Beabeitbarkeit

Für die motorische Erprobung und einer ersten Beurteilung der Bearbeitbarkeit des neuen Werkstoffs wurde ein Probelos aus 15 Zylinderköpfen hergestellt, die alle fertig bearbeitet wurden. Einige dieser Bauteile wurden für Dauerlauf- und Thermoschock-Versuche an Versuchsmotoren verwendet. Außerdem wurden 8 Zylinderkurbelgehäuse gefertigt, von denen 3 ebenfalls für eine motorische Erprobung verwendet wurden.
Zur Bewertung der Bearbeitbarkeit wurden neben den oben erwähnten Bauteilen zusätzlich Bearbeitungsproben ausgeliefert. Resultierend aus allen Bearbeitungsergebnissen, sowohl an realen als auch an Bearbeitungsproben, konnte eine Verbesserung im Werkzeugverschleiß von 10 – 15% festgestellt werden.

4. Fazit und Ausblick

GJV 500Si5 zeigt deutliches Potential zur Steigerung der Werkstoffeigenschaften von GJV. Insbesondere das TMF-Verhalten und die mechanischen Kennwerte lassen eine höhere Belastbarkeit des Werkstoffs vermuten. Erste Bearbeitungsergebnisse deuten auf eine Verbesserung des Werkzeugverschleißes und somit eine Reduzierung der Bearbeitungskosten hin. Vollständige Ergebnisse der motorischen Erprobung sind im Frühjahr 2019 zu erwarten.

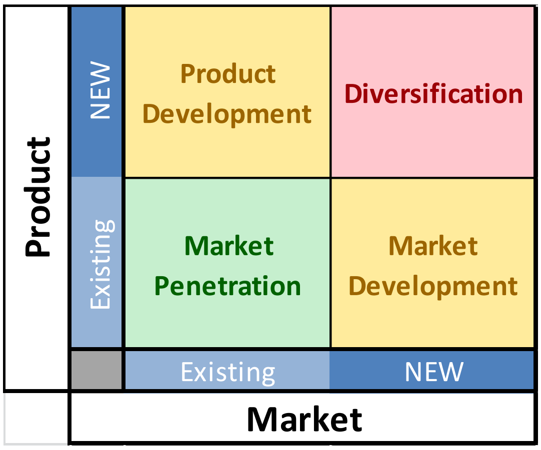
Lateral Diversification – Transformation of a high-volume automotive foundry to a mid- volume jobbing foundry

T. Ziehm, G. Holzem, M. Pampus-Meder, Eisenwerk Brühl GmbH, Brühl/Germany

Turbulent times have arisen for global markets and companies need to find their way to ensure prosper times for the generations to come. These turbulent markets and political challenges lead to a mandatory change of Eisenwerk Brühl's strategy. The focus of this change lies in remaining a prosper, stable and successful business for customers, a reliable employer and tax payer for the local community as well as an interesting asset for shareholders while expanding business opportunities and the product portfolio. Eisenwerk Brühl (EB) has produced cylinder blocks for the last 90+ years, henceforth, this has to change.

1. Strategic Evolution

Getting ready for the future includes rethinking todays strategy, aligning it with today's market needs and filling the gap with new ideas, products and approaches. The annual production volume of passenger cars will steadily increase from approximately 100 to 120 million units over the next decade. The makeup of this market regarding the power train/engine unit will change further from purely internal combustion engines (ICE – diesel, petrol, gas) to a growing share of hybridized power trains and a constantly growing amount of solely electric cars. Being one of the market leaders for cast iron passenger car cylinder blocks, the business model is not questioned and will continue well. Nevertheless, producing for one market only puts you in 100% dependency of the economic cycle of this market. With the knowledge of the global crisis in 2009, EB's shareholders decided to enlarge the product portfolio. By entering new markets with decoupled or displaced economic cycles, the effects of the single markets add up to a dampened overall effect on EB. This decision made, the strategy of EB will change to new opportunities in divers markets. The next challenge was finding the right opportunities in the right markets with attractive volumes, alloys, complexities and prices. EB's newly founded department for New Product Development started their work by using the information gathered from stakeholders, strategic consultants, data bases, customers, visiting fairs and building new networks outside EB's common market for the development of the strategy. There are different ways to change the product strategy in a company as shown in ***Picture 1.***



Picture 1: Ansoff Matrix [1] – Different types of strategic business development

The first option is to stay in the same market with the same products and increase market penetration. The second option is market development, where you enter new markets with the existing products similar to option three, product development, entering current markets with new products. Finally and most challenging, is entering new markets with new products, the diversification. Whether related or unrelated, this is the goal for EB's new products.
On top of conducting a diversification, EB is also extending the value-added chain and therefore is in the field of a high-risk lateral diversification.
By putting together all information the business plan and attractive niches/product groups became more and more tangible. After just a few months of intensive work, a clear picture and a precise business case was build and this major project initiated. The development would take place in three steps. The first step is the investigative phase of the evolution process. The second step is evolving the existing production to new requirements determent in step one. In the last step the factory is able to produce new products as serial parts and has overcome the challenges of a diversification.

2. Investigative Production

In a company that is 100% specialized in the high volume production of passenger car cylinder blocks, entering markets consisting of parts that have mid-volume annual demands is a disruptive event for all departments and processes in the company. New customers asking for different alloys, testing, packaging, finishing, surface qualities, lot sizes and size tolerances as well as many more additions and subtractions to existing processes and habits. The existing machinery is streamlined for the production of millions of cylinder blocks and now designated for the efficient production of new products with a larger share of the value-added chain.

3. Evolving Production

The second step in this evolutionary process is the steady adaptation of standard procedures to meet with the requirements of the new products by reducing and/or changing the extent of all measures taken from initial toolmaking to final machining. Getting this knowledge and feeling for new market dynamics and the right approach to implement new products in an existing production arises more internal than external hurdles to overcome. Originating in the automotive industry, the standards are high and the development process from first prototypes to final serial products can take up to two years, reaching peak output in high numbers after a few months after SOP. In the new markets evaluated, time-to-market duration has to be short, developments efficient, equipment reasonably priced, all processes adjusted to robust and flexible production conditions of a jobbing-foundry. A weekly amount of one cylinder block type represents an attractive annual volume of a new product. Henceforth, all parts need to be wisely chosen. The choice is aiming for beneficial sand-to-casting-ratios, manageable intra- and interlogistics, fettling effort, shot-blasting accessibility, quality control requirements and surface finishing. The value-added chain is to be enlarged to increase the revenue impact of the new products on the existing business. Therefore, the sales department has to apply thorough filtration in the choice of products considered for quotations, to make the Business Unit contribute to a prosper future of the company. To accomplish such tasks, investments will take place in crucial bottle necks to outperform competitors and remain one of the most efficient foundries in the world.

4. Serial Production

At the final step of this evolutionary process, all new parts for the new business unit are running smoothly through the remodeled, flexible quotation and production process. Customers RFQs are dealt with in a matter of weeks and not months. Product development from first idea to prototype and first serial production takes place in a matter of months and not years. This investment in the future and the new business unit will widen the horizon of all employees and ensure a stable future for the generations of customers, employees and other stakeholders to come.

[1] **Ansoff, H.I. 1965; Checklist for Competitive and Competence Profiles; Corporate Strategy, pp 98-99. New York: McGraw-Hill**

Data Becomes Facts – Improvement of production processes by digitalization Step-by-step implementation of a modular manufacturing execution systems (MES)

Dipl.-Ing. E. Winter, Eisengiesserei Baumgarte GmbH, Bielefeld/Germany

The iron foundry Baumgarte is one of the largest German foundries with three moulding lines and diverse references in very different branches of industry. The company stands for sophisticated and up-to-date cast technology, for highest quality and adherence to delivery dates as well as for future-orientated technology. The iron foundry Baumgarte feels committed to this leading position – not only today but also in the future.

On the way to Industry 4.0

In order to achieve more transparency, improved information flow and smoother processes within the company, Baumgarte decided to introduce a Manufacturing Execution System (MES). At the end of 2010, the go-ahead was given: the module for the machine data acquisition (MDA) was implemented as a pilot installation at two core-shooting machines. This MDA component could be put into operation easily and quickly since the requirements of the MES had been clearly worked out together with FASTEC. In the spring of 2011, just six months after the pilot installation, the system was expanded to the remaining 12 machines in the core shop. The same happened for the three moulding lines in August 2011.

Today, comprehensive data in real time is available for Baumgarte in order to analyse and optimise all production areas. This allows audits and date inquiries to be carried out within a few minutes, for example. With the gradual introduction of a modular MES, the company has successfully completed the first important steps towards Industry 4.0.

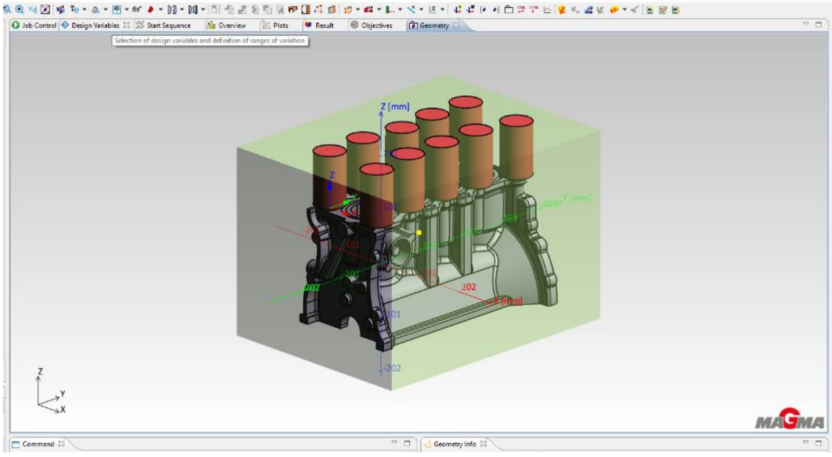
Overview of the Manufacturing Execution System

- In use: MES solution FASTEC 4 PRO with the following modules: machine data acquisition, production data acquisition, process data acquisition and document display
- Interfaces: XML-based SD interface
- Connected systems: core-shooting machines, moulding lines, machining centres

Optimizing a Smart Process to Make Lead Times Shorter

T. Kroes, Kimura Foundry America, Shelbyville, IN/USA

Kimura Foundry America is a new-age, high technology foundry. In November of 2018, Kimura Foundry America opened in Shelbyville, Indiana, USA, for production of low quantity/prototype castings. One item that makes Kimura Foundry America a high technology foundry is the 3D printers that we use to print our cores and our molds. Kimura Foundry America currently has two printers, one using a no bake furan resin and one that uses a cold hardening process. These printers use Kimura's own patented artificial sand to help ensure a quality casting. Another feature that we use is our simulation tools. With the use of the optimization and the analyzation of the many different results from the simulation we are able to predict zero-defect castings. We use the optimization feature to make efficient risers and other components in our casting system. Using different criteria, we can make an exceptional casting efficiently no matter what material the part is. The use of simulation is one of the first steps in our continually improving process and is a vital step to making a quality casting quickly.


Job Control
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Simple Steps to Increase Energy and Resource Efficiency in the Melting Shop. Our experience as a midsize cast iron foundry

Dr.-Ing. L. Lomina, Metallwerk Franz Kleinken GmbH, Dorsten/Germany

The iron foundry Metallwerk Franz Kleinken GmbH specializes in the production of individual parts and small series of high-quality gray and nodular cast iron castings. The family business, founded in 1904, is now run by the fourth generation and is committed to the continuous development and improvement of its organization and processes. Not only economic, but also ecological goals are pursued: conserving natural resources, reducing emissions and increasing plant safety. As part of the continuous improvement process, the procedure for inductive melting and the further handling of liquid iron was analysed, such as keeping warm and magnesium treatment, weaknesses identified and measures elaborated. In the present paper both the well known factors such as proper charging, quantity and purity of the recirculation material, keeping the furnace lid open, and the internally specific parameters, such as preheating and lining of the pans, minimizing the temperature loss of holding iron, and reducing the amount of magnesium wire is reported. Our nickel reduction for ferritic nodular cast iron is an example for increased efficient use of resources. Subsequently, achievements and experiences from our project "Open Innovation" are briefly explained.


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The LFS Concept: The new binder/additive/ coating package for cold box production to comply with formaldehyde limits in exhaust gas flow

F. Lenzen, Dr. J. Müller, ASK Chemicals GmbH, Hilden/Germany

With the LAI (German Federal-State Working Group on Immission Control) implementation recommendation of 09.12.2015 for the reduction of formaldehyde emissions in exhaust gas from 20 mg/m^3 (mass concentration) to 5 mg/m^3, some foundries are faced with the challenge of having to comply with these values at short notice (a deadline of 05.02.2020 applies to old foundries/plants).

While this primarily concerns German foundries, it is likely that other European countries are also considering tightening this benchmark due to the classification of formaldehyde as a category 1B carcinogen.

This value appears to be particularly relevant for exhaust gas flow from coating dryers. Cores produced by the cold box process have per se residual amounts of formaldehyde but, in combination with additive and coating at exactly temperatures around 150°C, also emit additional formaldehyde, so that the limit of 5 mg/m^3 can easily be exceeded.

To provide foundries with an immediate solution that does not require secondary investment (such as scrubbers or RTOs), a new concept has been developed that demonstrably reduces these formaldehyde emissions in practice by more than 70%.

An essential component of this low-formaldehyde system (LFS) is a specially designed combi-package of binder, additive and water-based coating which, on the one hand, provides the lowest possible base load (i.e. potential sources of formaldehyde) and, on the other hand, absorbs released formaldehyde, so that a value under the 5 mg/m^3 limit could be first achieved by users of this technology.

Design of New Green Molding Sand Binders with Lower Emissions and Enhanced Process Performance

Dipl. Geol. S. Böhnke, Dipl. Eng. P. Kantsou, Imerys Metalcasting Germany GmbH, Marl/Germany, C. Zetterstrom MSc, Imerys Minerals USA Inc., Atlanta/USA

The complexity of the molding sand and the molding sand process reflect the requirements towards the components and their behaviour during the casting cycles. To achieve the best casting quality with the highest efficiency or low emissions is the final target.
The bonding mechanism of the binder is the most important factor to achieve good results towards molding sand performance and efficiency. In our development efforts to improve this bonding mechanism, specific additives can be formulated into traditional preblends. They are designed to improve the green sand performance properties. These additives are not limited to the binder, but also supportive additives that are complementary to specific performance criteria. While to reduce emissions from green molding sand processes have been a challenge for many years, a new product designed via engineered raw materials have been achieved with a significant reduction in hazardous emissions during green sand molding with improved green sand properties and casting quality.

Testing procedures/Methodology

Different steps exist to control the quality of the molding sand and the casting quality in the development of new molding sand binders and additives. After the investigations in the IMERYS Science and Technology laboratories it is necessary to monitor the performance of these additives in several casting cycles. The validation of the consumption rates of the prepared green sand was evaluated with mold preparation and casting cycles at the University of Northern Iowa. Complete cope and drag molds were prepared in a tight flask to simulate actual foundry applications including cycle behavior in 4 cycles. The molding sand properties have been monitored, also the consumption has been calculated by the volume of replenished preblend based upon the Methylene Blue Clay content. The thermal behaviour e.g. sintering temperature and expansion characteristics of the designed binder, as well as the casting quality complemented the overall evaluation. For the emission analysis, bentonite and carbon preblends have been evaluated by casting cycles. Prepared molds were cast in an enclosed hood to completely capture emissions like HAP, VOC and carbon oxides according to EPA procedures 1, 2, TO-15, 25A and 10. Measurements of the emissions took place during pouring, cooling and shakeout, which at large contribute to the emissions characteristics in the foundry environment.
To verify the performance of the cast surface a novel approach has been developed to laser image the castings and complete a comparison beyond the traditional visual imagery of the casting. Since the cope and drag surface of a casting can result in very unique surface characteristics, both were analyzed to determine the overall casting quality. The casting surface evaluation included penetration as well as other possible casting defects, related to the amount and quality of carbonaceous additives and their interaction with further molding sand components in traditional customized preblends.

Results

With the selection of raw materials from the IMERYS mineral portfolio we were able to improve the bonding mechanism of the prepared molding sand. This has been verified with green sand molding properties like increased wet tensile strength, the lower consumption level of the formulated preblend as well as an increased sintering temperature (Figure 1), both related to an improved thermal durability.
During the selection of engineered raw materials with emission reduction potential we were able to achieve a significant reduction in emissions between 30 and 50% (Figure 2) to the comparable preblends. Simultaneously the testing protocols measured the green sand properties and proved that these testing parameters were maintained.

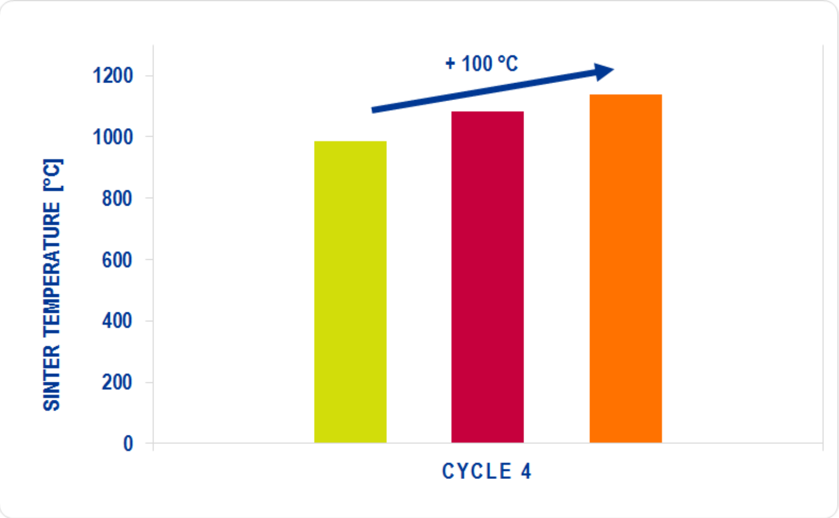


Figure 1: Increased sintering temperature with selected additives

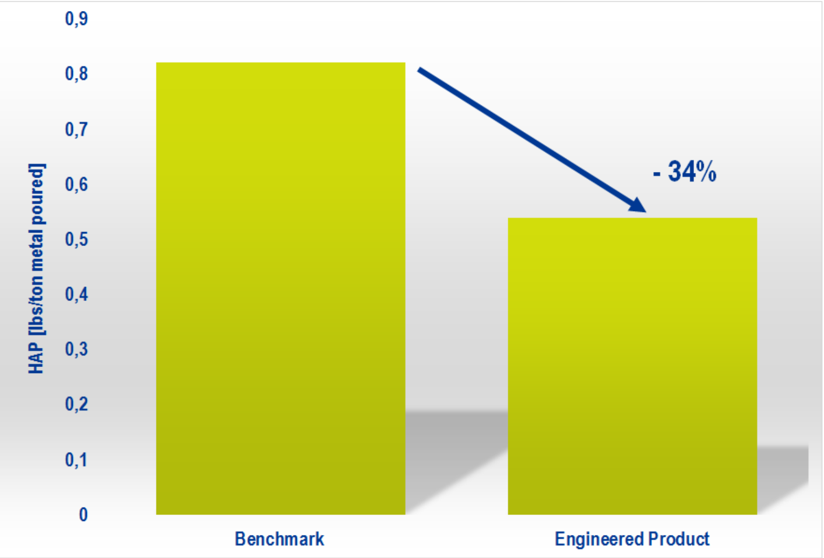
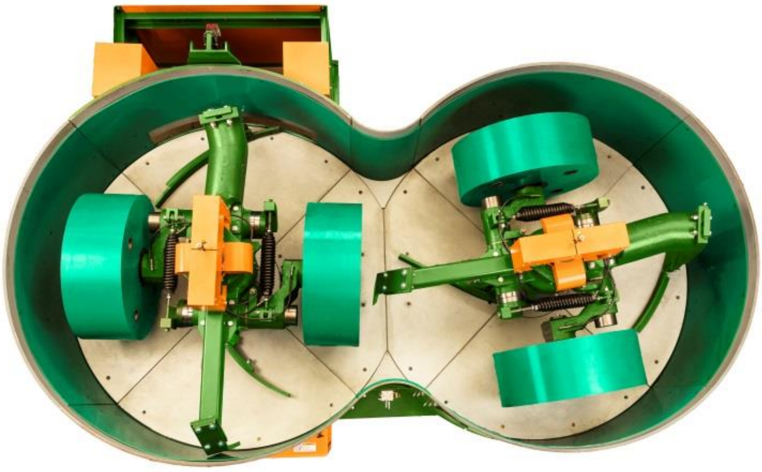


Figure 2: Decreased emission level [HAP's] with engineered raw materials

New Developments in High Efficiency Continuous Mixing in Green Sand System

B. Dienst, S. Strobl, A. Klimm, Simpson Technologies (Deutschland) GmbH, Euskirchen/Germany

In recent years, the competitive global market for complex, high quality and low cost metal castings has encouraged the leading manufacturers of molding machines to develop ever larger and faster molding lines to achieve previously unattainable levels of productivity per unit of time, space, energy and labor. The traditional sand preparation solution for such systems was to provide multiple, or much larger, batch mixers which increased significantly the complexity, size, purchase cost, maintenance and energy costs required to produce the larger volume of sand.



The original development of the Simpson Multi-Mull continuous green sand mixer anticipated by several years the development of automated molding systems and hundreds of continuous mixers are now in daily use in the global foundry industry. However, with the advancement in sensors, control systems, mechanical components and related technologies the latest generation Simpson Multi-Mull continuous mixer has been advanced to a new level of performance and capability unequaled by any batch mixer. The modern Simpson Multi-Mull, especially when combined with the Simpson Multi-Cooler, is an integrated system of machine and automation that supports the optimal performance of the new generation of automated molding lines to provide high volume, high quality, low cost and sustainable productivity in sand preparation further reducing the cost of casting production.
This presentation highlights the latest developments in continuous green sand preparation and presents the performance results from a recent installation.
Continuous sand preparation systems have the following advantages:

a) reduced capital investment costs by producing the greatest volume of high quality prepared sand with the fewest number of machines and components. The reduced number of components also reduces operating costs from maintenance parts and maintenance labor.
b) reduced operating costs by providing the most prepared sand per hour with the least consumption of electrical energy – frequently 30-50% less than comparably sized batch mixers.

c) improved casting quality by delivering prepared sand with superior physical properties, less variation and with optimal use of expensive raw materials. With an advanced on-line control system, such as the Simpson+Hartley compactability control & automation system, complete control over every aspect of the plant is possible.

Our presentation will explain the following key points –

1. How it works

The need for continuous sand preparation in green sand molding lines is a matter of simple economics that all engineers understand – foundry costs go down when equipment is used to is maximum potential. Many foundries measure this through Overall Equipment Effectiveness (OEE). It quickly become obvious that a continous mixer has a higher OEE than a batch mixer and benefits the foundry by optimizing energy efficiency and reducing maintenance costs.
We will explain –

1.1. How a continuous mixer is more efficient than a batch mixer.
1.2. How the Simpson Multi-Mull uses the unique principal of back-blending and controlled retention compared to flow-through mixing of other continous mixers.
1.3. How the Simpson Multi-Mull uses the same proven principal of „mix-mulling“ from batch mixers to effectively and efficiently prepare molding sand.
1.4. The difference between retention time in a continuous mixer and cycle time in a batch mixer and how retention time can be varied in a continuous muller to meet the needs of different applications.

2. How it's made

The new generation Simpson Multi-Mull incorporates features to minimize maintenance and operating costs. We will review some of the key developments such as –

2.1. Independent, electronically synchronized gearmotor drives
2.2. A new discharge door design featuring stainless steel & chrome plated components and a new servo actuator for ease of maintenance and improved retention control
2.3. New mixing tool design, including high visability urethane muller wheels with wear indicators and lifting points, to maximize part life and minimize maintenance time.
2.4. The mixer has a removable crib wall section makes it possible for maintenance to walk directly into the machine at floor level and remove parts without having to elevate them over a crib wall.

3. How it's used

Until the Simpson Multi-Mull was developed there was only one say to increase sand preparation capacity – add more, or larger, batch mixers. In doing so, equipment and operating costs significantly increase and foundry space shrinks as belts, hoppers, dosing components, control equipment and manpower for maintenance is added. In many cases, the foundry ends up with a batch mixing concept serving an otherwise continuous and automated molding line. The Simpson Multi-Mull continous mixer was developed to provide foundrymen with an economical, high performance system that delivers continuously, and on-demand, high quality molding sand with less space, as much as 35% fewer components, 30-50% less electrical power and less maintenance than batch mixing system of the same capacity. We will illustrate a layout where a single Simpson Multi-Mull provided the same quantity and quality of sand as two batch mixers significantly reducing the investment and operating costs for the foundry.

4. How it's controlled

To efficiently operate the Simpson Multi-Mull Simpson provides a newly improved Simpson+Hartley on-line control and automation system together with integrated additive dosing systems for bentonite and water. The new control system is designed with Industry 4.0 in mind and provides a variety of sensors to monitor the health of the machine in addition to controlling compactability within tight tolerances. The controller can be linked to the molding machines to automatically balance the rate of sand preparation with the rate of molding. Our presentation will highlight some of these new features.

5. How it performs

We will present data from the installation of a model #23G-250 Simpson Multi-Mull that replaced a large turbine mixer in a North American automotive foundry producing ductile iron castings utilizing two DISAMATIC molding machines – a 230B and a 231B. The foundry reduced the connected power to the mixer by 60%, reduced machine maintenance and produced more molding sand with the same or better properties.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A Logical Development: The Application of the Cordis® Process on Iron Casting

Dr. F. Iden, Hüttenes-Albertus Chemische Werke GmbH, Düsseldorf/Germany; Dr. B. Dudzik, Brembo Poland Sp.z.o.o., Dąbrowa Górnicza/Poland

By now, the use of inorganically produced cores in German automotive aluminium foundries has largely been established. The developments in the section of inorganic binder technology and the environmental and technical production advantages that have been reached are closely followed throughout the world. Thanks to continuous new developments doubts in the efficiency and profitability could be disproved by practical experience. Examples of success serve as model characters and are talked about in the world of foundries. Many renowned, globally acting foundries deal today with the subject "Inorganic Binders" and research the practicability of a change of technology. This development awakened inevitably the interest of iron-casters who are keen on applying the new and environment friendly technology to the serial production.

Especially for iron casting the application of inorganic binders to the core production is not really unknown. However, the most common inorganic binder system, the water glass-CO_2 system, shows considerable performance disadvantages. This means a short shelf life of the cores, an insufficient strength level, unsatisfying shake-out properties and an incompatibility with water based coatings.

The challenge for a new inorganic binder system in iron casting is to use the advantages of the inorganic binders and simultaneously overcome the special hurdles of iron casting. These are for example the substantially different casting conditions. A key topic here is the application of water based coatings on inorganically bound cores. Meanwhile, HA has registered a corresponding solution for patent.

Most important steps within this development have been reached through a joint project between HA and Brembo. As an important foundry group with production of iron and non-ferrous castings worldwide, Brembo is highly interested in improving its environmental footprint, the inorganic technology being one of the most important resources for decreasing hazardous emissions and waste.

Platform for developments

Significant jobs for the development and testing of binder systems, core sand-binders and coatings have been done in the HA Center of Competence during the past months. The CoC is the central development platform for testing and proving of new materials, binders and coatings. There, process parameters can be gathered, observed and determined under standardized conditions. Especially for the development of inorganic binder systems for aluminium casting as well as for iron casting it could be shown that it is not only a question of materials but also a question of the art of processing and of process parameters. Thus, the cores produced under strict parameters, with near practical conditions in the HA Center of Competence, were casted under real industrial conditions in one of the European foundries belonging to Brembo.

Visualization and Control of the Entire Foundry for Better Casting Manufacturing

Y. Ogura, Sintokogio, LTD., Aichi-Pref-/Japan

In green sand molding process, “preparing better molding sand” is required for “making better castings”; this means few casting defects. Because scrap rate caused from molding sand is even high. In addition, variation reduction of process control in sand plant is the most important issue and role for stabilization of quality. However, sand properties include many different parameters so that control is not easy. Consequently, improvement is required since many foundries trouble to adjust them according to the workers’ experiment.
On the other hand, recent development and improvement of measuring technology and processing ability enable various measurement and control. These technologies are utilized for meeting customers’ demands. In this lecture, utilization examples of data are described after proceeding “visualization” of measured sand properties on each process of sand plant, utilizing collected data for analysis, and using them for feedback control.

Sand Cooling

Sand cooling process measures return sand temperature and moisture, then feed particular amount of water to adjust moisture to target value and cool down to target temperature, and then cool down by sand cooler. Fig.1 and 2 show transition of temperature and moisture of return sand and amount of fed water. From Fig.1, though temperature range of sand before cooling is from 50 to 100 deg. C, temperature after cooling keeps around 30 deg. C. This result means superior cooling ability. And from Fig. 2, when moisture before cooling transits from 0.5 to 2.3%, moisture after cooling keeps around 1.5%. This result also shows moisture is controlled superiorly.

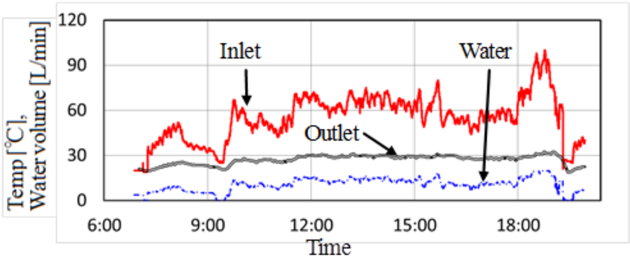


Fig.1 Sand Temp. and Water Amount Before and After Cooling

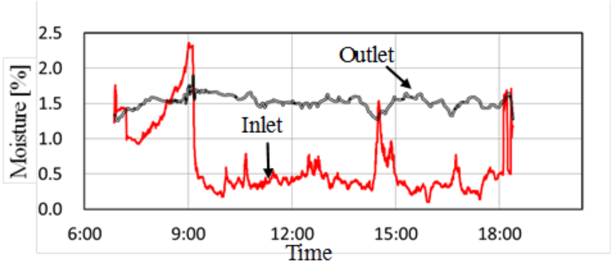


Fig.2 Moisture Before and After Sand Cooling Process

Mixing

In mixing process, moisture and temperature of return sand charged into the mixing equipment are measured, and mixing equipment feed primary amount of water, this means the amount to adjust to the target moisture. Then, compactability, temperature, and moisture are measured during mixing; and then compactability is adjusted to target value by additional water feeding.

Molding Sand

In traditional way, sand properties were measured manually and offline. However, developed inline sand tester has enabled automatic measurement. Measureable items are five items; temperature, moisture, compactability, permeability, and compressive strength. Especially, compactability influences moldability. However, influence of sand temperature and ambient temperature varies compactability on molding machine and cannot always satisfy the target on molding machine. Developed sand tester controls compactability of sand mixture to meet target value of compactability on molding machine by feedback control based on measured compactability on molding machine. Fig.3 shows the comparison with/without feedback control. Result of without feedback shows higher compactability in the morning and compactability is descending forward evening time. On the other hand, feedback control enables to supply steady compactability molding sand to molding machine all day.

Conclusion

Sand properties are sensed before and after each process in sand plant and are proceeded visualization. In addition, processes are controlled based on these data. These developments make status in each process clear and improve control by utilization of feedback control. We will continue to work for further development.

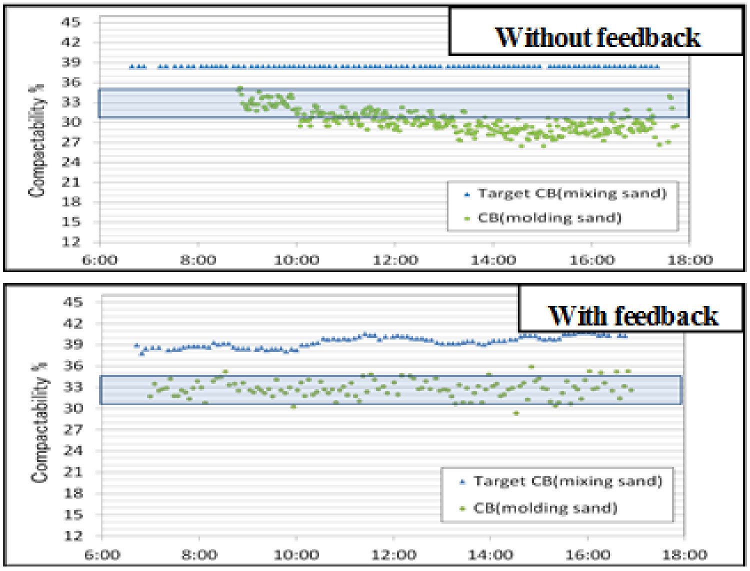


Fig.3 Compactability on Molding Machine With/Without Feedback Control

The Foundry of Tomorrow

Dr. P. Larsen, DISA Industries A/S, Denmark

1. Introduction
Green sand moulding has benefitted from enormous amounts of research and development. The current state-of-the-art process is proven, efficient, cost-effective and delivers reliable quality at scale. For many industrially produced cast iron parts, there is no viable alternative.

Despite reaching this peak of performance, it is not the ultimate by any means. There still remains great potential to further evolve and improve the green sand process in the coming years. New technical innovations and the ongoing digital revolution in the form of Industry 4.0 will help enhance traditional metrics like productivity – the most important focus for past innovation – as well as helping to satisfy new demands such as better sustainability and working conditions.

This presentation will discuss some of the practical answers to the challenges involved in preparing green sand moulding for the Foundry of Tomorrow. It will highlight both short and long term hands-on solutions which, if widely adopted, can move foundries beyond today's already impressive performance.

2. Sustainability
The modern foundry places a much greater emphasis on sustainability. Amongst other things, this includes consuming less energy and fewer materials, and lowering the physical effort required from the workforce.

Traditional working practices make great demands on operators' strength and endurance. Filter setting in uncored moulds is a good example, with workers forced to repeat the same movements hundreds of times every hour. Strains and repetitive injuries are frequently the result. Automating the filter setting process avoids this extreme repetition, leaving operators only to periodically restock the machinery and freeing them to perform other high value tasks around the foundry.

To reduce energy and materials use, there are many possible avenues to explore. One fruitful approach is to rethink the pouring system in order to increase yield (the ratio between the final weight of the castings in the mould and the total weight poured into the mould). Redesigning the mould to include a much larger pouring cup and at the same time updating the pouring device making it possible to drain the pouring cup at the end of mould filling means less melt remains in the cup, reducing wastage. Savings averaging 1kg of iron per mould have been reported.

Pouring two moulds simultaneously is another option. In combination with an optimized mould size, this technique delivered a yield increase of 25% at one site.

Avoiding scrap and rework by increasing quality levels also reduces material consumption. Mould gaps can cause both out-of-tolerance castings and downtime due to mould run-out. Checking the moulds for mismatch and mould gaps just before the pouring operation is an effective way to counter this. If the measured value for a mould gap is out of tolerance, an alarm can be set to stop the pouring of that mould. In this way, both scrap/rework and downtime can be avoided, along with the waste of valuable resources.

3. Industry 4.0
Industry 4.0 is a hot topic and offers huge potential for improving processes. However, it's worth remembering that very sophisticated control systems have been available for many years that can already achieve many of the benefits claimed for Industry 4.0 like reduced scrap. Industry 4.0 certainly makes vast storage and processing power accessible at lower costs, but improving process control is a good idea, whether it is "Industry 4.0" or not.

Industry 4.0's great promise lies in its ability to gather and exploit large volumes of process data cost-effectively. In the majority of today's foundries, separate systems often exist for sand preparation, moulding, pouring, scrap accounting and so on, and that data is not available from one central system. It may even not be held digitally but recorded manually on paper. Providing access to all casting process data in one place opens up many new opportunities.

For a start, it makes monitoring and analysis much faster and easier. So when a problem occurs, troubleshooting the cause becomes much quicker and more effective. Logging every piece of process-critical data also opens the door to efficient process optimization and, from there, allows foundries to reduce scrap to an absolute minimum.

The pouring operation is a critical area for data gathering because many quality-controlling parameters originate from this operation: pouring time, pouring temperature and performance of late inoculation are just a few of them. Full and instant access to these quality-critical pouring parameters and the ability to correlate them with the rest of the foundry process data creates a very strong tool for scrap analysis and reduction.

As described above, automatic inline mould-by-mould monitoring for gaps and mismatch before pouring reduces waste but also provides another opportunity to gather data. Checking that data in real-time allows operators to spot trends like increasing mismatch before they actually affect quality or require downtime to remedy. They can also instantly see the effect of small process changes. It's far ahead of traditional inline quality testing methods where the results were only seen 1-2 hours after the actual pouring of the parts took place, leaving room for much scrap to be produced in the meantime.

Being able to gather and centrally analyse much larger data sets sourced from sensors in every part of the foundry is where Industry 4.0 technology really changes the game. It helps us find new ways to predict issues and so improve both individual systems and the whole foundry process – while opening up these benefits to a much wider user base due to its better cost/performance balance.

4. Productivity
Green sand moulding has to become more sustainable and offer a better working environment, but improving productivity is still the central goal. As well as their other benefits, all the innovations already mentioned have a positive impact on productivity.

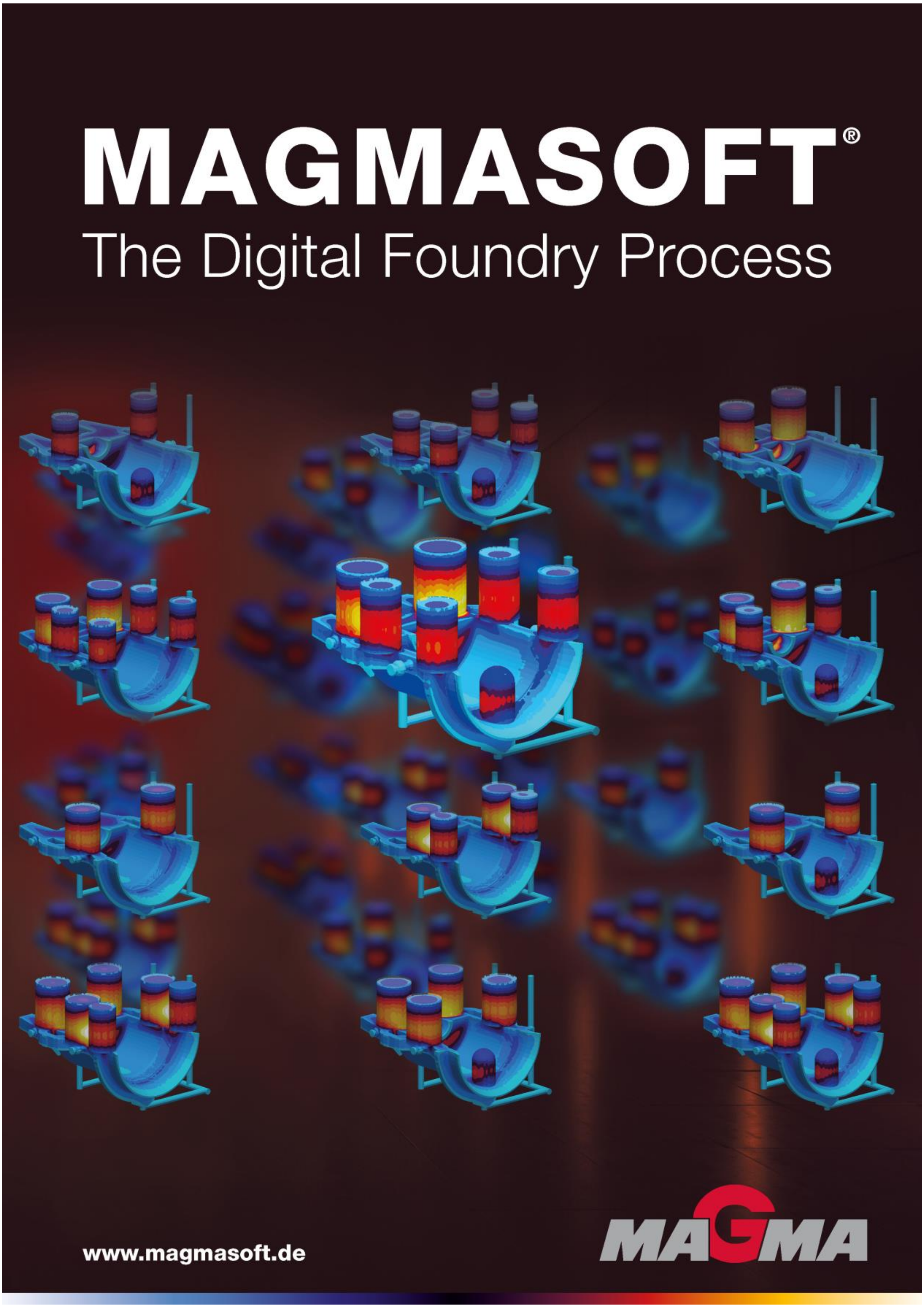
Automatic filter setting on uncored moulds isn't just about safeguarding operators' health, it also increases process speed and repeatability. Moving from manual to automatic setting allows up to 70 extra moulds to be produced every hour.

In the same way, fast pouring using the drainable large pouring cup or pouring two moulds simultaneously permit more moulds per hour without affecting quality-critical parameters like melt flow rate in the mould. With fast pouring, the moulding line can move as soon as the large pouring cup is full while mould filling still takes place internally in the mould. Double pouring extends pouring time and allows the moulding machine to work at full speed. Productivity increases of 20% with both solutions are not uncommon, depending on the pattern plate used.

Techniques like inline mould gap and mismatch monitoring do not increase the moulding rate directly but the early warnings of developing problems it gives avoids unplanned stops and reduces scrap/rework, so the overall productivity of the foundry increases.

5. Conclusion

Green sand moulding is now in a highly evolved state, but it is nowhere near the end of its innovation journey. As we have discussed, the development of new technology and the ongoing trend to digital transformation will help us remove current bottlenecks and so improve classic measures like quality and productivity, as well as meeting new challenges like sustainability.


MAGMASOFT®
The Digital Foundry Process
www.magmasoft.de
MAGMA

The Virtual Core Shooting Machine – Robust Core Production Using a Real-Time Controlled Process

Dr.-Ing. I. Wagner, Magma GmbH, Aachen, Dipl.-Wirt. Ing. K. Jenrich, HA Group, Düsseldorf, Dipl.-Ing. R. Wintgens, Laempe Mössner Sinto GmbH, Barleben/Germany

Today, successful cast component development depends decisively on the predictable feasibility of the core production, as well as on a reproducible core quality. This is especially true for complex cores in important promising and future markets for castings, whether in all heat exchangers in electrical or combustion engines or complex hydraulic applications.

Preconditions to realize the above objectives are robust process conditions and, ideally, the availability of an efficient process control. The multitude of influencing factors in core making processes (sand, binder, core geometry, tool design and maintenance, process setup and machine conditions) as well as the complexity of describing the physics of the processes in the core shooting machine is an obvious challenge. Therefore, all efforts to directly control the process conditions have up to now been limited to qualitative information received retrospectively from the running production.

Within the last years, important improvements to simulate the shooting as well as curing processes of cores have been realized. At the same time, binder suppliers have enhanced their efforts to quantify the influence of their products on the final core quality, beyond describing them by qualitative effects. In the meantime, core shooting machine producers provide a comprehensive technical infrastructure for real-time measurement and control. The missing link thus far was a direct model coupling the important influencing parameters with the resulting process. This is a precondition for a real-time control within the core shooting machine.

For this reason, three leading technology suppliers have joined their forces to realize a solution allowing a continuous adjustment of process conditions for a given core, binder systems and machine configuration used during production. This presentation describes the concept, joint efforts, validation and successful implementation in a real-life production environment.

The basis for this common project was a development which allows the simulation of the flow and the pressure situation in the coupled system of a core shooting machine and the core box tooling. As the simulation software calculates the complete shooting process in milliseconds, a main precondition to integrate this solution in the real-time controls of the machine is available. The results of the model allow a comparison with the current existing production conditions (e. g. height of sand in the hopper, cleanliness of the tool) for any single shot using simple sensor technology in the machine. The machine will become capable to "learn" to set the right process conditions for a reproducible core production considering the current tooling, sand system and machine configuration.

The results can be applied to realize a real-time, knowledge-based control of the core production. This enhances the potential for all parties involved, the machine maker as well as the binder and the software supplier, to offer their customers new and intelligent solutions for a digital transformation of core making processes aimed at optimized and robust core production.

Simulation and Optimization of the Decoring Process of Inorganic Sand Binder Systems for Light Metal Casting

Dipl.-Ing. H. Sehrschön, T. Rathner, Fill Gesellschaft m.b.H., Gurten/Austria, Dr.-Ing. D. Günther, F. Ettemeyer M.Sc., Fraunhofer IGCV, Garching, Germany

Inorganic sand-binder systems are more and more used for core-intensive light metal casting due to technological and environmental advantages over organic cold box systems. A key challenge in the application of inorganic bound sand-cores is the decoring of filigree inner cores, since the inorganic binder does not thermally decompose during casting. The decoring is typically done in a two-step process. In the first step the core gets perforated by targeted impacts of a hammer on the light metal component. In the second step the broken core fragments are then smashed against each other and removed from the casting part using a high energy vibrating system. So far, the process design has been experience-based due to a lack of simulation tools. With a new phenomenological material model it is now possible for the first time to predict the origin and extent of the core failure with sufficient accuracy. The simulation model includes position, intensity, number and frequency of the hammer impacts. Due to a user-friendly graphical interface, it is possible to ensure the possibility to decore filigree interior structures in an early phase of the construction of the casting components, as well as to design the coring process and to optimize it with regard to efficiency. With this approach, a central insight in the use of inorganically bound sand-binder systems is presented. The validation of the presented methodology is based on industry-related reference components.

State of the art of

By now the casting industry realizes prototypes of casting parts using 3D sand printed cores and molds. With these casting prototypes experiments on standard decoring equipement are done to estimate process times for automation and identify regions of cores that may cause difficulties [1]. Very often the experiments are not comparable with later industrialization of the production. Thus the result is not a real proof of an efficient crack and decoring process for the series production.

Virtual Decoring in the virtual testing laboratory

The virtual decoring process is structured in two simulation steps. In the first step the shrinking of the casting part onto the sand-core is simulated. This is necessary because the impact of heat and the pressure-forces onto the sand-core due to the shrinking has to be considered. In the second step the impact of the hammer onto the casting part is simulated. Therefore in the virtual environment the number of used hammers, the position of the hammers, the geometry of the hammer-head, the geometry of the casting part and the anvil as well as the impact energies and material-combinations can be examined. This offers the possibility to predict a field of suitable process tolerances that could lead to a satisfying decoring result. The data from the simulation process is furthermore supported by a heuristic approach which proves the calculated results in regard to plausibility and gives a fast assessment of the expected decoring result.

The occurring stress in the casting part as well as in the sand core are compared with limits from a database. If the stress in the sand core exceeds the stress limit the probability of core fracture is present and the location of the predicted core damage is shown in the user-interface.

Results

As specimen for the basic investigations a cast-in sand bar is in use. The casting part has a cross-section of 42.4 mm and a length of 150 mm. The inserted sand core has a cross-section of 22.4 mm which is a dimension that is widely used for scientific investigations, e.g in [2], [3] and [4]. In Figure 1 the graphical user-interface with a virtual specimen is depicted. The specimen is sliced along its longitudinal axis so that one can see into the casting part. The cast-in sand bar is decored from the outer edges of the specimen to the center of the specimen where the hammer induces pulses. This behaviour of the decoring progress can also be seen in a qualitative manner in the experiments on the specimens.

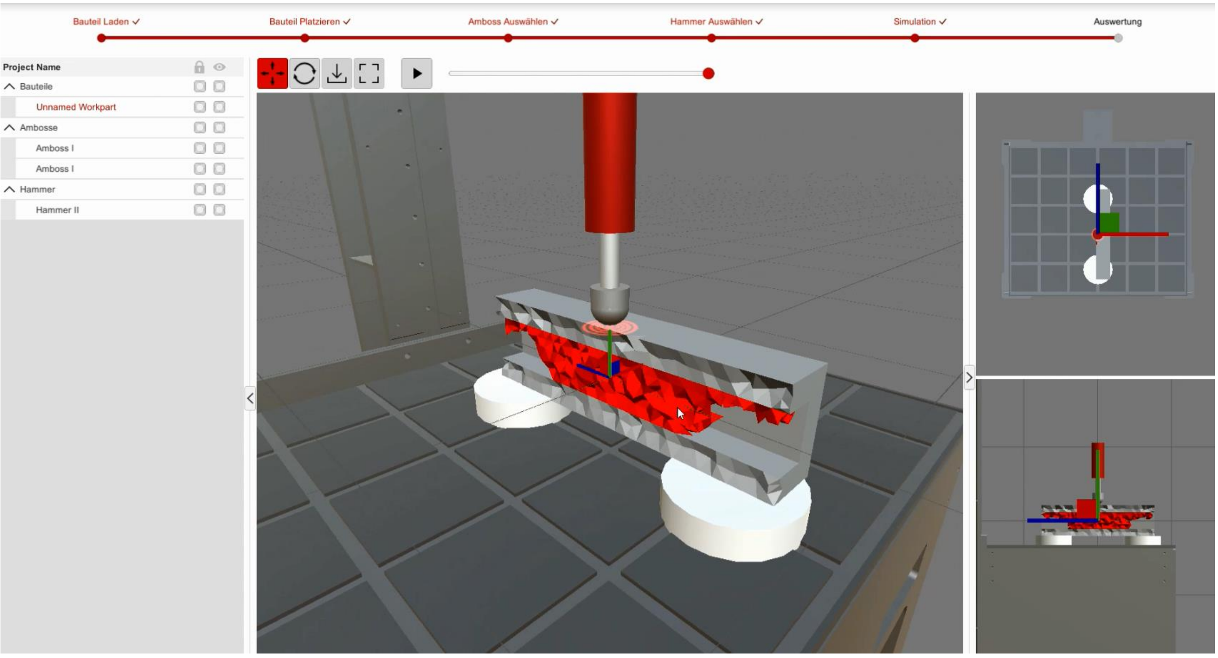


Figure 1: Design of the Graphical user interface for the visualization of the decoring progress of a cast-in sand bar

Conclusion and practical benefit

In the Fill Future Zone, the decoring test equipment is accompanied with decoring simulation and so the decoring process can be optimized in different ways. Thus also running series production can be investigated to reduce decoring process time, energy consumption and part stress during decoring. A great oppertunity could be the integration of the decoring simulation in the endineering and design phase of casted parts to estimate production costs or to realize shorter time to market.

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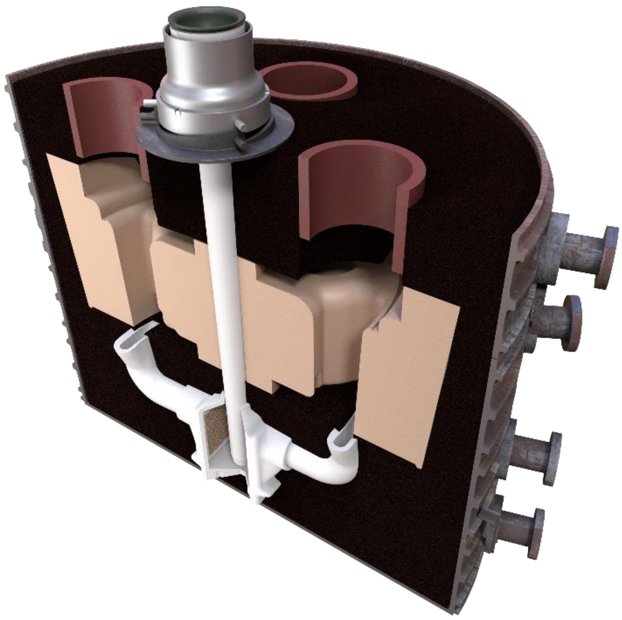
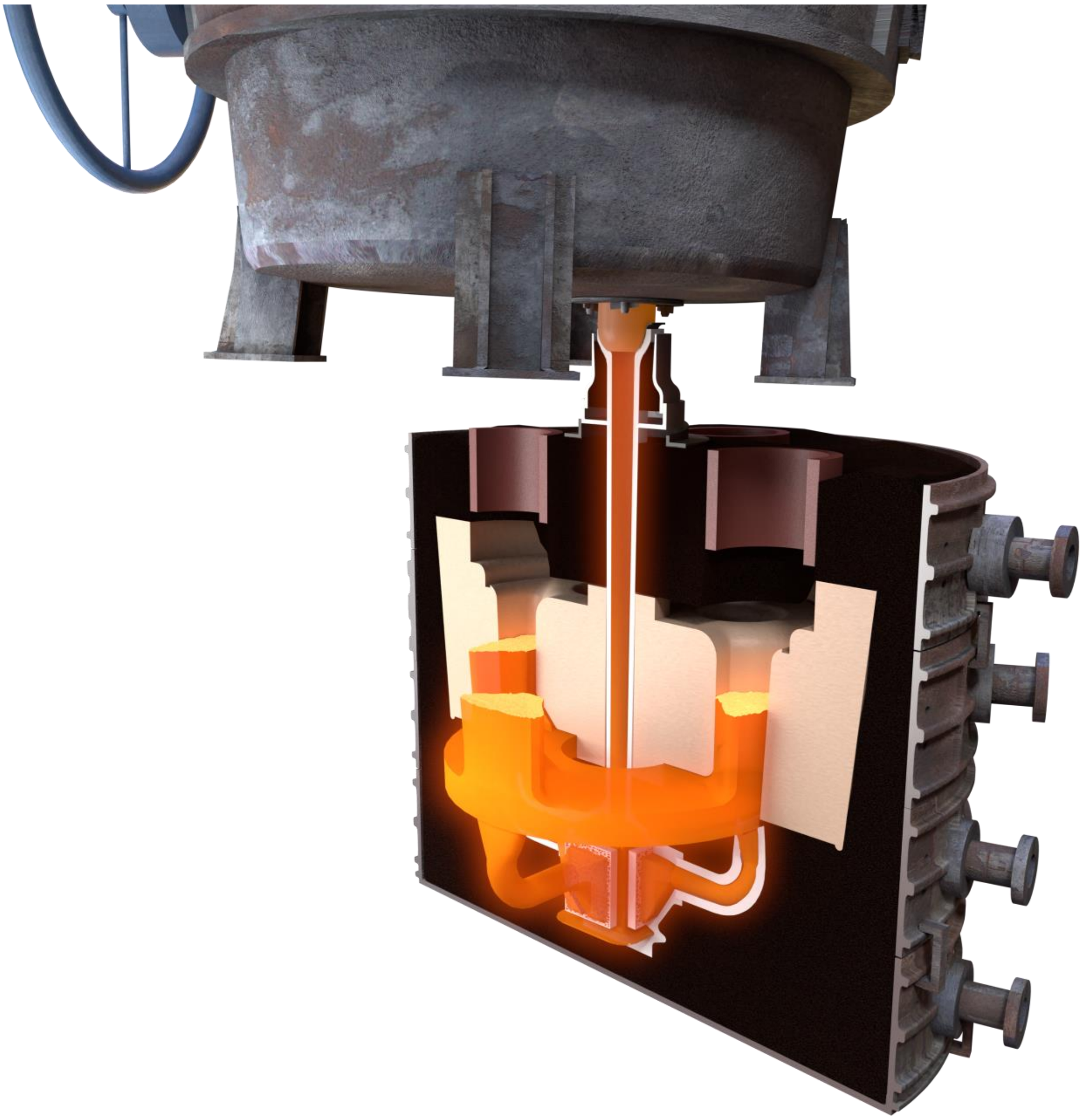
Advances in the Pouring of Steel Castings with a Shrouded Metal Stream

D. Hrabina, Foseco, M&T Europe, Trinec/Czech Republic

Foundries pay insufficient attention to the protecting the metal stream from the bottom pour ladle during the casting process. Oxide films readily form on the surfaces of the metal streams, then through metal turbulence these films are entrained in the metal and new oxide layers form. These films often exist as bi-films and initiate many defects in the casting, degrading the physical properties. For many years continuous casters of metals have been using processes to project the metal streams during casting, foundries are now able to enhance their casting quality using a shrouding concept. This paper describes a new process that can be effectively applied in steel foundries. A shroud is positioned in the mould, the bottom of the shroud penetrates into a filter block located at the base of the mould. When the ladle is in position the shroud is mechanically lifted so there is a seal between the nozzle and the shroud, the shroud still penetrates into the filter block. This allows the metal to flow from the nozzle, into the filter block, and then to the runner whilst being protected from exposure to air and eliminating the potential for air aspiration. The Czech foundry UNEX now applies this shrouding principal to a range of high integrity and quality demanding castings. Dramatic quality and productivity improvements are achieved due to the elimination of oxide and bifilm formation within the casting process. In addition to improved surface quality of the castings, significant reduction of X-ray and ultrasonic detected defects are experienced. In addition to improved surface quality of the castings, significant reduction of X-ray and ultrasonic detected defects are experienced as well as increased notch toughness value.





Reduction of CO_2 Emissions from Hot Blast Cupola Plants through Optimized Process Internal Waste Heat Recovery

Dipl.-Ing. F. Wondra, Herp Giessereitechnik GmbH, Freudenberg/Germany, G. Karlsson, Volvo Powertrain Corporation, Skövde/Sweden

In order to use the latent heat that is bounded in the fractional CO-volume carried by the flue gas from blast cupola furnaces the carbon monoxide has to be burned (oxidized) in the most efficient way. This process takes typically place in a separate burning chamber that is located downstream from the cupola flue gas outtake. This concept is valid for todays hot blast cupola plants with dry and wet gas cleaning systems in the same way.

To establish a stable, efficient and complete oxidation process of the carbon monoxide in the cupola flue gas, the controlled injection of burning air or pure oxygen into the burning chamber is necessarry.

After complete oxidation of the carbon monoxide to CO2 a significant amount of thermal energy is available in the burning chamber. In order to increase overall thermal efficiency of the cupola plant and to reduce CO2 emissions, the main goal is to make maximum use of this thermal energy. The todays standart heat recovery technics allow at first to use fractions of the given thermal energy from the burning chamber to heat up the burning air for the cupola furnace from ambient temperature to typical temperature values of 500°C to 600°C. For this heat recovery process tube bundle recuperators so called „hot blast bundles“ are used today. These apparatuses are inetrgrated in the cupola plant downstream from the burning chamber. This means that the hot burning chamber gases are directly passing the tube bundles after leaving the burning chamber. In order to prevent a thermal overload for these hot blast bundles and mechanical demage the burning gas is normally mixed with cooling air at the outlet of the burning chamber. This is of course a rather inefficient cooling mode. Alternatively the temperature in the burning gas flow can becooled to lower temperature values by using thermal oil or water heat exchangers upstream the hot blast bundles. These heat exchangers are typically connected to a secondary cooling circuit to transfer heat to external users out of the cupola process itsself.

In the present study the technical options to increase the amount of thermal energy recovery within the cupola process itsself to reduce cooling air mixing in the burning chamber and coke consumption of the cupola furnace are discussed in theory. Furthermore practical attemps in pilot plants as well as actual findings with respect to pratical cupola melting performance are presented and discussed as well.

On the Application of Big Data Analysis on Dosing Accuracy

Dr. Ir. T. van der Hoeven, StrikoWestofen GmbH,
Gummersbach/Germany

With the unstoppable march up of industry 4.0 into production environments, machine producers and customers are confronted with new technologies. Some of these technologies are portrayed as infinitely powerful and infallible. In the course of developments, StrikoWestofen tested one of these technologies: Big Data Analysis. In the presentation the successes and practical issues with the application of Big Data Analysis on dosing accuracy are presented.

Using the practical example of a series of dosing furnaces used to log months of production data, lessons learned on generating, communicating, pre-processing, analysing and post-processing data are discussed. The paper will show the added value of Big Data Analysis, and also focus on practical limitations of the current technologies.

LECTURER

Dr. Ir. van der Hoeven, Theodoor Adriaan
VP Product Development, StrikoWestofen GmbH

Responsibility:
- Trend detection
- Preparation of the product development plan
- Initiating and coordinating development projects
- Planning, organization, controlling of the product development department
- Leadership of the development team
- Optimization of development processes
- Trial operation in the pilot plant

2016 – today	Head of Research and Development	StrikoWestofen GmbH
2014 – 2016	Head of Department Development Energy Machinery	AVL SCHRICK GmbH
2013 – 2014	Head of Advanced Engineering Team	AVL SCHRICK GmbH
2010 – 2013	Senior Engineer Advanced Engineering	AVL SCHRICK GmbH
2007 – 2010	Engine Testing Expert	DAF Trucks NV
2006 – 2007	Engine Testing Engineer	DAF Trucks NV
2002 – 2007	Doctorate	Technische Universität Eindhoven
1997 – 2002	Studies (TU) Mechanical Engineering	Technische Universität Eindhoven

The High Pressure Die Casting OPC UA Initiative. An Industry-Wide data- and Automation-Interface Standard

Dr.-Ing. K. Kerber, Oskar Frech GmbH + Co. KG, Schorndorf/Germany

During Euroguss 2018, the Sub-Working Group SG 5 of the European Foundry Machinery Association CEMAFON was founded. The task of the working group is the definition and standardization of a new machine, process and automation data interface for the high pressure die casting industry. The technology used for this interface is OPC UA (Open Platform Communications Unified Architecture).

In 2019, during several working group meetings, the group members discussed fundamental issues of a new common interface for high pressure die casting cells. At the end of the discussion process the group decided to start an OPC UA Companion Specification Initiative. In January 2019, after approval of the initiative by the OPC Foundation, the Kick-Off meeting was held at VDMA the in Frankfurt.

The lecture will introduce the initiative, OPC UA and the modeling techniques used. Due to the generic approach, there is a high likelihood that large parts of the standardization can also be applied in other sectors of the foundry industry.

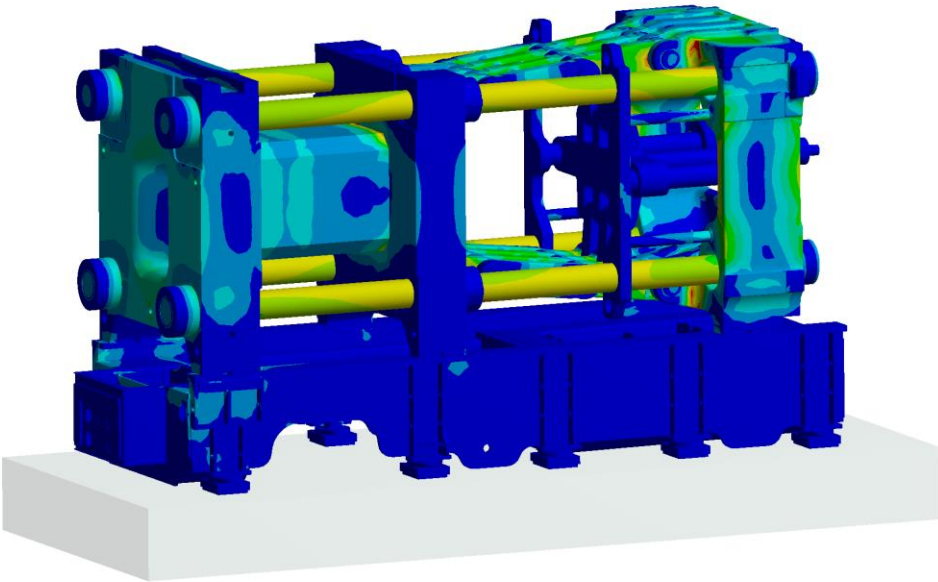
Role of Simulation in the Digital Die-Casting Cell of the Future

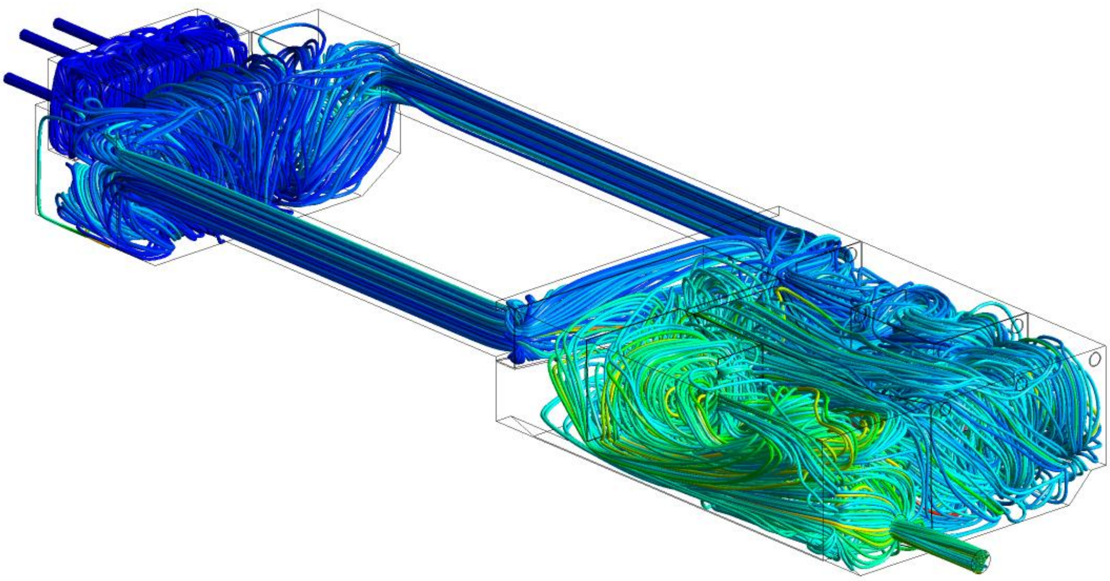
B. Eberle MSc ETH, Dr. P. Reichen, Bühler AG, Uzwil/Switzerland

Numerical methods and simulations play a major role in the development of the digital die-casting cell of the future; with lower cycle times, higher availability and zero scrap. Virtual models accurately represent the die-casting process, the die-casting machine and the interactions within the cell. This enables the design of optimised tool concepts, more reliable components as well as more robust process parameters.

Bühler has a focus not only on the modelling of the machine but also on the modelling of the whole die-casting process. A digital twin of the machine is built up based on system simulation to analyse the interaction of the hydraulic system with the machine mechanics. This model is used in R&D to improve performance, speed and robustness of the die-casting machine. In the future these models will be used to support predictive analytics that identify baseline deviations and automatically initiate counter-measures.

On the process side, the focus is on the development of methods to generate optimised tool designs. The gained knowledge and parameters can directly be implemented in the digital cell to ensure optimal operation. The overall target is higher productivity of the cell and reduce costs per part.





Prediction Based Component and Process Optimization

P. Kerst, Prof. Dr. J. Gottschling, Universität Duisburg-Essen,
Prof. Dr.-Ing. D. Hartmann, Hochschule Kempten/Germany

The production of casting parts is based on the application of various interrelated (sub-) processes that span the entire chain from melting to heat treatment and continue including processing. Each of these processes is controlled by appropriate control variables. This control is based on the adherence to defined process limits for each control parameter. In this way, the default is for compliance with technical and economic profiles of properties of the produced parts. However, the individual processes and their control parameters are interrelated with each other in a complex manner. There are interactions between different parameters of (partial) processes, so that the ultimate property profile is actually determined by these interactions. However, these are not explicitly considered in the standard process control, for example in the individual control of the individual (sub-) processes.

In a foundry, using modern sensors on machines and in production generates enormous amounts of data. This data contains implicitly the exact knowledge of interaction of parameters processes and their effect on certain properties or property profiles. Limitation is that with the usual commonly employed statistical tools, this knowledge cannot be extracted from the process data.

However, it is possible to identify and represent interrelated patterns and their relationships from this huge amount of data with process-specific prediction software. On this basis, for optimal process settings, decision-making processes can be initiated against defined component properties through an intelligent combination of process rules and process knowledge. The techniques used for the required precise predictions are based on machine learning algorithms and methods from the fields of Predictive Analytics, Predictive Computing and Predictive Modeling.

The presentation describes the basic methodology of prediction based optimization of production processes and component properties. Especially in context of the specific conditions in foundries, the risks, the opportunities and the possibilities of this type of optimization are presented. This is accomplished by performing selected analysis with the software package *EIDOdata* in foundry manufacturing and in the production of steel.

Keywords

Robust Processes, Complex production chains in foundries, Process- and Parameter interaction, Big data analytics, Data problems, implicit process knowledge, machine learning, predictive analytics, knowledge-based process control, Recommendation Systems,
prediction based process optimization, self-optimizing processes

The Journey to Olimpo – Description of the work developed by Sakthi Portugal in the pursuit of perfection

Dr.-Ing. V. Anjos, Sakthi Portugal SP21, S.A., Águeda, F. Vilela, Sakthi Portugal S.A., Maia/Portugal

Innovation is driven by ambition, knowledge and dreams. Sakthi Portugal's ambition is to be the best in class, applying knowledge to reshape the foundry industry.
Back in 2001, Sakthi Portugal realized that digitalization and data gathering was essential to improve its process, quality and customer satisfaction. This was the beginning a journey to become a benchmark company.

The path for digital development in Sakthi Portugal has been done in three phases: data gathering, transform data into information that finally leads to knowledge.

At Sakthi Portugal, data gathering started early in 2001, years before Industry 4.0 got its name in the market, as a need to end paper recording of process data, organize all data in just one place and accessible to everyone, and allow complete process traceability. This was when the development of DataPRO software began, a data base system that gathers all production related data. It took several years to further develop the system in order to include all process parameters, such as chemical analysis, thermal analysis, melting data, treatment data, pouring data, laboratory data, finishing data, sand preparation data and mould plate data. Nowadays, Sakthi Portugal registers approximately 5 Million data entries per day, all acquired automatically from the different equipment's and terminals.

The next challenge was to automatically analyse all data acquired daily from the production process, enabling the transformation of data into available information in the company. The solution was to further develop the DataPRO system to make the automatic statistical analysis of all data, including graphical display of process control charts, normal distribution curves and linear correlations between variables, allowing a deeper process control.

Apart from the great advantages that raises from data gathering and data analysis system, the path to perfection in casting production was not completed yet. It was still missing the extraction of all the value that information holds and enhance it into a knowledge-based system. An artificial intelligence software, named Olimpo, was born. Olimpo uses DataPRO data base to perform a predictive process control from the running production at Sakthi Portugal. Olimpo software reads the real-time process information and predicts the outcome quality of the castings, allowing immediate actions and segregation of castings that will not comply with customer standards in an automatic way.

Olimpo's artificial intelligence opportunities do not end here, as Sakthi Portugal is working with key partners to develop an algorithm capable of producing tailor-made alloys for its customers.

The future of the foundries depends on their ability to manage knowledge.

Picture 1: View from the process control room at Sakthi Portugal S.A.

Be a Digital Genius

A. Fill, Fill Gesellschaft mbH, Gurten/Austria, DI (FH) M. Keim, CORE smartwork GmbH, Gurten/Austria

Industry 4.0, working environment of the future, digitalization, knowledge management, organizational transformation, et cetera are buzz words that are resounded throughout the land at the moment. Tremendous changes are already in process – the question, that remains for entrepreneurs is, how can we meet the new challenges. For Fill, the most important resource is the employee itself, his/her knowledge and operating experiences. The industrial enterprise developed an innovative way of getting the whole staff into new processes like knowledge and idea management. Via the unique communication platform CORE Fill built a strong network of experts, no question of set time and place. From all over the world the Fill experts are connected, collaborate and succeed through their digital homebase. It will be shown how the knowledge hub of FILL was built, how it looks like and which plans for further development exist.

Picture 33:

FILL Gesellschaft m.b.H. exterior view 1

FILL Gesellschaft m.b.H. exterior view 2

Urgent Revolution Needed in Foundry Industry – New STAMina - Strategy, Technology and Management

P. Kemppainen, Karhula Foundry, Kotka/Finland

Main drivers to change foundry industry customers' needs are: globalization, climate change, education and R&D not foundry friendly.
Threats and opportunities: Globalization offers large market to high value added product: transport cost is no barrier, e-marketing is cheap, but new materials, products, management and effective manufacturing is needed. Very big changes in energy, transport, vehicles and water and food supply make revolution in casting industry. Change needs new ownership, strategy, technology and management.

Home Grown Talent - a people centred approach to strategic company development

Dr. Pamela Murrell, Cast Metals Federation, West Bromwich, United Kingdom

The challenges surrounding the development and recruitment of personnel for the castings industry are outlined and the example of a UK company is described as a case study in employee engagement and development. The company adopted a formal approach to talent development as part of a strategic approach to HR in support of the business goals. In addition, some other strategies being adopted by industry are explored.

Perceptions, image and work practices in foundries: a project to assess the company climate in Italian companies

Dr. L. Ciocca, Università Cattolica del Sacro Cuore, Milan/Italy

The objective of this research project is to understand how foundries are perceived by those who work there every day and by the main company stakeholders: this is what Assofond has decided to do in conjunction with Milan's Univesità Cattolica del Sacro Cuore, funding a three-year research doctorate with the aim of outlining a picture of the current situation in Italian foundries.
Understanding these perceptions means developing awerness about the way in which the foundry world is perceived; as result, we can envisage actions to implement employee wellbeing and to strategically orient communication that stimulates a better image of foundries and increases their attractiveness among potential new workers. The aim of the study will also be to gather a set of best practices, described in organizational guidelines for creating training courses, coaching and team building activities capable of guiding entrepeneurs and executives in the developement of cultures that can combine productivity, safety and employee wellbeing.
The project will be divided into three phases, integrating quantitative and qualitative analysis, using different research tools including observation, document analysis, interviews, focus group, tools for measuring and reshaping various phenomena:

In the first phase we expect to gain knowledge about the foundry world and its relative image. Facilitating elements and impediments for employee wellness will be identified;
The second phase consists in identifying actions to increase employee wellbeing and to strategically orient communications;
The third stage of the study may regard further investigation and International benchmarking, to compare the results that have emerged with the European Context.

Work Safety in an Extremely Ambitious Environment! Zero accidents, a most relevant corner stone in modern foundry´s business excellence activities

St. Mettler, DIHAG Holding GmbH, Essen/Germany

Working in a heavy duty industrial environment is demanding in many ways. To perform best with regards to world class safety, efficiency and quality is giving a hard to beat advantage within a competitive landscape.

Social responsibility for colleagues or staff is one main driver to implement a vision zero strategy better today than tomorrow. Possible cost for implementation will be more than paid by eliminating commercial disadvantages coming along with accidents. A culture of attention –here awareness for safety- is contributing enormously to further business excellence aspects requiring an attentive attitude with respect to an efficient working and a first time right policy (zero defects).

What is driving executives and employees the same way to gain the appropriate cultural setting in order to achieving best performance indicators? Learn how DIHAG Holding GmbH, one of Europe´s largest foundry groups is answering at least some of those questions.

EHS Legal Compliance - Five systematic steps to ensure compliance of the plant and avoid personal liability

Dr. T. Gutwinski, Gutwinski Management Gesellschaft m.b.H., Perchtoldsdorf/Austria

These steps have to be undertaken to ensure compliance of the plant and avoid personal liability:

Step 1 – Identify the relevant regulations and permits!
Running text (in English) You cannot reach compliance, if you do not know the regulations you have to fulfill!

Step 2 – Which legal requirements does the organization have to comply with?
Running text (in English) Which requirements result from the relevant regulations**?**

Step 3 – What to do with the relevant legal requirements / tasks?
Running text (in English) Assign responsible personnel to fulfill the relevant legal obligations

Step 4 – Monitor your compliance status
Running text (in English) In order to avoid personal liability, managers have to monitor the compliance status of the organization

Step 5 – New regulations and amendments
Running text (in English) New regulations and amendments generate new and modified legal requirements. Use external experience and workshops to easily organize and implement relevant legal changes.

An effective business model for innovative development and sustainable growth of aluminum castings production at Talum d.d.

A. Sibila, Talum d.d., Kidričevo/Slovenia

Talum d.d. is a Slovenian primary aluminium producer for more than 65 years. Aluminium market is a worldwide commodity and all the European industry has to compete in global market. Primary aluminium production in Europe is under a high pressure because of uncompetitive energy prices, higher environmental, labour and other costs. To decrease the sensitivity to LME and unpredictable energy prices has Talum developed its own higher value-added downstream segments as aluminium slugs and discs production, aluminium Roll-bond heat exchangers and in last ten years has increased aluminium castings production for different industries.
The development of aluminium castings production is based on utilization of three different casting technologies (HPDC, LPDC and GTC). With innovative approach, some technical solutions are transferred from one casting technology to another. As an aluminium alloys producer, Talum has developed specific knowledge to increase mechanical characteristics of final product by modifying the composition. Automatization, digitalization, machine learning, real-time data etc. are the topics which receive a lot of attention and resources. Talum built efficient and innovative R&D infrastructure with intensive co-operation with external companies and research institutions

Talum
Company Talum, is located in North-eastern part of Slovenia, it was established in 1947 as a producer of primary aluminium. Production started in 1954.
Today a day core business is production of foundry alloys, extrusion billets, slugs and castings. A total sales revenue in 2018 was 365 m€
In the last decade company turns strategy towards down stream products such as slugs and castings. There has been significant growth of castings production in recent years.

Castings
Castings started in 2006, first producing for non-automotive clients.
Over years other technologies have been implemented, such as Low-pressure casting, High pressure die castings, Machining, Assembly etc.
Products and client’s portfolio are now spread between diverse industries.

R&D Five Columns
Development of R&D competences based on present in-house supporting activities: long tradition and knowledge about aluminum alloys, designing and manufacturing of tools/dies; heavy duty machines manufacturing; in-house automatization; as well strong IT department.

R&D Five Columns - melting
In some business cases, custom made modification of chemical composition has been applied to achieve better mechanical properties. Benefit of that is to reduce or even avoid heat treatment of castings.

R&D Five Columns – casting
Mid/high-volume projects are extra challenging. Pouring of hot metal and casting dies operating at high temperatures require special attention when designing concept of such casting cell, having in focus full automatization on one side, but also some simplicity/flexibility on other side.

R&D Five Columns – raw part operations
When feeders and overflows are too tick to be trimmed then other technologies are implemented. Part-to-part cycle time dictates complexity of such a cell.
Robots have to be programed users-friendly, while corrections of robot curves are required, while geometry of parts is not completely equal to 3D model.

R&D Five Columns – machining
Automatization of machining process is combined with operations as washing, leak testing, geometry and optical checking, assembly etc. High OEE is an aim, therefore precisely equipment FMEA study and back-up solutions are crucial.

R&D Five Columns – production data follow-up
While process parameters are automatically recorded via SCADA program, all other data have to be inserted/selected, by operators at machines. Relevant data about Quantity, Quality, Productivity, Machines/Dies status, etc. need to be available in real time. Upon it, corrective actions should be taken in real time, as well.

R&D Five Columns – production data analyze
To follow up objectives, all production data must be analyzed. Daily meetings of Production Management must be effective and very focused therefore, data diagrams must be on screen 24/7.

Challenges – traceability; on line orders
Several thousand castings are daily transferred through different productions steps. That lid to necessity to follow up a history of each single part by checking-reading only one mark.

Some clients change call-offs very often. Sometimes shifting a robust production up-side down is big challenge starting from incoming orders, through internal procedure/program and finally to transfer new requirements-production orders on machines.

Challenges – machine learning
Machine learning is the most common term when we talk about Industry 4.0. that’s. Machines will operate based on data exchange in cloud computing. All processes inputs and outputs will be in digital-form and monitored, analyzed, regulated, automatized, balanced etc. all the time. Sounds a bit futuristic now day, but reality is in the future.

Challenges – How to attract new generations to work in foundries
Mostly we are focused on technical challenges. What about social aspects? How to attract young generation for work in foundries?

From Magdeburger Tor in Nowgorod (1152) to Bronze Symposium (2018) – more than 1000 years of foundry tradition in Magdeburg

Von der Magdeburger Tür in Nowgorod (1152) bis zum Bronzegießer-Symposium (2018) – über 1000 Jahre Gießereitradition in Magdeburg

Prof. R. Bähr, Otto-von-Guericke-Universität Magdeburg/Germany

Magdeburg ist eine Stadt, die auf eine weit über 1200 Jahre zurückreichende Geschichte verweisen kann. Ihre Lage an der Elbe hat zur Ansiedlung und zum Wachsen der Stadt beigetragen. Das Handwerk konnte sich entwickeln und Handel wurde betrieben. In der Nähe der Elbe in Kieswerken wurden Bronzegussteile gefunden, die auf ein Alter von über 3000 Jahren datiert wurden; ein eindrucksvolles Zeugnis der Fertigungstechnik hier schon zur damaligen Zeit. Es wurden Schwerter, Beile, aber auch Schmuckgegenstände ausgegraben, die man sich nun im Museum ansehen kann. Die bronzezeitlichen Handwerker verfügten über ungeheuer komplexes Wissen zu den Legierungen und der Gießtechnik, zum Schmieden und zur Oberflächenbearbeitung.

Der Bronzeguss entwickelte sich in Magdeburg weiter und hatte im Mittelalter seine Blütezeit. Über vielfältige angefertigte Arbeiten erlangte man ein hohes Ansehen und einen Ruf, der dazu führte, dass große Aufträge hier platziert wurden. Man spricht heute von der *Magdeburger Gießhütte*. Hier wurden mit Sicherheit auch die handwerklichen Fähigkeiten, das Formen und Gießen, der Umgang mit dem Werkstoff Bronze und das Schmelzen gelehrt und das Wissen nicht nur an Interessenten aus der Region weitergegeben. Heute kann man die hier meisterlich gefertigten Bronzegussstücke nicht nur im Magdeburger Dom als Grabplatten sehen. Auch der Braunschweiger Löwe und der Wolfram-Leuchter im Erfurter Dom gelten als Produkte der Magdeburger Gießhütte.

In diesem Ensemble nimmt eine in Magdeburg gefertigte monumentale Bronzetür eine besondere Stellung ein. Eine bewegte Geschichte macht dieses Portal auch ein wenig geheimnisumwoben: War die Tür ursprünglich für den Magdeburger Dom bestimmt? Wurde sie mit zusätzlichen Platten auf ein neues Format gebracht und dann nach Płock gebracht? Wurde sie verschenkt oder gar von den Tataren geraubt? Machte sie Zwischenstationen? Wie kam sie dann in das von hier fast 2000 Kilometer entfernte Nowgorod? Und wie und von wem erfolgte die künstlerische Konzeption des Gesamtwerkes? Es gilt als sicher, dass die Bronzetür mehrmals auseinandergenommen, transportiert, vergraben und wieder erneut zusammengesetzt wurde. Wie dem auch sei, diese Tür gehört zu den wichtigsten Gussprodukten des hohen Mittelalters und ist ein Zeugnis für den herausragenden technologischen Stand der Magdeburger Gießhütte des 12. Jahrhunderts.

Im Jahr 2018 wurde durch die internationale Bronzegießer-Künstlergruppe *El Vuelo de Br*once dieser Tradition im Rahmen eines Symposiums gedacht. Als Ergebnis kann stolz ein neues Bronzeportal präsentiert werden.

Precious metal, cast iron, light metal and heavy metal – a general view on the historical casting production in the mountain area Harz

Vom Edelmetall über das Gusseisen zum Leicht- und Buntmetallguss – die Gussfertigung im Harz im Überblick

K.-H. Schütt, Halberstadt/Germany

Der Corveyer-Mönch Widukind berichtet in seiner Sachsenchronik „Res gestae Saxonicae“, wie Kaiser Otto I. im Jahr 968 Erzadern im Harz am Rammelsberg bei Goslar erschließen ließ. Der Harzer Bergbau wurde hier zum ersten Mal schriftlich erwähnt. Unter der Herrschaft der Ottonen begann vor etwa 2000 Jahren die systematische Erzgewinnung am Rammelsberg im Westharz, deren Edelmetalle damals zur Sicherung und zum Ausbau der Ottonischen Macht dienten. Die Zisterziensermönche mit ihrem geistigen Zentrum in Halberstadt spielten ebenfalls eine wichtige Rolle bei der montanistischen Erschließung des Harzinneren. Die auf den eigenen Zechen geförderten Erze wurde zur Verhüttung in Gebiete geschafft, wo der Orden die vom Kaiser verliehenen Nutzungsrechte hatte. Von hier und vom damaligen weltlichen Zentrum Goslar aus breiteten sich der Bergbau im Oberflächenabbau und später mit abnehmenden Flözen im Tiefbau und die nachfolgende Metallverarbeitung durch Gießen und Umformen in der Folgezeit in den anderen Regionen des Harzes aus, was mit einer Herausbildung einer zunehmend leistungsfähigen Verarbeitungsindustrie mit Hüttenwerken entlang der Harzflüsse und der Gründung von Dörfern und Städten durch Rodung für die erforderlichen Berg- und Hüttenleute einherging. Bis heute sind Gießereien und Umformwerke wirtschaftliche Leistungsträger der Harzregion, die es immer verstanden haben, sich an die Weiterentwicklung anzufassen – von den kleinen privaten Hüttenwerke im frühen Mittelalter über die fiskalen Hütten der Landesherren von Hannover, Braunschweig, Anhalt, Preußen und Stolberg-Wernigerode bis ins Spätmittelalter zum Übergang in die Industriegesellschaft und letztendlich zur Herausbildung von modernen Groß- und Mittelstandsunternehmen ab dem 20. Jh.

Verbunden war dieser Entwicklungsprozess für die hier exemplarisch beschriebene Gießereiindustrie mit einer werkstoffseitigen Entwicklung von den Edelmetallen des Rammelsbergs über die Kupferverarbeitung im Nordwestharz von ebenfalls Rammelberger Erzen und später auch solchen aus dem Mansfelder Land im Südharz, über die umfassende Ausnutzung der reichen Eisenerzvorkommen im gesamten Harz vom Mittelalter an bis zu den Leichtmetallen Aluminium und Magnesium im 20. Jh. Viele der alten Harzer Unternehmen haben diesen Prozess nicht überstanden, da sie sich nicht entsprechend weiterentwickeln konnten. Aber auch diese haben zu ihrer Zeit vielfach Hervorragendes geleistet. Das gilt vor allem für den bekannten und hochqualitativen Ofen- und Kunstguss, der sich im 19. Jh. in den Harzer Gießereien zu seiner Hochzeit entwickelte, bevor er im 20. Jh. wieder an Bedeutung verlor und der Industrieguss begann zu dominieren, der heute vor allem dem Automobilbau beliefert. Deshalb wird neben einem Überblick über die Harzer Gießereien im Aufsatz auch auf die bedeutendsten Leistungen dieser Gießereien in diesem Entwicklungsprozess eingegangen.

In kaum einer anderen deutschen Landschaft hat der Reichtum an Bodenschätzen die politische und wirtschaftliche Entwicklung so nachhaltig beeinflusst wie im Harz. Am Beispiel des Rammelsberg wird sichtbar, dass es beim Harzbergbau aber nicht nur um die

Förderung, sondern auch um das Gewinnen und Aufbereiten der in den Erzen enthaltenen Metalle, um ihre Verhüttung und Umwandlung in Fertigfabrikate ging, was auch dem Gießen große Anwendungsgebiete erschloss. Die vielen Pochwerke, Hüttenwerke, Gießereien und Handwerksbetriebe zur Zerkleinerung und Verarbeitung der Metalle, oft an Bachläufen in der Nähe der Gruben gelegen, beschäftigten bis ins 19. Jahrhundert die Bewohner des Harzes, oft auch in Kinder- und Jugendarbeit. Eine leistungsfähige Eisenguss- und Hüttenwerksindustrie entwickelte sich so über die Jahrhunderte, die ihren Höhepunkt im 18. und 20. Jh. fand. An der Schwelle zum 18. Jh. verdrängten zunehmend neu entstehende fiskalischen Hütten die damaligen privaten Eisenhütten. Der gesamte Harz war nun in fünf Herrschaftsgebiete geteilt, die wiederum ihre eigenen Hütten errichteten: das Kurfürstentum Hannover, das Herzogtum Braunschweig, die Grafschaften Wernigerode und Stolberg, das Königreich Preußen und das Fürstentum Anhalt-Bernburg.

Dem kurhannoverschen Bergamt zu Clausthal unterstanden die Eisenhütten Rothehütte, die Sollinger Hütte in Uslar, die Königshütte in Bad Lauterberg, die Altenau-Lerbacher Hütten sowie die Hütte Elend. Die Königshütte Bad Lauterberg war eine Gießhütte, die neben dem Gebrauchsguss auch viele hochwertige Kunstgussteile hergestellt hat. Dem Herzogtum Braunschweig gehörten die Hütten Rübeland, Tanne, Sorge, Wieda und Zorge. Das Hüttenwerk Rübeland bildete zusammen mit der Gießerei in Zorge 1870 eine Aktiengesellschaft mit dem Namen „Harzer Werke zu Rübeland und Zorge“. Die Gießereien in Rübeland, Wieda und Tanne existieren heute nicht mehr. Lediglich die später nach Blankenburg verlegten Harzer Werke produzieren heute noch Schleuderguss für den Automobilbau. Die Eisenhütten in Schierke und die Fürst-Stolberg-Hütte Ilsenburg waren im Eigentum der Grafen und späteren Fürsten zu Stolberg-Wernigerode. Die Fürst-Stolberg-Hütte entwickelte sich zu einer der bedeutendsten Kunstgussgießereien im Harz. Im Fürstentum Anhalt-Bernburg produzierte die Eisenhütte Mägdesprung vor allem im Kunstgussbereich, die von der Genauigkeit und Vielfalt mit der Fürst-Stolberg-Hütte im direkten Wettbewerb stand. Im preußischen Harz lag die aber unbedeutende Hütte Thale.

Schon Ende des 19. Jhs. setzte der Niedergang der Harzer Eisenproduktion ein, als die Versorgung durch die regionalen Eisenbergwerke nicht mehr ausreichte und die Vorkommen begannen zu versiegen. Zudem war mit den Kohlefunden im Ruhrgebiet und der dort entstehenden eisenmetallurgischen modernen Großindustrie ein übermächtiger Konkurrent entstanden, dem die doch eher mittelständig strukturierte Harzer Industrie wenig gegen zusetzen hatte. Das führte zum Niedergang der Eisengießereien und zur Herausbildung einer leistungsfähigen Aluminiumindustrie im Harz im 20. Jh. Dort produzieren heute die TRIMET Harzgerode (ehemals Mitteldeutsche Metallwerke) und Pressmetall Hoym moderne Druckgusskomponenten. Abgerundet wird diese Aluminiumgussfertigung durch die auf Kokillenguss spezialisierten Unternehmen NEMAK Wernigerode (ehemals Rautenbachguss) und KSM Casting, die neben dem Hauptwerk im nahegelegenen Hildesheim ein Zweitwerk in Wernigerode betreibt. Alle fertigen vor allem hoch beanspruchbare Aluminiumgussteile für die Fahrzeugindustrie.

Ein weiteres großen Anwendungsgebiet bis heute ist die Aluminiumverpackung sei es in Form von Folien, Büchsen oder Tuben. Das Leichtmetallwerk in Nachterstedt im Harzvorland war als Betrieb des VEB Mansfeldkombinat in DDR Zeit ein Großproduzent für gegossene und gewalzte Aluminiumfolien, der die gesamte DDR versorgte. Heute ist der Betrieb das größte Umschmelzwalzwerk des US-amerikanischen Umformkonzerns ALCOA in Europa mit Spezialisierung auf Sekundärverwertung des aufwendig recycelten Werkstoffs Aluminium und damit ein umwelttechnisch bedeutendes Unternehmen.

Paths to highest performance in foundries – review and outlook

Wege zur Höchstleistung in der Gießerei - Rückblick und Ausblick

H.-D. Landwehr, Mettmann/Germany; Dr. R.P. Jung, DR. JUNG CONSULTING GmbH, Engen/Germany

Der Vortrag zeigt die Entwicklung der Methoden und Effekte auf dem Weg zur Höchstleitung in der Gießerei in den letzten 30 Jahren und gibt einen Ausblick auf das, was uns heute und in den nächsten Jahren an Möglichkeiten zur Verfügung steht: Von den Anfängen der Lean Production Anfang der 1990er bis hin zu den Möglichkeiten einer datenbasierten integrierten Prozessregelung mit Industrie 4.0.

In der hocheffizienten Gießerei sind Prozesse definiert und standardisiert. Mit der Einführung von Lean Production wird der kontinuierliche Fließprozess (Nullpufferkonzept) vom Gießen bis zum fertigen Rohteil realisiert. Mit dem Nullpufferkonzept sind die Kosten für Zwischenlager gespart, die Durchlaufzeiten drastisch reduziert und die umgehende Fehlererkennung möglich und wegen der fehlenden Materialpuffer auch nötig. Die konsequente Anwendung der Lean-Methoden hat zur Höchstleistung - und damit auch zu spektakulären wirtschaftlichen Erfolgen - geführt und die Wettbewerbsfähigkeit in den letzten Jahren entscheidend gesteigert.

Der Weg zum Erfolg lag bereichsübergreifend in einem Denken in anderen Bahnen.
Der Erfolg war nicht von heute auf morgen da, sondern es waren neben einigen großen Schritten in der Prozessgestaltung viel kleine konsequente Schritte erforderlich: Die frühzeitige Einbindung der Mitarbeiter in die Konzeption und Umsetzung der Maßnahmen war ein wesentliches Element der Lean Production Erfolge. Alle Mitarbeiter im Unternehmen sind trainiert, ihre Prozesse möglichst verschwendungsfrei zu gestalten und kontinuierlich zu verbessern.

Auf die mit Lean Production geschaffene Basis von geregelt und kontinuierlich verbesserten Prozessen kann Industrie 4.0 aufsetzen: Durch die Nutzung der in den Unternehmensdaten verborgenen Informationen lässt sich die Verbesserungsgeschwindigkeit und die Prozessqualität signifikant weiter steigern. Entscheidend ist, durch intelligente Datenanalyse in Echtzeit den Mitarbeitern Werkzeuge an die Hand zu geben, mit deren Anwendung sie sich dem Idealbild verschwendungsfreier Prozesse mit wenig Aufwand immer weiter annähern können und dadurch auch für die Zukunft die Wettbewerbsfähigkeit der hocheffizienten Gießerei ausbauen helfen.

Recycling – a foundry success story

Recycling – eine Erfolgsgeschichte in Gießereien

Prof. R. Deike, Universität Duisburg-Essen/Germany

Mit dem "Circular Economy Action Plan" aus dem Jahr 2015 hat die EU begonnen, den Übergang zu einer nachhaltigen Kreislaufwirtschaft einzuleiten. Hier spielt das Recycling eine große Rolle, da über diesen Weg auf unterschiedliche Weise Rohstoffe wieder in den Wertstoffkreislauf zurückgeführt werden können. Die Gießereiindustrie ist eine Industrie, die seit Jahrzehnten Kreislaufwirtschaft par excellence praktiziert.

Im Zusammenhang mit einer Verbesserung der Rohstoffeffizienz durch das Recycling von Reststoffen kommt den Metallen aufgrund ihrer nahezu unbegrenzten Wiederverwertbarkeit ohne Qualitätseinbußen, in tatsächlich geschlossenen Kreisläufen, eine ganz besondere Bedeutung zu. Prinzipien eines modernen Produktdesigns wie die Langlebigkeit von Produkten und eine anschließende leichte Wiederverwertung sind schon seit Jahrzehnten – allerdings wenig beachtet von der Öffentlichkeit - typische Eigenschaften von Stahl- und Gussprodukten. In der Gießereiindustrie ist es Stand der Technik, dass z.B. aus ausgedienten Bremsscheiben oder anderen Produkten aus Gusseisen unter der Verwendung von Stahlschrott, Kreislaufmaterial, Roheisen und geringer Mengen an Legierungs- und Impfmitteln wieder neue Sicherheitsbauteile wie z.B. Bremsscheiben mit den gleichen und möglicherweise noch verbesserten Werkstoffeigenschaften – da Werkstoffe kontinuierlich weiter entwickelt werden - hergestellt werden können. Dieser Prozess des Recyclings wird unter minimalen Verlusten (Rost, Abbrand usw.) ohne Qualitätseinbußen unendlich oft wiederholt, so dass in der Gießereiindustrie bei den metallischen Einsatzstoffen sehr weitgehend geschlossene Stoffkreisläufe in den letzten Jahrzehnten fast selbstverständlich geworden sind. In Abhängigkeit der konjunkturellen Entwicklung werden in Deutschland ca. 4 Mio t Eisen-, Stahl – und Temperguss produziert, wobei durch den Einsatz von Stahlschrott, Gussbruch und Kreislauf eine durchschnittliche Recyclingrate von ca. 90 % realisiert werden kann. In Abhängigkeit von der Größe der Schmelzaggregate, der zu produzierenden Menge und der Werkstoffqualität gibt es auch in der Gießereiindustrie Unternehmen mit Recyclingraten von nahezu 100 %.

Damit praktiziert die Gießereiindustrie schon seit Jahrzehnten das, was die EU mit ihrem Aktionsplan „Circular Economy" für die Zukunft fordert. Unter diesem Aspekt kann die Gießereiindustrie zu Recht, trotz ihrer jahrtausendealten Geschichte beanspruchen, eine herausragende Zukunftsindustrie zu sein, da in der Gießereiindustrie aus etwas Altem, nämlich Schrott, etwas Neues, nämlich neue Gusstücke für die Automobilindustrie, den Maschinenbau und die Elektroindustrie produziert werden, die für diese Industrien unverzichtbar sind. Damit zeigt die Gießereiindustrie, dass es in industriellen Prozessen möglich ist, Rohstoffe im Kreislauf zu nutzen, damit Wirtschaftsstrukturen aufbauen zu können, die nachhaltig Wertschöpfung und Arbeitsplätze in einer Kreislaufwirtschaft sichern können, sofern dies von der Gesellschaft wirklich gewollt wird.

The historical development of organic and inorganic sand binder systems

Entwicklung organischer und anorganischer Bindemittelsysteme im Spiegel der Zeit

N. Benz, Hüttenes Albertus Chemische Werke GmbH,
Hannover/Germany

Bindemittel sind unerlässliche Bestandteile zur Fertigung von Formen und Kernen in der Gießereiindustrie.

Beginnend mit der Patentierung des Croningverfahrens in den 40er Jahren des vergangenen Jahrhunderts nahm die Entwicklung organischer Bindersysteme in der zweiten Hälfte des 20sten Jahrhunderts mit rasanter Geschwindigkeit zu.

In den 50er Jahren gesellte sich für die serielle Kernfertigung das Hot-Box Verfahren dazu. In den 60er Jahren erwies sich das Furankaltharzverfahren als gewaltiger Fortschritt für die Herstellung handgeformter Gussteile.

In den 70er Jahren eröffnete das Cold-Box Verfahren eine vollkommen neue Dimension für die Serienkernfertigung. In den 80er Jahren wurde das AlphaSet Verfahren vorgestellt und konnte sich im Stahlguss etablieren.

In den ausgehenden 90er Jahren machten dann Umwelt- und Arbeitsplatzaspekte die Entwicklung von umweltfreundlicheren Bindersystemen notwendig. Und so wurde HA in den letzten 20 Jahren zum Schrittmacher bei der Entwicklung anorganischer Bindersysteme.

Der Vortrag soll die Entwicklung der Bindersysteme mit dem Schwerpunkt Anorganik beschreiben.

Aluminium and cast iron light weight castings

Beitrag zum Leichtbau mit Aluminium- und Eisen-Gusswerkstoffen

Ph. Weiss, Schmidt+Clemens GmbH & Co., Edelstahlwerke Kaiserau/Germany, Prof. R. Döpp, Ennepetal/Germany

Leichtbau ist technisch und wirtschaftlich eine Herausforderung. Ein Bauteil muss bei minimalem Gewicht die Funktionen voll erfüllen und so kostengünstig wie irgend möglich herzustellen sein. Die freizügige Formgebung durch Gießen ist bereits ein wesentlicher Beitrag zur Kostenoptimierung. Das geringe Gewicht trägt nach Herstellungsaufwand und Betriebskosten ebenfalls zur positiven Gesamteffizienz bei. Insgesamt ist Leichtbau ein Beitrag zur Sicherung der Zukunft, weil Rohstoffe und Energie gespart werden. Leichtbau ist mit ganz unterschiedlichen Werkstoffen möglich. Typisch für metallische Grundwerkstoffe sind Aluminium mit 2,7 kg/cm^3 und Eisen mit 7,9 kg/cm^3 sowie deren Legierungen. In einer nach Inhalt und Zeitpunkt bemerkenswerten Veröffentlichung beschreibt Hans Zeuner [1] sinngemäß: Wenn Eisenlegierungen der Konkurrenz der Leichtmetalle standhalten wollen, müssen Sie die dreifache Festigkeit aufweisen, weil das Verhältnis der spezifischen Gewichte etwa 3:1 ist. Dann sind 3x500 MPa = 1500 MPa erforderlich. Mit legierten Stahlguss und spezieller Wärmebehandlung werden 1500 MPa erreicht. Das ist aber sehr teuer. Eine technisch und wirtschaftlich sinnvolle Alternative ist ADI, Austempered Ductile Iron, ein zwischenstufenvergüteter Eisenguss mit Kugelgraphit. Serienmäßig erreicht werden bereits 3x400 = 1200 MPa, entspricht Werkstoff ADI 1200 gemäß DIN EN 1564. Auch 1500 MPa sind möglich. Das Ziel Leichtbau sollte dazu anregen, die etwas höheren Herstellungskosten systematisch zu verringern.

Die 1965 von H. Zeuner erörterte Leistungsdichte als Maß für das Leichtbaupotenzial eines Werkstoffes bei Bewahrung geringer Material- und Herstellungskosten beschreibt die Triebkraft zahlreicher aktueller Werkstoffentwicklungen. [2, 3]. Ein Beispiel ist die Entwicklung der seit 2012 in der DIN EN 1563 genormten hochsiliciumhaltigen, mischkristallverfestigten Sorten des Gusseisens mit Kugelgraphit. [4, 5] Wie auch ADI vereinen diese Sorten hohe Festigkeit und Bruchdehnung, jedoch ohne Notwendigkeit der zur Herstellung von ADI erforderlichen technologisch und wirtschaftlich aufwändigen Wärmebehandlung. Während das Verhältnis aus Festigkeit und Bruchdehnung mit 500 MPa bei 14 % bzw. 600 MPa bei 10 % auf dem Niveau der ADI-Werkstoffe liegt, ist die durch Mischkristallverfestigung der vollferritischen Matrix erzielbare Festigkeit der Sorten auf 600 MPa beschränkt. Durch Zugabe weiterer mischkristallverfestigender Elemente wie Nickel und Aluminium konnte in Untersuchungen des Gießerei-Instituts der RWTH Aachen die Festigkeit dieser Sorten weiter gesteigert werden. Gleichzeitig werden Potenziale zur Zähigkeitssteigerung aufgezeigt. Die Untersuchungen führen zur Steigerung der Leistungsdichte und liefern damit einen Beitrag zur weiteren Stärkung des Leichtbauwerkstoffes Gusseisen.

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[3] S. Prukner, W. Menk: Neue Perspektiven für Gusseisen mit Kugelgraphit - Gegossene Bauteile als Alternative zu geschmiedeten, Giesserei Rundschau 54 (2007) Nr.9, S.170-173

[4] L.E. Björkegren, K. Hamberg: Silicon Alloyed Ductile Iron with Excellent Ductility and Machinability, Keith Millis Symposium on Ductile Cast Iron (2003)
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MAGNESIUM – a story

MAGNESIUM – eine Geschichte

Prof. K. Eigenfeld, Konstanz/Germany

Das Streben der Menschheit nach „schneller, höher, weiter“ oder einfach nur „besser“ besteht seit Anbeginn des Denkens. Dabei spielten immer schon die Werkstoffe eine besondere Rolle; ganze Zeitalter wurden nach ihnen benannt. Mit Beginn der industriellen Revolution kam nun auch besonders die Mobilität in den Vordergrund und damit das Streben nach Reduzierung bewegter Massen in vielen Bereichen der Technik. Nach der Etablierung der Eisen- und Stahlproduktion im großtechnischen Maßstab begann Mitte des 19. Jahrhunderts die Epoche der Leichtmetalle, die anfangs von Magnesium dominiert war.

Der schottische Physiker und Chemiker Joseph Black untersuchte als erster Magnesiumverbindungen systematisch und erkannte 1755 in seinem Werk *„De humore acido a cibis orto et Magnesia alba“* den Unterschied zwischen Calciumcarbonat und Magnesiumcarbonat. Deshalb kann man Black als Entdecker des Magnesiums bezeichnen, obwohl er nie metallisches Magnesium erzeugte. 1808 gewann dann Sir Humphry Davy Magnesium durch Elektrolyse von Magnesiumhydroxid in Form von Amalgam. 1828 stellte der französische Chemiker Antoine Bussy geringe Mengen von reinem Magnesium her. 1833 erzeugte Michael Faraday als Erster Magnesium durch die Elektrolyse von geschmolzenem Magnesiumchlorid; ein Verfahren, das von Robert Wilhelm Bunsen fortgesetzt wurde und bis heute in Anwendung ist. In Deutschland wurde das „deutsche Metall“ in Hemelingen bei Bremen und besonders in Bitterfeld hergestellt, da hier die verstromte Braunkohle die Elektrolysezellen speisen konnte.

Das erste nennenswerte Magnesiumgussstück war das Kurbelgehäuse des Adler Luftschiffmotors, der 1909 auf der Internationalen Luftfahrtaustellung in Berlin gezeigt wurde. Daraufhin nahm die Magnesiumproduktion einen vehementen Aufschwung sowohl im Bereich der Verkehrstechnik bei Motorrädern, Automobilen, Nutzfahrzeugen und Flugzeugen als auch im allgemeinen Maschinenbau. Es wurden neben Kurbel- und Getriebegehäusen viele Teile des Motors gefertigt und darüber hinaus Hinterachsgetriebegehäuse, Räder, Lenksäulengehäuse und viele weitere Teile. Um 1924 war die Gießerei Edmund Becker& Co., Leipzig, weltweit die größte Magnesiumgießerei mit einem Spektrum, das von Automobilteilen, Baumaschinen, Werkzeugmaschinen und besonders Spinnereimaschinen bis hin zur Medizintechnik reichte.

Mit der Entwicklung des Druckgusses erreichten Magnesiumteile auch den Bereich des täglichen Lebens. Die geringe Dichte und die mögliche Dünnwandigkeit der Gussteile standen hier naturgemäß im Vordergrund. Vom Kameragehäuse bis zur elektrischen Handbohrmaschine reichte das Spektrum. Doch dann kam der II. Weltkrieg und die Fertigung war nur noch militärisch ausgerichtet.

Nach dem Krieg musste die Magnesiumproduktion eingestellt werden, und erst mit dem VW Käfer erreichte der Magnesiumguss in der Bundesrepublik Deutschland 1972 mit 42.000 Jahrestonnen einen Höhepunkt. Dann kam der Absturz und 1993 wurden gerade einmal 3.600 t Magnesiumguss hergestellt.

Wo stehen wir heute? Die Umweltdiskussion fordert Energiereduzierungen und damit leichtere Fahrzeuge und die Wellnessphase fordert ein bequemes Leben. Magnesium ist hier das Material. Die Herstellung hat sich aber verlagert: 2018 wurden in China knapp eine Million Tonnen Primärmetall erzeugt.

Testing of complex castings – the historical development from 2D x-ray testing to Inline CT

Die Entwicklung von 2D-Röntgen bis Inline CT an komplexen Gussteilen

M. Ulbricht, Baker Hughes, eine GE Company, Wunstorf/Germany,
Dr. F. Hansen, formerly at/früher Volkswagen Gießerei Hannover

Nach der zufälligen Entdeckung der Röntgenstrahlen im Jahre 1895 durch Conrad Röntgen lernten die Mediziner schnell mögliche praktische Anwendungen kennen, wie die Röntgendiagnostik mit Fotoplatten sowie die Bestrahlung von Krebs- und Tuberkulose-Kranken.
Kurze Zeit später verstand auch die Industrie den Nutzen des Röntgenstrahls z.B. für die Materialprüfung von Leichtmetallgussteilen. Die Begründung der Erfolgsgeschichte der Firma Seifert (inzwischen Baker Hughes, a GE company), welche 1896 die erste Röntgenanlage in Hamburg baute.
Nach der jahrzehntelangen Verwendung von 2D-Röntgen auf Film, Bildverstärkern und schließlich auf digitalen Flat Panel Detektoren für die Inspektion von einfachen Gussteilen im Offline-, Atline- und Inline-Betrieb begann - um den Informationsgehalt der Daten zu steigern - vor ca. 15 Jahren die Entwicklung von schnellen 3D-Computertomographen zur Untersuchung von z.B. Poren, Porositäten, Sandresten, Kernbrüchen, Wandstärkenanalysen und Fremdmaterial in Leichtmetallgießereien.
Somit konnten nun an auch hochkomplexe, hochintegrierte Leichtmetallgussteile zu einer großen Stückzahl oder gar 100 % automatisiert inline geprüft werden. Ein Produkt, welches explizit für diesen Anwendungsbereich geschaffen wurde, ist die speed|scan CT 64. Hiermit sind z.B. Zylinderköpfe in ca. 15 Sekunden zu scannen, was noch kurzer Zeit 400 Minuten andauerte.
Hersteller dieser Gantry CT, basierend auf einem modifizierten System von GE Healthcare, ist Baker Hughes, a GE company.
Die Spezifikation des Systems lautet: 140 kV Drehanodenröngtenröhre mit einer Peakleistung von bis zu 72 kW, ein Detektor mit 64 Zeilen und 912 Kanälen. Das Messvolumen beträgt 500 mm (Durchmesser) x 900 mm (Länge).
Die typische Voxelgröße am Beispiel von Zylinderköpfen beträgt ca. 0,5 x 0,5 x 0,5 mm.
Funktionsmodi sind der axiale Scan für die Auswertung von neuen Teilen sowie die schnelle Helix CT für Serienteile.
Das weltweit erste System dieses Typs wurde 2013 in der Volkswagen Gießerei in Hannover in Betrieb genommen. Schnell konnten interne- wie externe Ausschussraten durch Anwendung der speed|scan CT 64 signifikant reduziert werden.
Inzwischen haben viele der weltweit größten Leichtmetallgießereien ebenfalls die Vorteile dieses Systems für die Produktion erkannt und nachgezogen.

List of Speakers in Alphabetical Order
Referentenliste in alphabetischer Reihenfolge

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