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NOVEMBER 19, 2024

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Die casting – casting under pressure

The EUROGUSS trade fair in Nuremberg was exciting and inspiring. Visitors, exhibitors and editors were able to experience internationality in the best sense of the word. Die casting is booming and is also being pushed by the topic of mega or gigacasting.

Photo: BDG

Martin Vogt
Editor-in-chief
e-mail: martin.vogt@bdguss.de

But die casters in the home country of EUROGUSS – Germany – are facing a variety of challenges that are overwhelming even the very resilient medium-sized foundries. That is my impression after many conversations.

In addition to ongoing topics such as decarbonization or increasing bureaucracy due to ever more reporting obligations, political and economic facts – the latter also politically influenced – are a particular burden on foundries. The longing for consistent framework conditions from politicians can be heard in every discussion at the trade fair. Reliability is the keyword here.

And then there are the economic facts. Quite a few die casters, for example, have bet on a boom in electromobility made in Germany and have invested extensively in recent years. Credit-financed investments that naturally have to be serviced on an ongoing basis. It is therefore more than unfortunate for the industry if the boom does not really get off the ground and is also stifled politically: The abrupt end of e-car subsidies in Germany shortly before Christmas completely pulled the plug on electric cars.

We have taken a closer look at what foundry managing directors want and what they expect from 2024 in our comprehensive EUROGUSS report in this issue. Other topics in this special include the award ceremony of the European Die Casting Competition with the top castings and the Die Casting Day with its lecture program.

Of our other topics, three articles are of particular interest to die casters: The first deals with the development of a new type of sand core that is solidified with a water-soluble binder. The second presents an intelligent sealing system for die casting molds. Finally, the third is dedicated to the topic of minimum quantity lubrication, which reduces the consumption of release agents and energy to a minimum and thus improves the sustainability of production.

In addition, among others, there is also an article on the recycling of organically contaminated aluminum scrap using induction furnaces powered by green electricity, as well as an overview of the advantages of hybrid mold and core production, which combines traditional sand mold making with 3D printing of complex sand cores.

Have a good read!

FEATURES

SPECIAL: EUROGUSS 2024

EUROGUSS
Rising visitor numbers and intensive business discussions.

Photo: Volkswagen AG

MOLD MATERIALS
The main reasons for permanent mold damages are complex thermo-chemical processes.

Photo: AdobeStock

CONTENTS

Photo: Trimet

COMPETITION
Best die castings in the categories of aluminum, magnesium and zinc.

Photo: Reissaus & Baumberg Maschinenbau GmbH

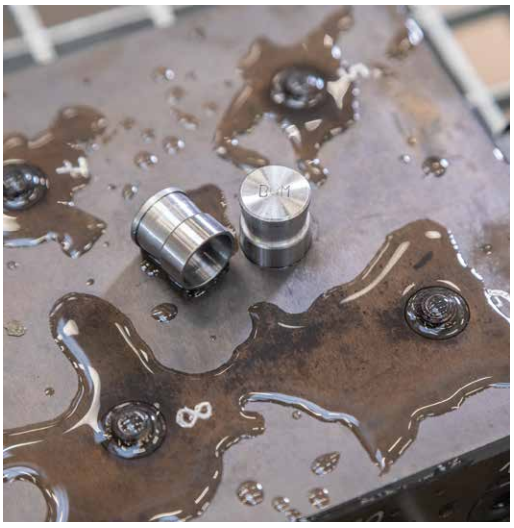

Photo: AdobeStock

Photo: EXONE

SEALING SYSTEM
b&m-KL Plugs: easy installation, reliable sealing.

COLUMNS

DIGITAL SERVICES

Product finder for mixers

Since the beginning of the year, interested parties have been able to find the right mixer for their application on the Eirich website based on their requirements and needs.

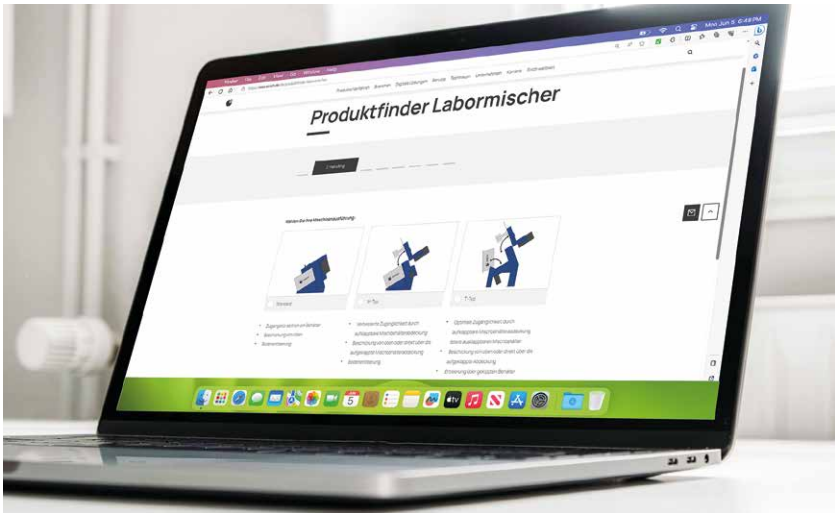

PHOTO: Eirich

The new tool is used to guide potential customers to help them find the perfect match.

This digital guide is designed for small-scale and laboratory mixers up to a capacity of 150 liters, which are used as free-standing solutions at the customer with no need for line integration planning. The search tool intuitively guides users through specifications and options before offering the matching mixer at the end of the process. Further options and accessories can also be selected with just a few additional clicks. Afterwards, a summary with a clear overview of the product requirements can be sent to the sales team, who will draw up a tailor-made offer.

"Our goal is to help our customers find the right products faster. What would have taken many work steps with multiple phone calls and e-mails before, now works with just a few clicks", explains Philipp Pahl, Product Manager at Eirich, Hardheim, Germany. "The tool is not intended to replace personal contact and advice from our experts but will instead assist them and help them to optimize their work. After working with the tool, customers will have already done some homework and will be much better informed about the products we offer, which makes it easier for us to serve them much more directly," explains Pahl.

Over the coming weeks, internal and external feedback will be collected and used to develop and refine the Product Finder tool. The goal is to ensure continuous optimization of workflow and customer service. The valuable findings from demand trends will, in turn, be fed back to the specialist departments to help them meet customer wishes even better in the future.

www.eirich.com/en/productfinder-lab-mixer

BIRN: AI TECHNOLOGY

Iron foundry's energy consumption reduced

The iron foundry BIRN, Holstebro, Denmark, has recently completed an AI project in cooperation with pour-tech AB to optimize dosing of molten iron from casting machines into molds. The project aims to reduce energy consumption.

PHOTO: BIRN

An AI based technology has been successfully implemented to optimize the foundry's energy consumption.

Two laser sensors have been installed on two of BIRN's pouring units to monitor and analyze, using AI technology, how the liquid iron is dosed into the molds. The dosing process plays a crucial role in the heating process and, consequently, energy consumption, as explained by BIRN's CTO, Lars Jørgensen: "The technology helps us save a significant amount of energy because precise dosing into the molds is essential for determining the exact amount of energy needed to fill the molds adequately and allow the molten metal to flow perfectly into the molds".

The project had its beginnings in 2020, during which the technology collected data from BIRN's casting production. Subsequently, the technology was tested in BIRN's operations, where it significantly reduced energy consumption. As a result, BIRN has decided to scale the technology to nearly all the foundry's pouring units.

The AI based technology, named EASYpour, was developed by the global market leader in automatic pouring solutions pour-tech AB and had the opportunity to be tested in BIRN's production before its market launch. BIRN provided the technology with a valuable learning experience, drawing from the expertise of the foundry's seasoned employees.

www.birn.com

PHOTO: ASK Chemicals

In 2023, products based on recycled materials accounted for approximately 15 % of global resin production.

ASK CHEMICALS

Fostering circular economy

ASK Chemicals, Hilden, Germany, has achieved a significant reduction in waste and resource consumption through intensive R&D efforts by utilizing production side streams as a raw material source to develop new product formulations.

In its endeavor to reduce greenhouse gases, ASK Chemicals is taking another important step towards a more sustainable future through targeted distillate recycling. The company's research and development activities have a clear focus on developing efficient products, while actively seeking more environmentally friendly and efficient raw materials and ways to reduce waste. One way to improve the environmental footprint and save waste is to use distillates.

Over the past few years, researchers at ASK Chemicals have investigated a variety of distillates and their suitability for use in formulations. The results are compelling: the Hilden-based company reports that in 2023, products based on recycled materials made up to approx. 15 % of global resin production. The use of distillates at ASK Chemicals is subject to strict quality control to ensure the company's well-known high product performance.

www.ask-chemicals.com

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NEW SOFTWARE VERSION

Loss-free Conversion of 3D/CAD Data

The French-German Software developer CT CoreTechnologie has further developed the CAD converter 3D_Evolution and is now also offers native interfaces for reading Solidedge and writing Nx and Solidworks files.

CoreTechnologie presents a further developed CAD converter 3D_Evolution for the seamless integration of 3D/CAD systems and downstream applications. Thanks to optimized memory management, the new software version promises an improved processing speed and enables optimized processing of very large models.

The CAD converter offers engineers and designers a powerful solution for the precise and efficient conversion of CAD data into various formats. The new interfaces fulfil the current requirements of the industry. The Software with its latest improvements offers substantial benefits for users who heavily depend on 3D modeling and design, utilizing 3D models as their primary source of information, for the development of complex products.

The new version of 3D_Evolution supports a wide range of CAD formats such as CATIA, NX, Creo, Solidworks, Solidedge, Inventor, Step and JT, facilitating smooth interoperability between different systems and collaboration in development environments with different CAD systems. The geometry kernel created specifically for data conversion enables high accuracy and reliability in the translation of CAD data and ensures that even complicated design details are retained without gaps during the conversion process. With its intuitive user interface, the CAD converter simplifies complex and time-consuming conversion tasks.

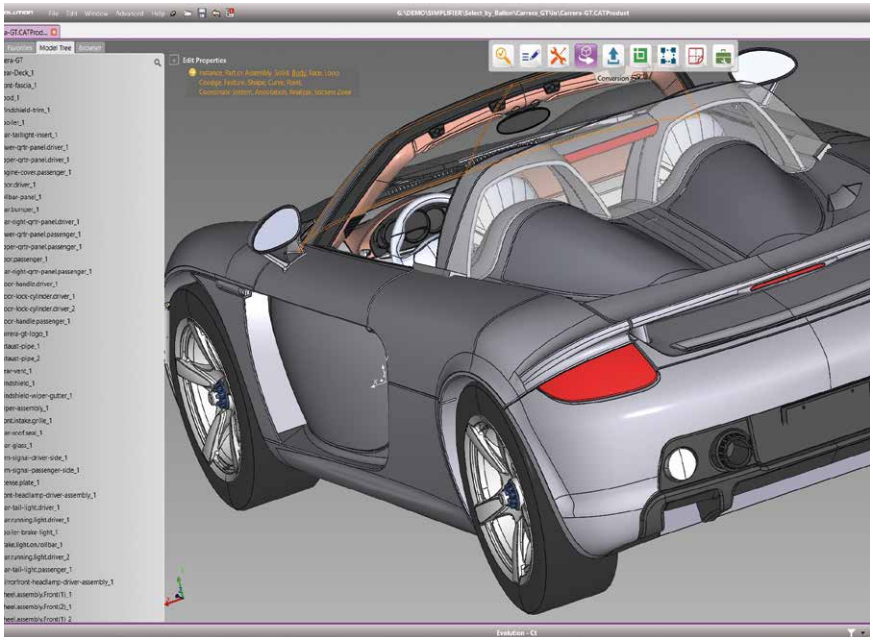

Photo: CT CoreTechnologie

The new software version allows the conversion of large amounts of data.

www.coretechnologie.com

PRINTED CASTING PLATFORM

Rahul Prasad new CTO

Rahul Prasad has joined German printed casting platform Castfast as chief technology officer (CTO). He took up the role at the start-up in Mainz in January 2024, after 5 years at Norican Group's IIoT brand Monitizer in Munich, where he was Head of AI & IoT.

Castfast was spun out of specialist foundry Römheld & Moelle at the end of last year, after successfully building a technology platform around the foundry's 3D sand printing operation. The idea: to radically transform and improve the way castings are purchased, by combining 3D sand printing (fast molding entirely without pattern) and process digitization to allow casting buyers to easily procure high-quality castings online, with instant quotes and fast order processing. Castfast's ambition is to connect a whole ecosystem of foundries to the platform, so buyers can choose from a multitude of suppliers with ease.

PHOTO: Castfast

https://castfast.de

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FURNACE SOLUTIONS

Environmentally friendly heating

Otto Junker, Simmerath, Germany, presents the EcoJet preheating oven, which, together with the JuDy induction-heated oven that has already been launched, enables environmentally friendly preheating without fossil fuels.

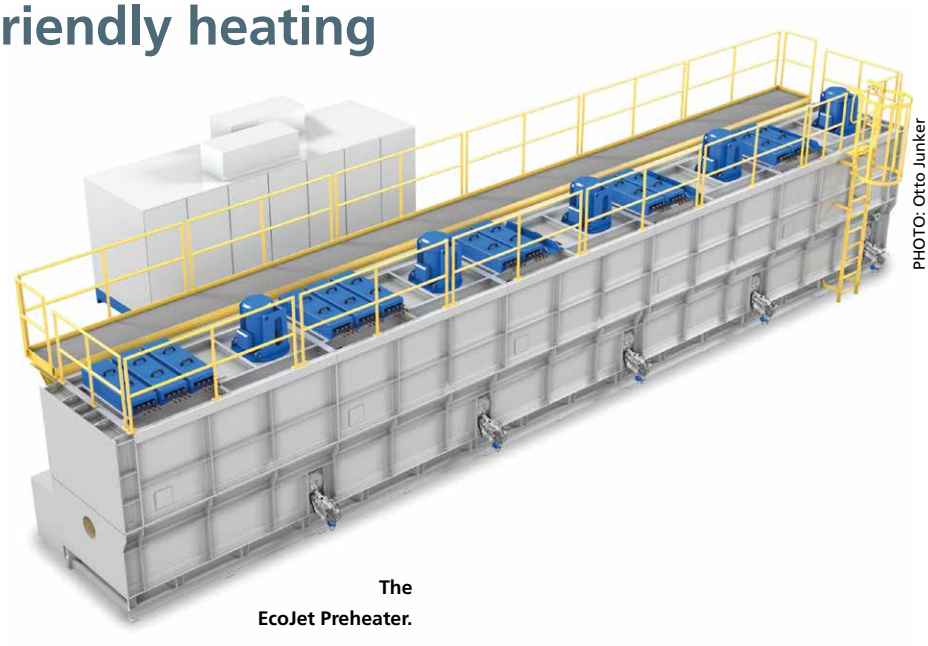


PHOTO: Otto Junker

The EcoJet Preheater.

According to the company, the EcoJet preheater has an efficiency of over 95 %. The temperature is monitored using thermocouples to ensure optimum heat transfer. By using the EcoJet preheater, companies can not only improve their ecological footprint, but also ensure their productivity in times of fluctuating gas supplies. With a fast heat-up time and precise temperature control, the oven promises a future-proof solution that combines environmental protection and cost-effectiveness.

The JuDy (JunkerDynamicHeater) is an induction-heated furnace with an efficiency of approx. 58 % and its ability to produce a precise temperature profile in the billet across individual zones. According to the supplier, the use of a ceramic melting protection tube considerably reduces the energy requirement. Thanks to the trough conveyor system, marks and scratches on the billet surface are avoided. By using the mathematical process model „Billet Pilot“, the heat can be be applied in an optimized manner and the heat-up time can be reduced. Both the IGBT converter and the coils are core components produced in-house which are extensively tested and fine-tuned before shipment. JuDy offers the flexibility required for special applications while at the same time guaranteeing a repro-ducible temperature profile. This solution complements electrically-heated preheating furnaces – as “stand alone”, parallel and in-line.

Together, EcoJet and JuDy achieve a high level of efficiency and are suitable for use in various industries. For example, for foundries and metal processing – here EcoJet and JuDy can help to optimize energy consumption, speed up production processes and improve the quality of the end products. This is particularly important for the production of aluminum and copper

www.otto-junker.com

CHEMETALL

Aluminum Competence Center in Italy

Chemetall, the Surface Technology business unit of BASF Coatings, celebrated the opening of its new global aluminum center of excellence in Giussano, Italy, in February.

Chemetall is a global provider of surface treatment solutions with a comprehensive range of advanced pretreatment solutions for the aluminum industry. In the new aluminium competence centre, Chemetall bundles its comprehensive expertise in the surface treatment of aluminium in a single laboratory. „Depending on the specific alloy, not only the mechanical characteristics change, but also the chemical and corrosive properties of aluminum. This fact poses chemical challenges for pretreatment solutions. Our new technology center will allow us to better understand the complexity of this material and will enable our team to establish new standards in the industry,“ said Arjan Termaten, Director and Head of Global Technology at Chemetall.

www.chemetall.com

Photo: Chemetall

Chemetall's new global aluminium centre of excellence in Giussano.

WORKPIECE CLAMPING TECHNOLOGY

Tool-free quick-change jaws

With the Tandem BWA power clamping blocks from Schunk, Lauffen, Germany, it is possible to clamp small batch sizes of different workpieces fully automatically, according to the supplier.

Photo: Schunk

The quick-change jaws contained in the clamping devices can be changed automatically in seconds without the use of tools.

Application specialist Schunk has developed a suitable module to expand the possibilities of autonomous machining processes. With the new jaw quick-change system BWA, jaws of the Tandem clamping force blocks can now be changed manually or fully automatically via a robot. In future, the system will be available as standard for the pneumatic and hydraulic 2- and 3-jaw clamping force blocks in sizes 100, 140, 160 and 250.

The quick-change jaws included in the clamping devices can be automatically exchanged in seconds without the use of any tools. The supplier also offers the matching pneumatic PGN-plus-P parallel gripper for automated placement for this purpose. The gripper fingers are equipped with special, spring-loaded holding pieces. This allows the top jaws to be automatically unlocked, picked up and reinserted in a positive fit. The application can thus be flexibly adapted to new clamping tasks at any time. The jaw quick-change system enables five times faster manual changing compared to conventional jaw changes, too.

In terms of automation, the monitoring options integrated as standard in the clamping devices are particularly future-compatible. As well as patented dynamic pressure monitoring for the basic jaw positions „opened“ and „closed“, monitoring of compressed air transfer to the jaw already comes as integrated. In this way, a workpiece contact control or cleaning of the clamping surfaces can be done by the customer.

All Tandem clamping force blocks have one thing in common: They offer consistently high clamping forces with a compact design and optimum accessibility in 5-sided machining, even in the tightest of spaces. Increased competitiveness in all industries through maximum flexibility and short response times in addition to the clamping force block and jaws, the handling components on the robot are also essential for an automated process sequence.

www.schunk.com

ALTAIR ENLIGHTEN AWARD

Open for Entries

Altair, Troy, Mich., USA, announced that the 2024 Altair Enlighten Award is now open for submissions. Entries must be received by May 31, 2024.

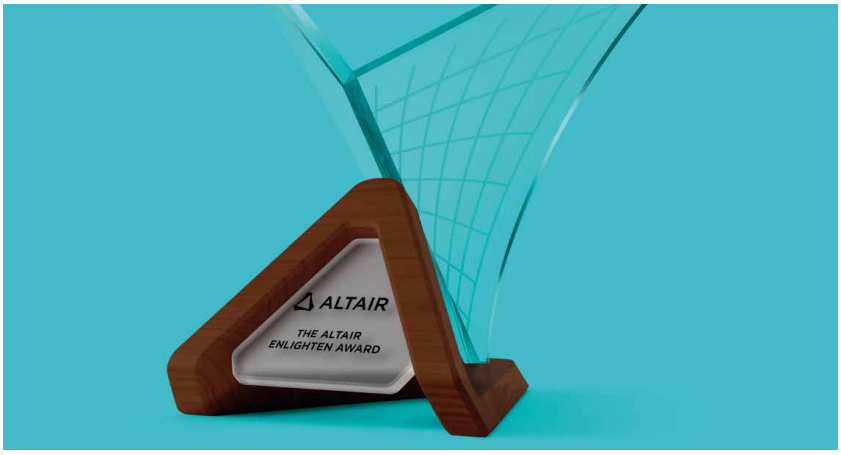


Photo: Altair

This year marks the 12th edition of the Enlighten Award.

Presented annually in conjunction with the Center for Automotive Research (CAR), the award honors the greatest sustainability and lightweighting advancements that reduce carbon footprint, mitigate water and energy consumption, and leverage material reuse and recycling efforts.

This year the Enlighten Award features a new category, “Sustainable Computing,” sponsored by Google Cloud, which recognizes implementing practices and technologies that prioritize sustainable measurement, optimizing resource and energy efficiency, unlocking new opportunities for low-carbon transition, and building more sustainable and eco-friendly computing. This year’s full category list is: Sustainable Product, Sustainable Process, Module Lightweighting, Enabling Technology, Future of Lightweighting, Responsible AI and Sustainable Computing.

www.altair.com/enlighten-award

Photo: Otto Junker

OTTO JUNKER

Celebrating 100 years

Otto Junker, Simmerath, celebrates 2024 its centenary. As recently as 2023 had the company consistently towards sustainability and transformation towards sustainability and transformation. For the future it is confident about the future. New plants and modernizations are planned in the direction of electrification.

The system provider for metallurgical processes and the refinement of metallic materials is satisfied with 2023. New systems and modernizations were geared towards electrification. Two practical seminars on inductive melting were well attended by over 60 specialists from the aluminum, copper and cast iron industries. The company also referred to strategic alliances and the expansion of its business through Otto Junker Solutions in November 2023. In its anniversary year, Otto Junker intends to focus not only on its core business but also on tapping into new markets in the recycling and energy supply industries.

"Our primary goal is to drive technological progress to increase customer benefits in the foundry and semi-finished products industry, but not only in this industry," emphasizes Erik Míček, CEO of Otto Junker GmbH. Non-metal processing industries such as the food, beverage, glass, ceramics, cement, chemical and paper industries are also set to benefit from the use of recycling and electricity storage systems from Otto Junker Solutions. In early fall, Otto Junker is planning several events to celebrate its centenary.

www.otto-junker.com

THE BRIGHT WORLD OF METALS

New trade fairs Turkcast and Aluexpo

The Messe Düsseldorf Group is expanding its global network in the growth market of Turkey and is gaining three new strong events for its global metal trade fair portfolio with the leading Eurasian trade fairs for the metallurgy, foundry and aluminum industries – Ankiros/Turkcast and Aluexpo.

Two of Germany's biggest trade fair companies pool their expertise in a joint venture: Messe Düsseldorf and Deutsche Messe AG will in future each hold a 50 % share in "Hannover Messe Ankiros Fuarcilik A.S.". Company founder Ibrahim Anil will continue acting as General Manager of the company.

Under the roof of "The Bright World of Metals" Düsseldorf already hosts the world's biggest trade fairs in the industry – GIFA, METEC, THERMPROCESS and NEWCAST. Add to this, a portfolio of trade fairs abroad in India, Thailand, Indonesia, Egypt and Mexico, which is now growing further with the addition of Ankiros/Turkcast and Aluexpo in Istanbul. "We are opening up the attractive Eurasian growth market for our customers and strengthening our company's international competitive position", says Wolfram N. Diener, CEO & President of Messe Düsseldorf.

www.tbwom.com

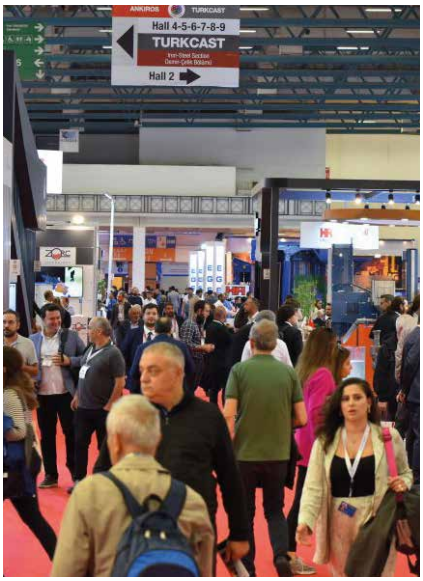
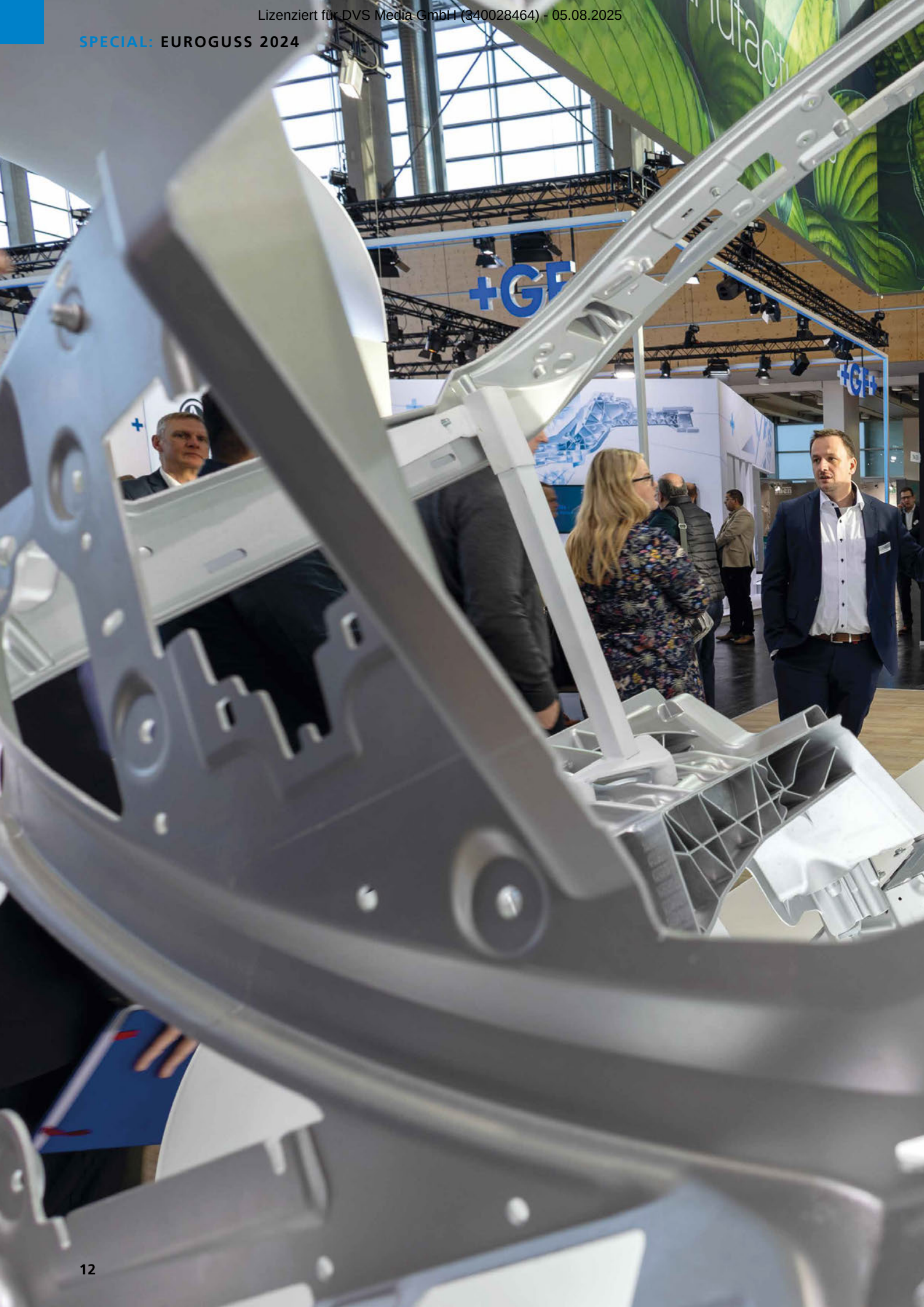


PHOTO: Hannover Messe Ankiros Fuarcilik AS

Ankiros/Turkcast and Aluexpo are now part of Messe Düsseldorf's metal trade fair portfolio.



EUROGUSS 2024

Great popularity, big worries

EUROGUSS 2024 was characterized by rising visitor numbers and full stands with intensive business discussions, but also by concerns, especially from a German perspective: about the slowing e-car economy and the increasingly poor location and framework conditions for production in this country.

By Katharina Koch, Kristina Krüger, Christian Thieme, Martin Vogt and Monika Wirth

EUROGUSS 2024 showcased the entire diversity of die casting. This traditionally includes many automotive components such as battery trays, housings and body components. Alloys were also on show, with a component made from a recycled alloy on the left, an important driver in terms of the circular economy.

The Nuremberg trade fair company released the formal key data for EUROGUSS just in time for the end of the die casting trade fair: 60 percent of exhibitors came from abroad, with Europe continuing to lead the way. The focus was on Italy, Turkey, Spain, Austria and Switzerland. The turnstiles at the two trade fair entrances counted 14,341 visitors, significantly more than the 10,700 at the last edition – which, however, was also postponed from January to June 2022 due to the coronavirus pandemic. The figures are comparable with the 2020 edition of EUROGUSS – which was marginally better attended at 14,599, but did not have to contend with the onset of winter, which tends to inhibit visitor numbers and was widely announced in the media. „In my view, the figures are all the more significant for the relevance of EUROGUSS“, says Christopher Boss, Executive Director EUROGUSS, interpreting the popularity. „We were able to give the die casting industry a home and orientation in difficult times“.

Economy for e-cars „Made in Germany“ is slow

Which gets to the heart of the situation: in addition to all the technical and specialist issues, political and economic developments are hovering over the European and, in particular, the German market, which are causing die casters massive concern. Following the ruling of the Federal Constitutional Court, the German government announced the abrupt end of subsidies for the purchase of e-cars shortly before Christmas in a panic of cutbacks, which has further torpedoed the already sluggish sales of e-cars „Made in Germany“ – with drastic consequences for the die casters supplying them. „We need predictable quantities because we have invested massively in this area“, says Klaus Bruchner, Managing Director at Schüle Druckguss, for example. „When will electromobility take off?“, asks Wolfgang Schmidt from the management team at Handtmann, against the backdrop of major investments and corresponding production volume expectations for e-parts, „what we are seeing at the moment is that combustion engine components are running up at an above-average rate“.

There is still potential for die casting

These are undoubtedly bizarre market caprices that are difficult to calculate from a business perspective and have a highly volatile effect. These market

PHOTOS: MARTIN VOGT, CHRISTIAN THIEME, NÜRNBERGMESSE

Annual kick-off

Voices from the die casting industry

Die casting is definitely booming – but Germany has special circumstances and framework conditions. We asked around at the trade fair to kick off the year. Below you can read the statements of seven managing directors on what they expect from 2024.

"The prospects are not good at the moment. We hope for and need the increase in demand that we expect in the second half of the year. What we definitely need is for the mistakes of the past – with regard to energy policy – to be corrected as quickly as possible so that we can become competitive again in terms of energy prices. Otherwise, we will certainly see a greater relocation of jobs".

Hartmut Fischer
Managing Director Stihl Magnesium Die Casting

"A competitive electricity price is fundamental for us – which we don't currently have. The government once promised us four cents, today we're more like three to four times that price – and that means we're not competitive and have too little future. This means that we are now demanding the industrial electricity price of four cents that our Chancellor promised. Absolutely necessary for us to look to the future".

Rolf Cramer
Managing Director of Druckguss Westfalen

dynamics – which are also politically driven – are taking place against the backdrop of an unstable economic policy situation, particularly in Germany. „A lot has to happen. We expect politicians to improve the conditions for business locations, reduce bureaucracy and ensure that the industry receives an appropriate, good electricity price", says Gerd Röders, Managing Director at G.A. Röders. The longing for stable, reliable framework conditions can be heard in every conversation. Bureaucracy with ever new laws and requirements, high electricity prices – these are the most important issues.

At least in the German market – because the die casting business model is not fundamentally in question, on the contrary, it is booming. „We are convinced that there are many opportunities to take the die casting process even further. In the housebuilding and infrastructure sectors, for example", says Alexander F. Marks, Managing Director at Oskar Frech GmbH, citing the example of sanitary fittings. „We still work a lot with brass components here, which are produced using gravity die casting or low-pressure die casting. The transition to zinc die casting offers enormous opportunities in terms of unit costs".

Growth potential that is actually being exploited in some areas. „We have succeeded in winning many new projects for the foundry in Kitzingen", says Franken-Guss Managing Director Josef Ramthun, „We will be investing heavily to even expand our capacities".

Gigacasting is underway – especially in China

And, of course, there is the perennial trend topic of mega- or gigacasting, which refers to the casting of particularly large body parts on machines with a particularly high clamping force. Germany's automotive industry, for many

„**Our expectations** for 2024 are such that we naturally forecast unit volumes for this year's planning that will not materialize due to the short-term cancellation of funding by the German government. So what we are seeing at the moment is that combustion engine components are running at above-average levels and all the investments we have made for electromobility – for example in modern, interlinked systems – are currently virtually empty. In addition to the discussions about energy and materials management, we are most concerned with the question: when will electromobility take off?"

Wolfgang Schmidt,
Management Albert Handtmann Metallgusswerk

„**I want more clarity,** more direction. Directional decisions from our politicians on the issues of electricity and prospects – so that we know which way Germany is heading. I believe that many people lack this clarity in politics. I would like to see this clarity, that is my wish for 2024".

Hans-Peter Grohmann,
Managing Director Grohmann Aluworks

years the global flagship and market leader for combustion models, is still struggling in this area. Young manufacturers such as Tesla or some Chinese carmakers and also Volvo – which is known to be in Chinese hands – are more radical here.

Fittingly, machine manufacturer Bühler from Switzerland announced its latest deal on the fringes of the trade fair: Chinese automotive supplier Duoli Technology is purchasing four new Carat 920 machines. The order is one of the largest single orders for the Bühler Group's megacasting business. The two-platen technology with clamping forces of 10,500 to 92,000 kN is specially designed for the production of large and complex parts such as front and rear underbodies in one piece.

Well-received guided tours gave visitors to the trade fair an overview of where gigacasting is heading. Presentations by practitioners on the implementation of the new technology were fully booked. For example, Volvo Cars reported on „Lessons Learned" at the Die Casting Day – the company is currently in the process of bringing gigacasting to series maturity in plants in Sweden and Slovakia. And the largest machine ever to be seen on the exhibition grounds in Nuremberg, a huge deburring press from the North Bavarian mechanical engineering company Aulbach Automation abk Pressenbau, was one of the crowd-pullers.

Exciting topics such as automation or AI

The dynamism in the die casting industry was unmistakable at EUROGUSS. The exhibitors not only presented impressive exhibits, but were also convincing in terms of content. Topics such as automation, production interlinking and the use of artificial intelligence are increasingly coming to the fore. Topics that offer foundries new opportunities. Production processes can be linked ever more easily through the use of highly

Left: Trade fair boss Peter Ottman (left) with State Secretary for Economic Affairs Tobias Gotthardt (Bavaria/Freie Wähler) in front of a deburring press from abk Pressenbau with Managing Director Lisa Aulbach-Heinecke. Above: Sarna Röser, entrepreneur and SME activist.

„This year, it may sound surprising, we are expecting sales growth – because we have succeeded in winning many new projects for the foundry in Kitzingen and filling these opportunities with life. This will enable us to more than compensate for the decline we are experiencing in our standard business, which can be heard everywhere in the industry. We will invest a lot to even expand our capacities"

Josef Ramthun
Managing Director
Franken Guss

flexible driverless transport systems and robot or gantry solutions.

Solutions such as „cybernetics", a technology from Austrian machine manufacturer Fill, are implemented in the company's own machines and enable the monitoring of complex individual processes or ensure seamless component tracking through to automated system optimization using AI. Data visualization through customer-specific and platform-independent dashboards provides an optimal overview and enables detailed analyses in real time.

Reis Robotics also returned to the trade fair under the motto „we are back". Following the takeover by KUKA in 2013 and the subsequent change of name, the company was recently acquired by a consortium consisting of the Italian technology company CT Pack, the Aretè Cocchi Technology Group and the Swiss investment company FAI Holding. Reis Robotics presented its „ROBOTstar" robot controller, which is operated via an external tablet and enables precise simulation of casting cells. This facilitates precise system monitoring without the operator having to enter the cell. The company is also planning to use Siemens hardware in the control components in the future in order to offer extended analysis and processing options for system parameters, which will be important for the digital product passport, for example.

Sand casters at the die casting fair

Pinter Guss from Lower Bavaria is also keeping an eye on these developments. As a sand caster, the company was an exotic exhibitor at the trade fair, but felt encouraged to visit the fair by the good response from customers, reveals Dipl.-Ing. Felix Jaruszewski, Managing Director of the company. The focus of the presentation was on special components for rail and medical technology, including the housing of a DNA scanner.

Gerd Röders
Managing Director G.A. Röders

„A lot has to happen. We expect politicians to improve the conditions for business locations, reduce bureaucracy and ensure that the industry receives an appropriate, good electricity price. We expect our employees to continue to be hungry for training, to embrace change and to be active. We expect our customers to be happy to pay for the services they receive from us and thus ensure that our location can develop properly".

Above: At the Student Day, candidates came into close contact with companies, here Oskar Frech. The Talent Award honored outstanding final theses.

The company is particularly active in research projects such as „ReGain", which aims to digitally link foundry production systems in order to increase efficiency, flexibility, resilience and sustainability. The aim is to develop a new digital manufacturing concept that supports environmental sustainability in the foundry industry in line with the 2021 update of the European Green Deal. ReGAIN aims to lay the foundation for the creation of a standardized digital product passport for each foundry product and make it available as part of Catena-X, an open data ecosystem for the automotive industry.

The Wilhelm Funke metal foundry exhibited as an expert in prototypes and pre-series. At the joint stand with voxeljet, the foundry demonstrated its expertise in rapid prototyping. Thanks to advanced sand printer technology, Wilhelm Funke is able to go from digital data set to finished product in just five working days. The technology is mainly used for gearboxes for cars, motorcycles and helicopters. The company pays particular attention to the production of highly complex components that impress with their functional integration – a focus that is very popular in Nuremberg. „We have surprisingly good discussions here and many interested parties come to us with specific projects," says Quality Manager Florian Topp.

Student Day with talent award

The final day of the trade fair was all about promoting the next generation of industry professionals. Under the motto „Student Day", prospective engineers were offered a comprehensive program with keynotes, specialist presentations and guided tours. A live survey conducted among the participants revealed that the majority of them had little prior knowledge of die casting – a bull's eye for the organizers.

In his keynote speech „Casting without limits – what competitive technologies do casting processes have and where are the limits of economic efficiency and feasibility?", Prof. Dr.-Ing. Sven Roeren discussed the challenges and opportunities in the design of die

EUROGUSS attracted more than 14,000 visitors – many of them from abroad. Left: Axle housing for a high-speed train, manufactured by Pinter Guss.

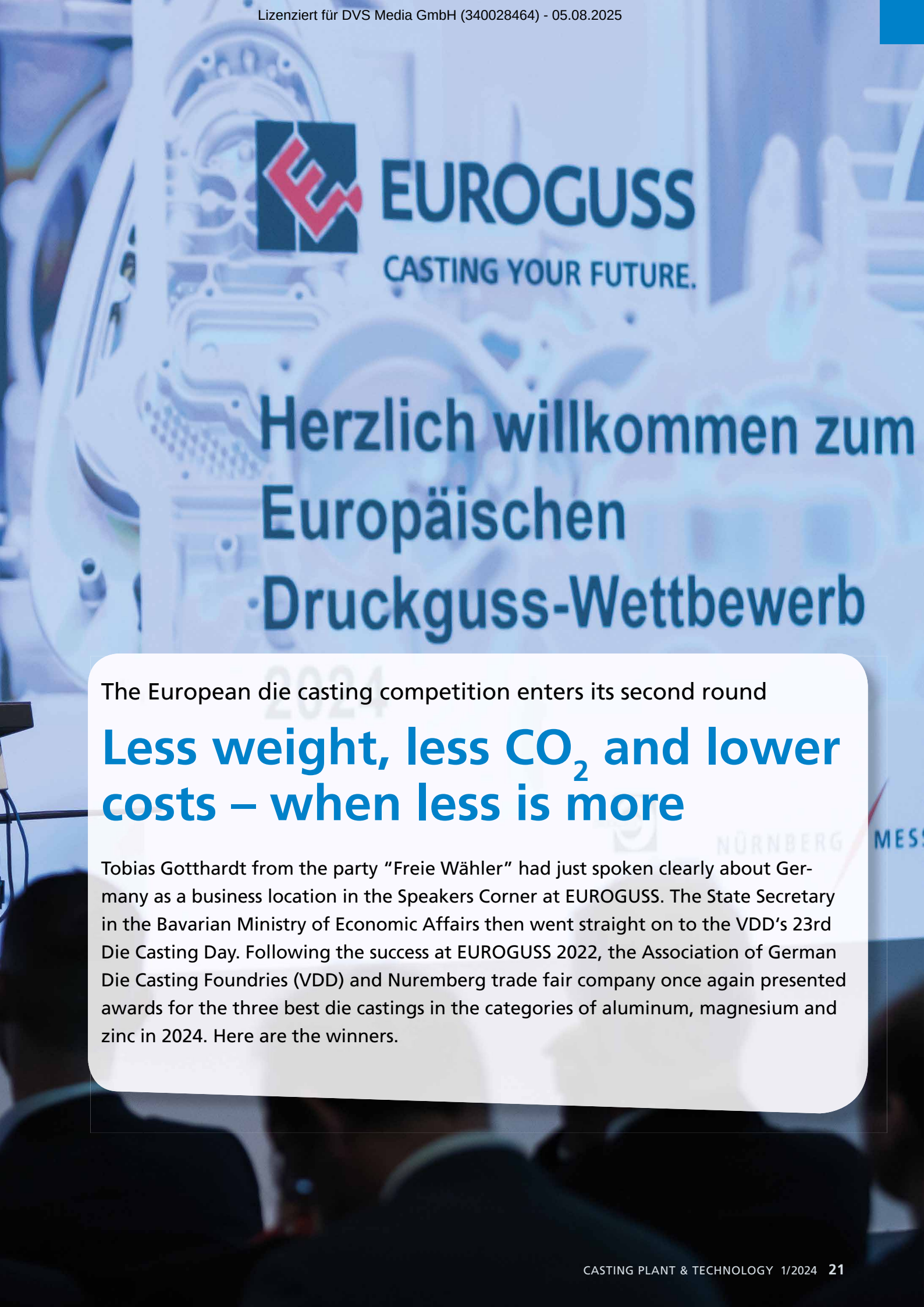
„What we need above all as a medium-sized foundry in 2024 are stable framework conditions – 360 degrees. It starts with politics – keyword bureaucracy – and continues with energy, which is of course a huge influencing factor for us as a foundry. The next topic is the customer side – and the keyword here is e-mobility. We need predictable quantities, because we have invested massively in this area. And then there's the financial side. Interest rate stability is very important for us as a company with a high level of investment. All in all, I can say that as a medium-sized company, we have learned to adapt over the years. Now we also have to manage the transformation. It would be nice if we had stable framework conditions for this over the next twelve months".

Klaus Bruchner
Managing Director
Schüle Druckguss

casting machines. He shed light on the tension between technical feasibility and economic viability and provided valuable insights into which production technologies can play to their strengths under different conditions. The students benefited from Roeren's pragmatic approach, and he encouraged them to ask as many inquisitive questions as possible.

The students were able to deepen their knowledge during a guided tour, during which they had the opportunity to discuss industry-specific topics directly with experts. The spectrum ranged from research and robotics to temperature control solutions and provided participants with a wide range of insights. A particular highlight was the demonstration of a running die-casting machine at the Frech stand, which gave participants a practical insight into the machine technology.

The highlight of the Student Day was the presentation of the Talent Award in the SpeakersCorner. This internationally renowned prize aims to recognize outstanding theses in the field of die casting and to promote young talents. Five finalists had the opportunity to present their academic work in a presentation and then had to answer technical questions from the audience and presenter Franz-Josef Wöstmann. The submitted abstracts were evaluated by an international, high-caliber jury consisting of representatives from industry and research. The audience also had the opportunity to vote for the best presentation. The first prize of 1500 euros was awarded to Danny Rohde from the University of Kassel. Second place went to Michael Moodispaw from The Ohio State University, while Neelima Gottumukkala from TU Freiberg won both third place and the favor of the audience and won the public vote.



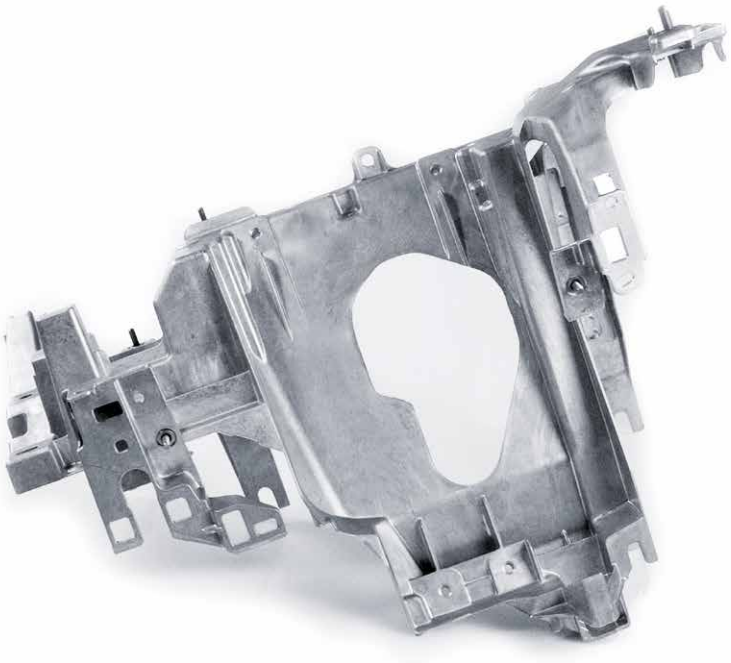
The European die casting competition enters its second round

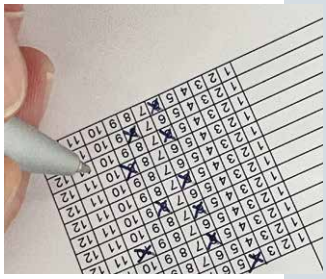
Less weight, less CO_2 and lower costs – when less is more

Tobias Gotthardt from the party "Freie Wähler" had just spoken clearly about Germany as a business location in the Speakers Corner at EUROGUSS. The State Secretary in the Bavarian Ministry of Economic Affairs then went straight on to the VDD's 23rd Die Casting Day. Following the success at EUROGUSS 2022, the Association of German Die Casting Foundries (VDD) and Nuremberg trade fair company once again presented awards for the three best die castings in the categories of aluminum, magnesium and zinc in 2024. Here are the winners.

1st Place

ALUMINUM: Support structure for a hybrid instrument panel, BMW Group, Landshut, Germany. The central component of the instrument panel is relevant to safety, e.g. due to screw connections to the steering column or the knee airbag. It is lighter than a tubular steel construction and has a higher rigidity than a plastic construction.





„The European Die Casting Competition was a very impressive showcase for our industry."

1st Place

ZINC: the 4-consumer panel of a sanitary shower system from HDO Druckguß- und Oberflächentechnik GmbH, Paderborn, Germany. Wall mounting places high demands on the flatness of the casting. The variable tool concept – a family tool with separate inserts – can accommodate various types of four to two consumers.

An industry shows what it can do – excellent die casting

Kick-off and highlight of the 23rd Die Casting Day: the award ceremony of the European Die Casting Competition. The award winners are intended to show the public and customers how diverse, innovative and efficient the die casting process is. It is therefore not surprising that the jury's statements reflect the EUROGUSS megatrends. The focus was primarily on savings – in terms of weight, resources, CO_2 emissions and, quite classically, costs.

The Association of German Die Casting Foundries was once again supported by Aluminium Deutschland (AD), the European Magnesium Research Association (EFM) and the Federal Association of the German Foundry Industry (BDG), where the jury members met on October 17, 2023. The experts from industry and research selected the winners from the 25 entries. First things first: technological complexity and quality could be assumed for all die-cast parts.

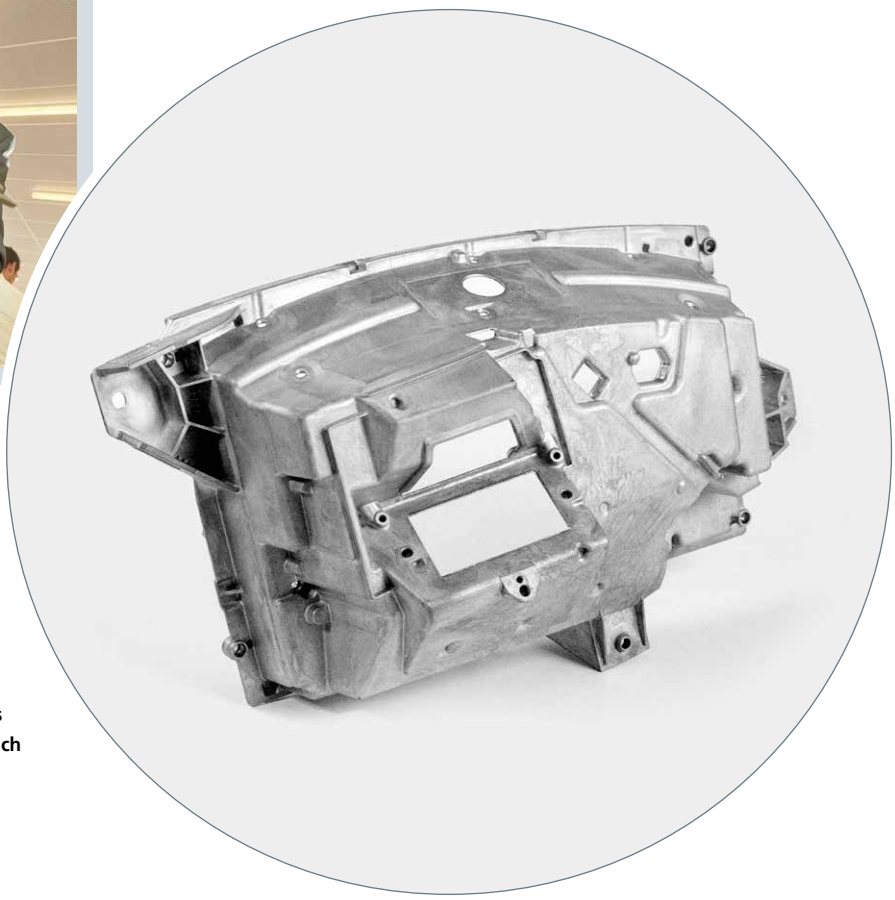
Category Aluminum – First Place

First place in the aluminum category – a support structure for a hybrid instrument panel for the BMW Group, Landshut, Germany – was distinguished by a 75 percent reduction in CO_2 emissions and thin wall thicknesses of just 1.5 mm. The casting thus made optimum use of the advantages of the process. The central component of the hybrid instrument panel made of cast and plastic parts in the steering column area is

PHOTOS: MARTIN VOGT, BDG/MANUFACTURER

The men behind the award – the jury

Almost a who's who of the industry: Martin Lagler (Bühler), Horst Bramann (Magma), Norbert Hoffmann (Leichtmetallzentrum Soltau), Stuart Wiesner (Aluminium Rheinfelden), Christoph Schendera (European Magnesium Research Association), Martin Tauber (International Magnesium association), Lothar Kallien (Aalen University), Didier Rollez (Grillo-Werke), Helmar Dannenmann (Oskar Frech), Franz-Josef Wöstmann (Fraunhofer IFAM), Martin Fehlbier (University of Kassel) and Achim Keidies (non-ferrous specialist at the BDG).



1st Place

MAGNESIUM: the housing for a head-up display from TGG UNITECH GmbH, Kirchdorf a. d. Krems, Austria. The sub-processes that made mechanical processing superfluous include dry ice deburring and cleaning, which reduce distortion caused by blasting.

safety-relevant and must withstand extreme climatic conditions from -35 °C to +80 °C. The four-panel technology reduces flow paths and brittle surfaces, allowing wall thicknesses to be optimized for function instead of flow paths. On the other hand, larger components can also be produced on existing systems.

Category Magnesium – First Place

TCG UNITECH GmbH from Kirchdorf a. d. Krems, Austria, took first place in the magnesium category. Their housing for a head-up display is a highly complex, thin-walled component which, despite tight tolerance specifications, does not require machining in large quantities, thus saving the customer costs. This requires a precise mold and new sub-processes.

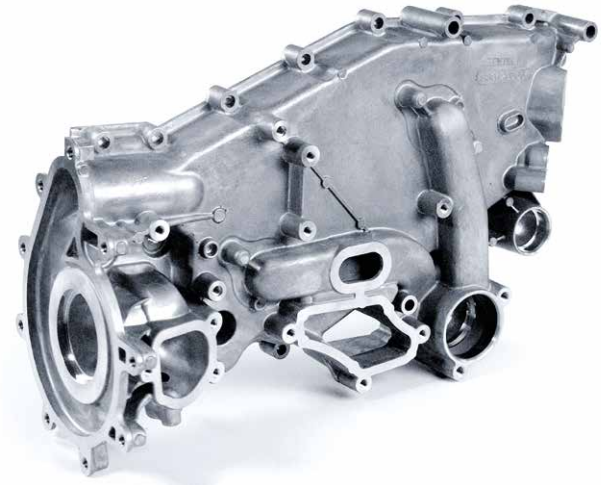
Category Zinc – First Place

First place in the zinc category went to HDO Druckguß- und Oberflächentechnik GmbH from Paderborn, Germany.

Their 4-consumer cover for a sanitary shower system is a large component with a large visible surface that is produced in large series. It places high demands on the surface coating and therefore also on the surface and quality of the casting. CO_2 is saved through the use of recycled zinc – up to 97.5 percent compared to the use of primary material.
Just as interesting: the 2nd and 3rd places, to be found on the following pages.

2st Place

ALUMINUM: E-coil for a wheel hub motor, Oskar Ketterer Druckgießerei GmbH, Furtwangen, Germany. Compared to wound copper coils, the component saves 50 percent in weight and 60 percent in material costs and reduces the CO_2 footprint thanks to lower processing temperatures. As the use of the installation space has been optimized, the performance data remains almost the same. The development for the wheel hub motor of a light vehicle is the result of a collaboration with Fraunhofer IFAM, Bremen, Germany.



3st Place

ALUMINUM: Oil Cooler Cover, Lijunghäll Grub AB, Gnutti Carlo Group, Maclodio, Italy. The component has two large water channels, which are mapped with two composite salt cores. Production using the lie casting process with the recycled alloy AlSi9Cu3 aves weight and costs and reduces the CO_2 footrint. The component is produced in large series.

2st Place

ZINC: Lion Housing PMCR 2.0, Dipl.-Ing. Siegfried Müller GmbH & Co. KG, Velbert, Germany. The component replaces a steel construction and thus saves 50 percent in weight. The electronics housing is used in mining and has to meet high requirements in terms of explosion and corrosion protection as well as dimensional requirements. It saves costs in production and during operation and makes tests for IP65/68 tightness requirements superfluous.

3st Place

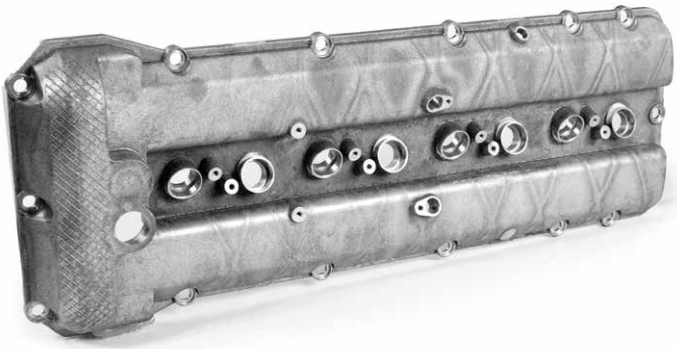
ZINC: SACC CT P12M5X grommet housing, Dynacast Deutschland GmbH, Bräunlingen, Germany. The grommet housing of a data connector with push-pull locking is a single component and therefore cost-effective. It also meets high explosion protection requirements and eliminates the need for IP65/68 tightness tests. The challenges included: near-net-shape geometry, good mold filling for coatability and challenging demolding due to the large number of openings.

Further details on the award-winning castings can be found at

https://www.guss.de/themen/die-gewinner-des-druckgusspreises-stehen-fest

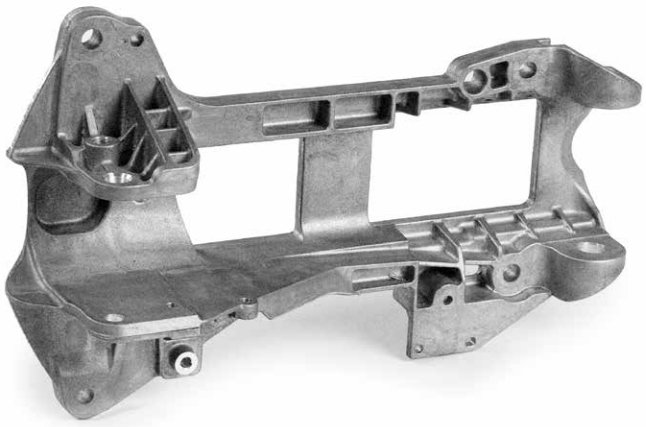
Spoilt for choice

On October 17, 2023, the jury did not make it easy for itself when it selected the three winners in the aluminum, magnesium and zinc categories at the premises of the Federal Association of the German Foundry Industry (BDG). The experts from research and practice exchanged ideas intensively before finally giving their verdict. Keen eyes can identify some of the winners in the pictures, which are described in more detail on these pages.



2st Place

MAGNESIUM: W16 cylinder head cover, Audi AG, Neckarsulm, Germany. High pressure tightness with low wall thickness and at the same time high load in the powertrain area – these were the requirements of the component produced in small series. The uniform cast raw part for mirror-symmetrical finished parts of the left and right cylinder bank saves costs and 30 percent weight.



3st Place

MAGNESIUM: Console for the MC 3.0 steering column, Power Cast Zitzmann GmbH & Co. KG, Stockheim, Germany. The bracket is the connecting element between the cockpit cross member and the steering column. It replaces many individual parts, saves weight and conserves resources by reducing the amount of spraying. Other requirements include Dual die-casting mold with four slides per cavity, long flow paths. The advantages also include high elongation and energy absorption with high strength and good crash behavior.

23rd Die Casting Day 2024

Think big, plan in detail

When OEMs talk about their plans for e-mobility, Tier 1 suppliers give their (partial) answers and the major machine manufacturers present their developments, it becomes clear that the future of die casting lies in functional integration, megacasting, artificial intelligence and secondary alloys. The goal of net zero has been set, and CO_2 balancing is becoming an integral part of every technical and business consideration. The Die Casting Day organized by the BDG and VDD once again set new standards in terms of topics and thus remains an integral part of EUROGUSS.

In his welcoming speech, Hartmut Fischer, Chairman of the Association of German Die Casting Foundries (VDD), emphasized that the situation in the foundry industry is serious, especially for die casting foundries, which are heavily dependent on the currently weakening automotive industry. However, giving up is not an option, he said, because "there are so many of us at EUROGUSS to think about opportunities and solutions, to show our potential". He reminded politicians that castings are part of every forward-looking technology, whether for the energy transition, electromobility or digitalization. In order to be able to develop, plan, invest and produce here, German companies need stable and reliable framework conditions.

Functional integration or megacasting?

Volvo has decided to produce its own megacastings for electromobility. Klaus Hansen gave an impressive account of how detailed such a changeover has to be planned. From the development of the casting itself and the die-casting tools, to the correctly dimensioned plant and the production environment with furnaces, transportation and recycling. It should be borne in mind that 130 t molds are used, which alone are 6 m high. Every little thing that is overlooked during the planning stage has a serious impact later on. This also applies to the car itself. The plan is not to replace component groups of the current models, but to develop new variants tailored to the megacastings. As a tier 1 supplier, Handtmann Metallgusswerk GmbH has also decided to move in the direction of megacastings and go into series production with a rear end in 2026, says Stefan Kneer. It is important to include "design for manufacturing" in the planning from the very beginning.

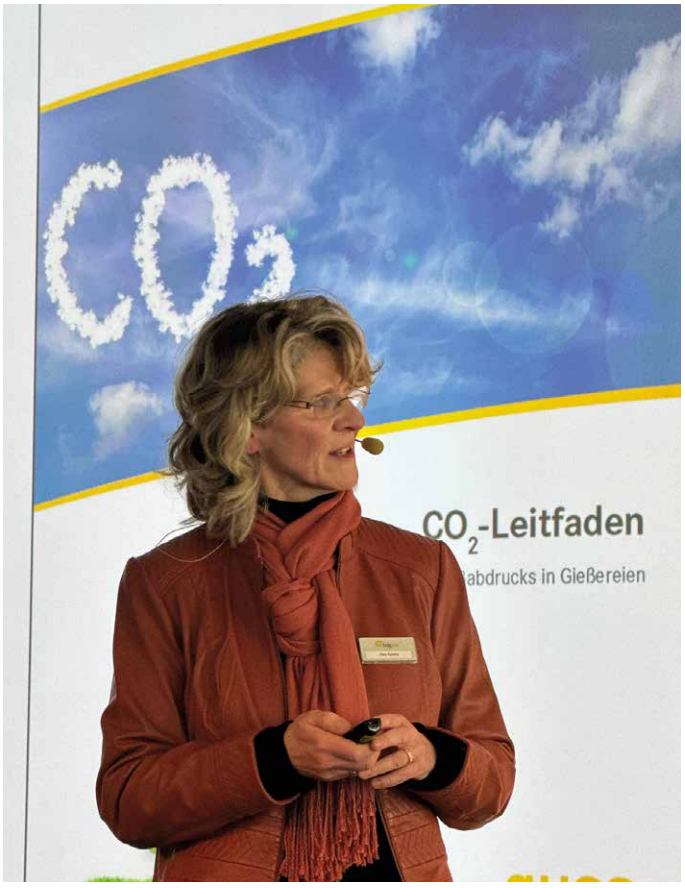
Other manufacturers tend to focus on more moderate functional integration. Marc Schönefelder and Michal Luszcak demonstrated the development process of an e-bracket for BMW at

Nemak. By using specially created material cards and extensive material, design, casting and function simulations, the wall thickness of the bracket could be reduced to 1.5 mm and the weight to almost half while improving durability. Thomas Kopp and Klaus Sammer, BMW, presented the concept behind the successful substitution of magnesium with aluminum in the support structure for hybrid instrument panels that won an award in the die-casting competition. First of all, the higher specific density had to be achieved by reducing the material. In addition to a functionally optimized design, the 4-plate tool technology was developed, which allows the component surface to be cut directly and the gate to be torn off in a targeted manner. This allows the clamping force to be lowered and the amount of material used to be reduced.

Elmar Beeh, DLR (German Aerospace Center), explained how lightweight construction must be thought of from the ground up. A completely new topology concept for a gearbox cover made it possible to save 25 % in weight.

Alexander Marks, Oskar Frech GmbH, also explained that the status quo must always be questioned and developments must be driven forward. Product and technology openness are important success factors here. This applies not only to the machine and the actual casting process itself, but also to the entire periphery, including digitalization.

Stefan Prockl, Bühler AG, also believes that the industry has a responsibility to reduce its carbon footprint. He sees megacastings, with their high potential for lightweight construction and the savings in production steps and transportation routes, as the right step towards greater sustainability, which also offers financial benefits.



Above: The carbon footprint calculator FRED, co-developed by the BDG, was very well received, presented by Elke Radtke, Head of Environmental Protection and Occupational Safety. Right: Klaus Hansen enthusiastically explained Volvo Sweden's activities to introduce megacasting in vehicle production.

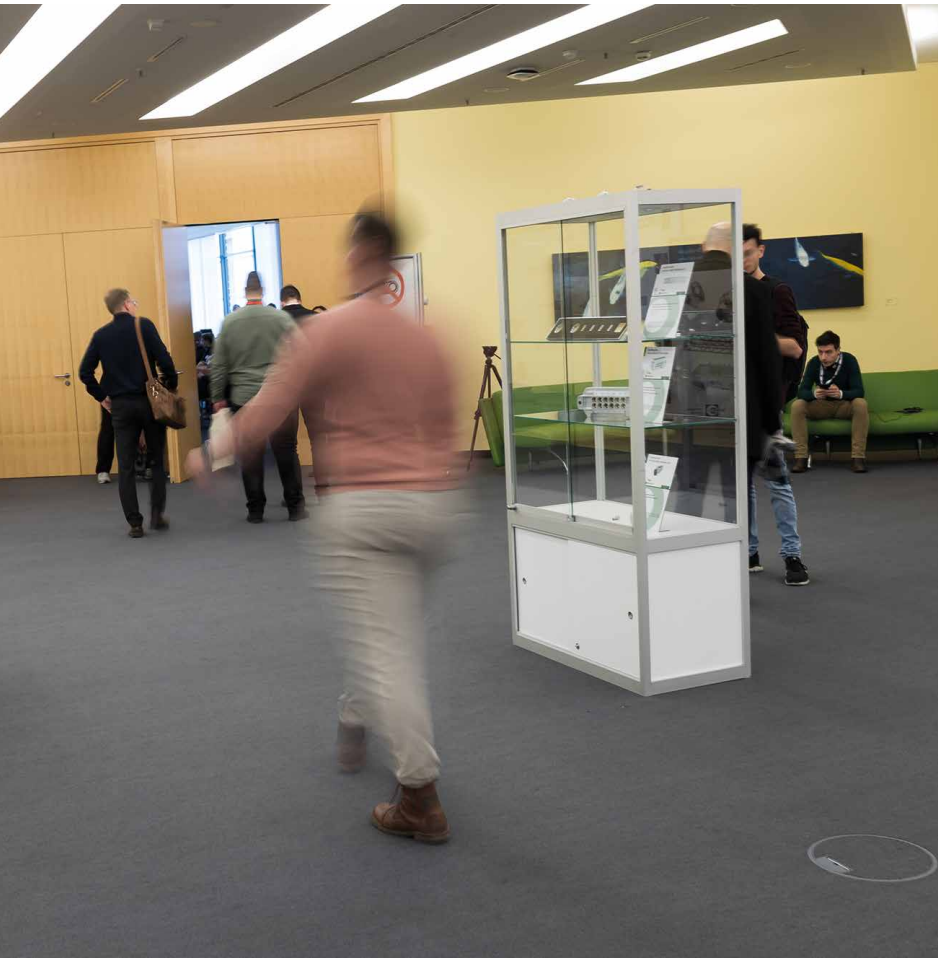
Alternative alloys and casting technologies

The exploitation of primary aluminum accounts for a large part of the CO_2 footprint of cast products. It is therefore desirable to achieve the highest possible recycling rate with consistent quality. Together with Albert Handtmann Metallgusswerk GmbH, Aalen University is systematically investigating the influence of recycled content and its foreign elements on the properties of die casting alloys. As a result, it is becoming apparent that higher recycled content allows a wide range of applications with regard to mechanical and corrosive properties. The standards and regulations will have to be adapted accordingly in the near future.

Stuart Wiesner, Alu Rheinfelden, also sees a need for action here so that high-quality components can be produced from scrap. He presented both established secondary alloys and new developments consisting of up to 90 % recycled material. Although these require adjustments to the process with slightly different casting properties, they achieve high-quality component properties as naturally strong alloys without heat treatment.

Asier Bakedano Abaunza reported on the development work at Azterlan on the new secondary aluminum AlSi10MnMg(Fe) for structural components with high ductility requirements.

Is rheocasting an alternative to die casting? Fabian Hofstätter, Salzburger Aluminium Group, explored this question and concluded that the additional process-related effort makes sense where a very dense structure is required, for example in helium-tight welding or when forged parts can be replaced.



Above: Lively participation at the Die Casting Day. The winning parts of the European die casting competition were on display in the foyer. Left: Hartmut Fischer encouraged those present to look to the future with innovative strength despite the current worrying situation.

With high-temperature casting, Daniele Grassivaro presented a new casting concept that falls between die casting and low-pressure casting. The mold is filled more slowly, but with a hotter melt, which results in a very laminar flow.

Net Zero

The environmental and climate protection aspect must always be taken into account in all technically functional innovations, as the net-zero target must be achieved. Elke Radtke from the Federal Association of the German Foundry Industry (BDG) presented the newly developed carbon footprint calculator FRED, which is now ISO certified and available online. The web tool guides the user step by step through the production process. If the companies are missing individual primary data, it is possible to use some of the databases that have been entered for estimation purposes. The assessment takes into account all three scopes (cradle to gate).

Norbert Hoffmann presented the work on determining the energy requirements and CO_2 balances of various mold spraying technologies at the Institute for Joining and Welding Technology, University of Braunschweig.

Thomas Niehoff, combustion POTENTIAL GmbH, discussed concepts for avoiding emissions in combustion technology, even if the availability of green hydrogen is still insufficient. One example was the supply of technical oxygen obtained from waste heat. The production environment also usually still has energy-saving potential, for example in lighting. Jandrik Ebel, Conled Lichtcontracting GmbH, explained the idea behind lighting contracting, which involves re-equipping production facilities with an optimized LED system, including advice, installation, maintenance and repair.

Industry 4.0

Developments in automation, digitalization, artificial intelligence and augmented reality can make production more efficient in many ways. Alexander Buchele, Ansbach University of Applied Sciences, presented the ZIM network "Digitalization and resource efficiency in the foundry industry": the aim is to develop standardized solution concepts for the conversion of heat exhaust streams into electricity as well as a neutral benchmarking of efficiency parameters as a benchmark for innovative solutions.

Cornelia Juds, Industrial Application Software GmbH, explained how customized ERP systems can control and manage resources sustainably. The aim is to move from an "Internet of Things" (IoT) to an "Internet of Energy" (IoE).

Theodor Scherer, Schertech GmbH, reported on the integration of lean management systems in the foundry. He emphasized that complete digitalization with technical process monitoring using AI systems and the mapping of the job floor on digital twins initially meant a high upfront financial outlay but would bring effectiveness that was worth the investment.

Jürgen Schmiezek, TVARIT GmbH, also pointed out that in view of the increasing shortage of skilled workers, the future of die casting lies in industrial AI, which checks and regulates all parameters using hybrid models.

However, no digital process acquisition works without robust hardware components. Slava Pachandrin, TU Braunschweig, presented work on how this item can be kept cost-effective.

PHOTOS: FOSECO

The WASCO binder system from Foseco promises stable and easily releasable die cast cores.

Die cast cores

Innovative water-soluble binder systems

For HPDC applications, Foseco developed a new type of sand core using innovative WASCO water-soluble binder systems and optionally with adaptable coatings to avoid liquid metal penetration into the pores of the sand core.

By Vincent Haanappel, Thomas Linke

This paper focuses first on some fundamental aspects on the development of such a water-soluble binder system, followed by two practical examples, one producing cores for explosion-proof instrument housings, and the other manufacturing sand cores for automotive applications. Irrespective of the high flexural strength of the sand cores, after the casting process the complete casting was immersed in cold water after which the binder showed excellent water-solubility. Due to the short cycle times resulting in a relatively low thermal impact, no issues occurred with the generation of volatile organic compounds (VOC's) as the organic binder thermally decomposes.

After washing-out core residue, a smooth, defect-free and sand-free casting surface was obtained, indicating that the sand cores with the WASCO water-soluble binder can be a promising candidate for structural castings.

Introduction

In most casting processes, the molten metal is poured in a pre-formed mold, with the metal filling of the mold under gravity or low pressures resulting in the need for slightly higher metal temperatures to ensure a complete casting fill. When applicable the internal cavities

Table 1: Composition of various batches with a 2-component liquid binder.

Composition	1	2	3	4	5	6
2-C Liquid Binder (wt%)	5	5	5	5	5	5
Comp. D (wt%)	0	20	40	60	80	100
Comp. A (wt%)	100	80	60	40	20	0
Additive (wt%)	2	2	2	2	2	2
Heat treatment – 0	none	none	none	none	none	none
Heat treatment – 1	2h/140 °C	2h/140 °C	2h/140 °C	2h/140 °C	2h/140 °C	2h/140 °C
Heat treatment – 2	2h/200 °C	2h/200 °C	2h/200 °C	2h/200 °C	2h/200 °C	2h/200 °C

Table 2: Flowability (consolidation stress as a function of the compressive strength) of various sand mixtures with a 2-component liquid binder and as a function of the LB_A/LB_D ratio.

Composition	1	2	3	4	5	6
2-C Liquid Binder (wt%)	5	5	5	5	5	5
Comp. D (wt%)	0	20	40	60	80	100
Comp. A (wt%)	100	80	60	40	20	0
Additive (wt%)	2	2	2	2	2	2
Flowability – Consolidation stress (kPa) as function of the compressive strength						
0.60 kPa	0.45	0.39	0.38	0.42	0.42	0.40
1.13 kPa	0.63	0.58	0.56	0.56	0.57	0.56
2.19 kPa	0.84	0.80	0.73	0.71	0.72	0.72
4.35 kPa	1.11	1.02	0.92	0.86	0.87	0.89
8.70 kPa	1.37	1.33	1.14	1.03	1.06	1.08

Table 3: Water solubility of various sand cores with a 2-component liquid binder and as a function of the LB_A/LB_D ratio and without or with a heat treatment.

Composition	1	2	3	4	5	6
2-C Liquid Binder (wt%)	5	5	5	5	5	5
Comp. D (wt%)	0	20	40	60	80	100
Comp. A (wt%)	100	80	60	40	20	0
Additive (wt%)	2	2	2	2	2	2
Water-solubility in s						
As-received	5 – 10	5 – 10	5 – 10	10 – 15	20 – 25	20 – 30
2 h / 140 °C	20 – 30	10 – 15	15 – 25	5 – 10	20 – 30	20 – 25
2 h / 200 °C	weakening	weakening	weakening	50 – 60	30 – 40	30 – 40

needed in the castings are commonly defined by the use of disposable cores, which is typically an inorganic or organic resin-bonded sand core. Advantage of such a system is that due to the heat from the molten metal, the resin binder in the core starts to degrade resulting in an easy shaking out of the core residue. In die casting processes, such as Semi-Solid Casting [1-4] or High Pressure Die Casting (HPDC) [5-10], the metal is cooled very quickly, so the core itself will not be exposed anymore to high temperatures. Combined with the high core strengths needed to withstand these filling pressures, this results in difficulties to remove the sand core after the casting has solidified. Furthermore, the core will only be exposed for a short time to elevated temperatures up to 300 - 400 °C, which is insufficient to thermally decompose the binder.

This paper is focusing on the development of cores suitable for HPDC, consisting of a liquid polymer binder and a powder-like solid consisting of (various) minerals. This new and innovative WASCO water-soluble binder system is developed by Foseco.

Achieving high quality castings with the use of cores including the WASCO water-soluble binder system depends not only on the casting process itself and their processing parameters, but also on the quality of these cores. Use of cores with insufficient strength or with locally low compaction results in lower surface smoothness and can result in defects of the casting surface if not properly controlled. The main requirements to achieve high quality castings (from HPDC, Semi-solid processes) and received from the foundry industry are:

- High strength values
- Sufficient water solubility after the casting process
- No gas formation during the casting process
- Use of cost-effective and non-dangerous materials
- Easy to handle and able to be mixed with various types of sand
- Sufficient bench life of the sand mixture
- Good flowability of the sand mixture

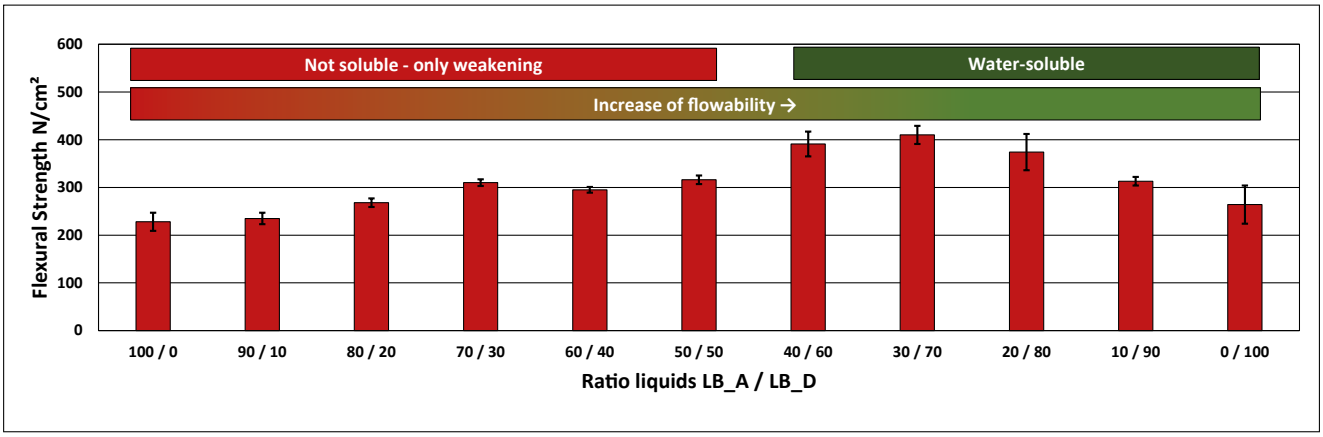


Fig. 1: Flexural strength of sand cores (quartz sand H33) as a function of the type of liquid binder with various ratio's LB_A/LB_D.

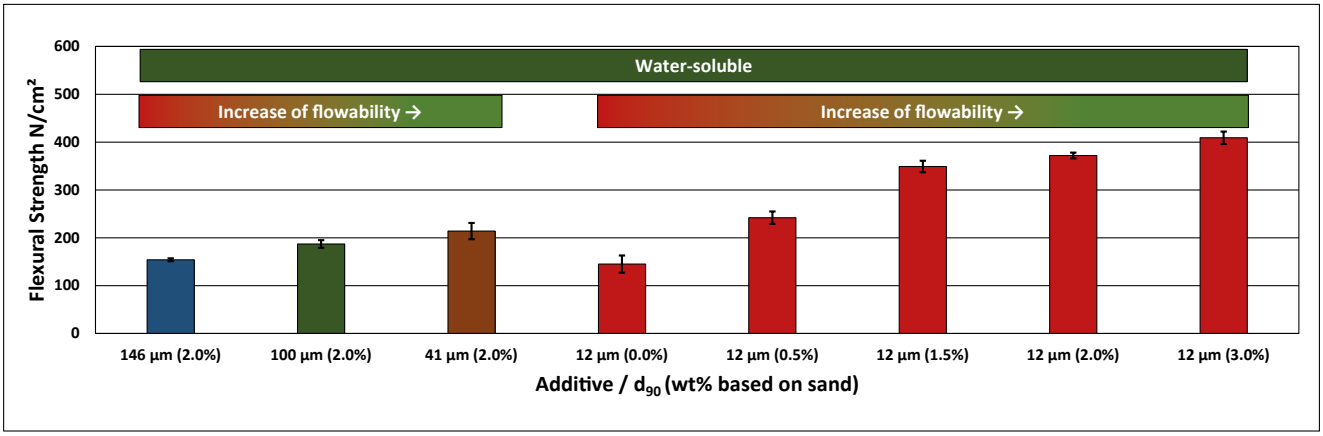


Fig. 2: Flexural strength of sand cores (quartz sand H33) as a function of the grain size of the additive. The LB_A/LB_D ratio was set at 30/70 (5.0 wt%) and the additive concentration at 2.0 wt%.

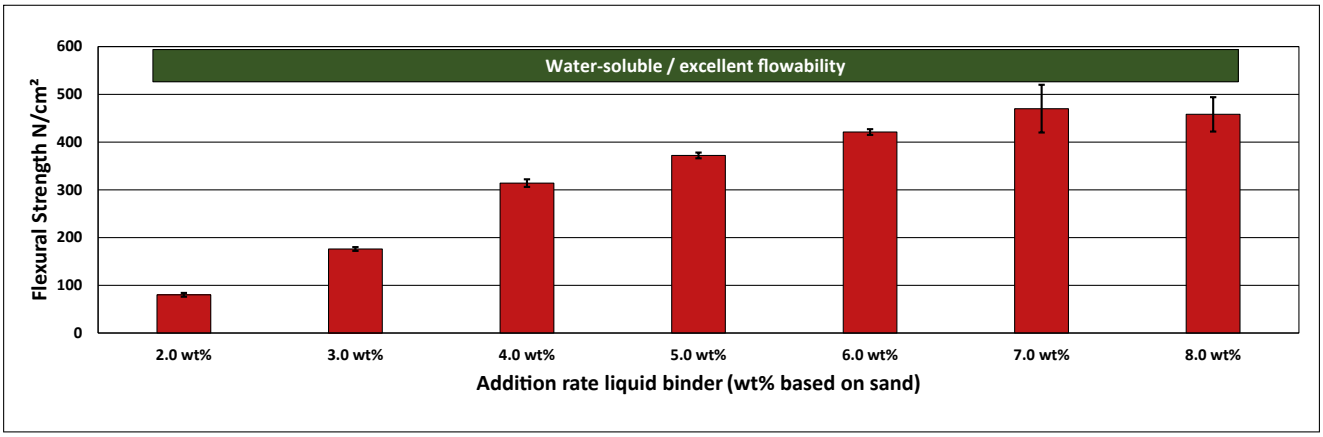


Fig. 3: Flexural strength of sand cores (quartz sand H33) as a function of the addition rate of the liquid binder. the LB_A/LB_D ratio was set at 30/70 and the additive concentration at 2.0 wt%.

> High quality cores with sufficient compaction and surface smoothness
> Short cycle times = short core production times

Some fundamentals are highlighted on the manufacturing of cores based on sand and optionally with the presence of a coating. In more detail, flowability of the sand mixture, mechanical strength, surface smoothness, water solubility of the binder, and first casting results from HPDC processes will be presented.

Experiments and results

First step in the optimization of sand cores for HPDC applications was based on a 2-component liquid binder system and one additive. In this part, the ratio between both components were tested on flowability of the sand mixture, flexural strength and water solubility of non-treated sand cores and those treated for 2 hours at 140 °C and 200 °C (Table 1). These testing conditions were chosen to find out the optimum ratio for best performance on strength and water solubility.

Using the Powder Flow Tester Brookfield [11], the flowability of the various batches was determined and listed in Table 2. It was clear that the higher the

contribution of component D, the higher the flowability; corresponding with the lowest consolidation stress.

Flexural strength was measured using standard-type transverse bars with dimensions of 22.4 x 22.4 x 180 mm. The flexure test (three-point measurement) measures the bending behavior of material subjected to simple beam loading. The flexural strength as a function of a 2-component liquid binder consisting of a liquid LB_A and a liquid LB_D is determined. The total addition rate of the liquid is kept constant at 5.0 wt%. Regarding the additive, a concentration of 2.0 wt% was chosen. All samples were manufactured with quartz sand H33 (Quarzwerke, Germany).

From **figure 1** it is obvious that the flexural strength showed a maximum for the ratio 30/70, thus with 30 wt% LB_A and 70 wt% LB_D. Considering the potential applications of such types of sand cores, these cores should also meet other requirements, in particular water-solubility.

Solubility of the binder was determined by immersing cylinder-type cores in cold (20 °C) or hot (65 °C) tap water and with a rotation speed of 60 rpm (in cold water) and 150 rpm (in hot water); the first one related to moderate conditions and the other to more severe conditions. The outcome of the immersion test is shown in **Table 3**.

Interesting to observe is that the as-received samples with the highest contribution of component A showed fast solubility, whereas those with a higher concentration of component D showed a slightly slower solubility rate. After the cores were exposed to heat for 2 h at 200 °C, those with a relatively high contribution of component A were not soluble, only weakening of the sand cores occurred. Since the application of these sand cores will be exposed to elevated temperatures during casting and cooling, those with the highest addition rate of component D is recommended.

In case of using these formulations for sand cores for HPDC high flexural strength is needed, this to avoid core breakage during the casting process. **Figure 2** shows the flexural strength as a function of the grain size of the additive and the concentration. In case of an addition rate of 2.0 wt%, highest flexural strength was achieved with a grain size of 12 µm. This strength decreased to lower values with an increase of the grain size from 41 µm, 100 µm to 146 µm. From this figure it is clear that the smaller the average grain size of additive as well as the higher the addition rate, the higher the flexural strength of the sand cores. During HPDC process the liquid metal is fed under high pressure into the die and solidified to obtain the desired component. This process takes place in a fraction of seconds. The general description is that cores with 1000 N/cm² or higher are targeted [6-10].

To improve further the mechanical properties, the flexural strength as a function of the addition rate of the liquid binder was investigated. **Figure 3** shows the data of the flexural strength and in relation to the amount of liquid binder added to the sand mixture. In this case the concentration of the additive was set at 2.0 wt%. Interesting to observe is that the strength values increased with a higher addition rate of the liquid binder up to 7.0 wt%. More binder did not result anymore in higher strength values, this due to a certain over-saturation. This means that the highest flexural strength values were achieved with a combination of the individual liquids LB_A and LB_D and with an addition rate of 7.0 wt%.

Higher flexural strength values will now only be achieved when more attention is paid on the type and concentration of the additive(s). Since the usage of the additive resulted in flexural strength values up to about 500 N/cm², different types of other minerals or components were considered too.

It is well-known [12,13] that in case of inorganic binder systems, other types of additives can achieve high strength values. Based on these documents, a selection was made of certain types of additives indicated as A – G. **Figure 4** shows the flexural strength as a function of these various types of additives. Based on these values, also another type of additive was chosen indicated as type S. With this additive strength values could be achieved up to values higher than 1200 N/cm², as shown in **figure 5**.

Since this type of additive, here type S showed very promising results, also flowability of the modified sand mixture has to be determined again. More information about measuring and improving flowability of sand mixtures can be found in reference [14]. The fastest indirect method to obtain information about flowability of the sand mixtures is related to the core or sample weight after curing. In relation to figure 5, showing the bending strength values as a function of the addition rate of type S, **figure 6** shows the corresponding sample weight as a function of the amount of type S added to the sand mixture. In case no additive was added, the sample weight was about 670 g (5 samples), but with an increase of the amount of the additive, the sample weight also increased up to values of around 740 g (with 6.0 wt%). Worth to mention is that the additive particles are completely spherical which induced higher flowability of the sand mixture. On the contrary, irregular shaped particles resulted generally in lower flowability. The type of sand can also be a parameter to affect flowability. The most important structural parameters influencing the flowability of the sand mixture are the average grain size and grain size distribution and the shape (angular or well-rounded and with low sphericity or high sphericity). Foundries generally will use the sand that is available from a local quarry near the production site, this to reduce transport costs. This means that flexibility in the type of sand is very limited which means that the type is generally a given parameter hardly to be replaced by another type of sand.

One main component of a sand mixture with a water-soluble binder system is the liquid part of the binder. As already reported, this liquid binder is a 2-component polymer system based on one liquid type LB_A and one on type LB_D and with addition of a small amount of water and with a special type of surface-active agent. In case the viscosity of the liquid binder is high, it will have a detrimental impact on flowability and therefore on the quality of the sand cores. With a water-based polymer solution, a lower viscosity can be achieved in case the chain length of the polymer is shorter, thus with a lower n-value. The viscosity of a polymer can be expressed by the Mark-Houwink equation:

$$\eta = K \cdot M\alpha \qquad (1)$$

whereas η = viscosity of the polymer, K and α depend on the specific polymer, and M = molecular weight.

2 types of the WASCO water-soluble binders were considered, one the standard-type and the other with a shorter chain length of the polymer. The viscosity of both WASCO water-soluble binder systems was measured between 10 °C and 40 °C and results are depicted in **figure 7**. From this plot, it can be concluded that between the above given

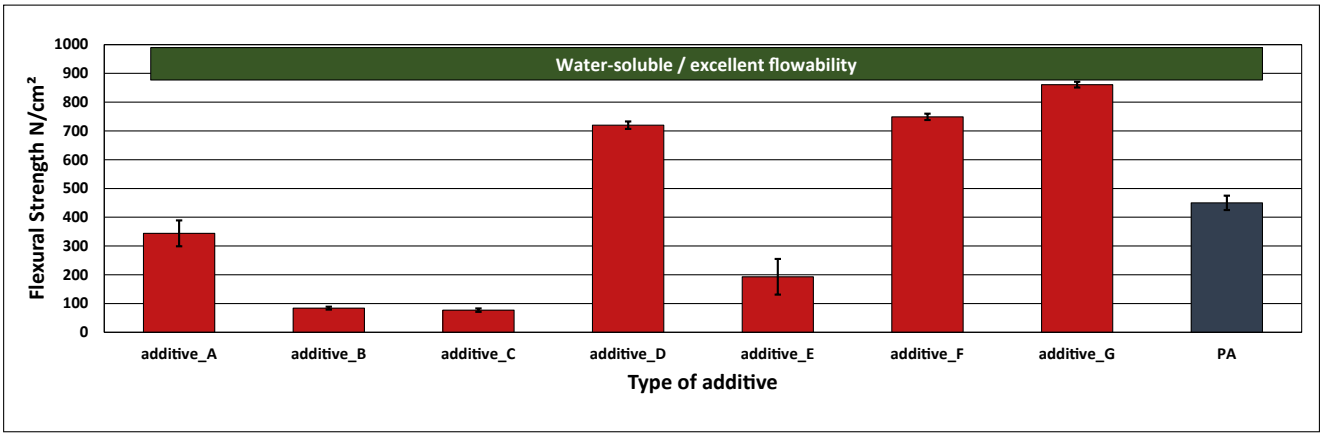


Fig. 4: Flexural strength of sand cores (quartz sand H33) as a function of the type of additive. The liquid binder LB_A/LB_D ratio was set at 30/70 and at 4.0 wt% and the additive concentration was 4.0 wt%.

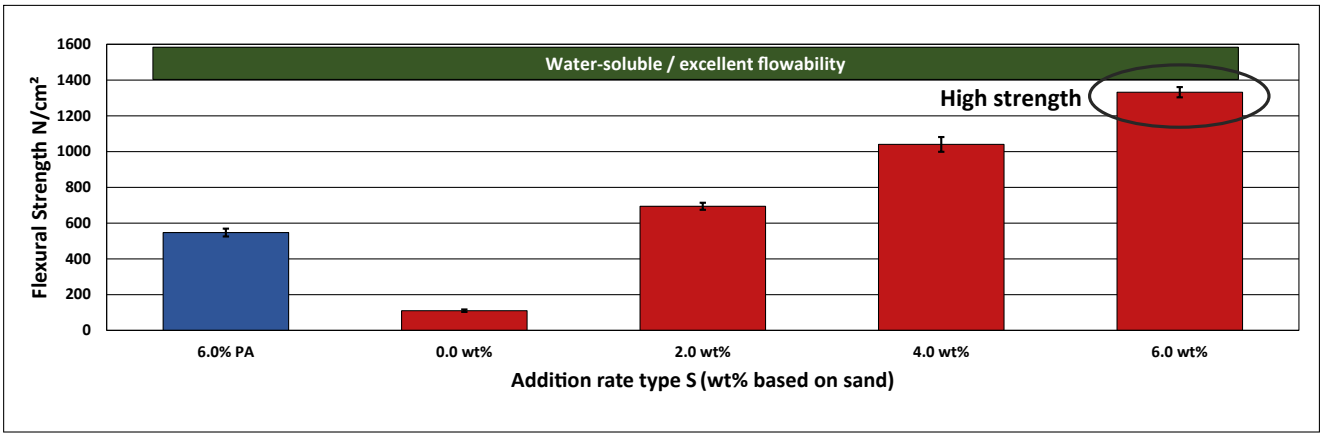


Fig. 5: Flexural strength of sand cores (quartz sand H33) as a function of the addition rate of the additive S. The liquid binder (6.0 wt%) LB_A/LB_D ratio was set at 30/70.

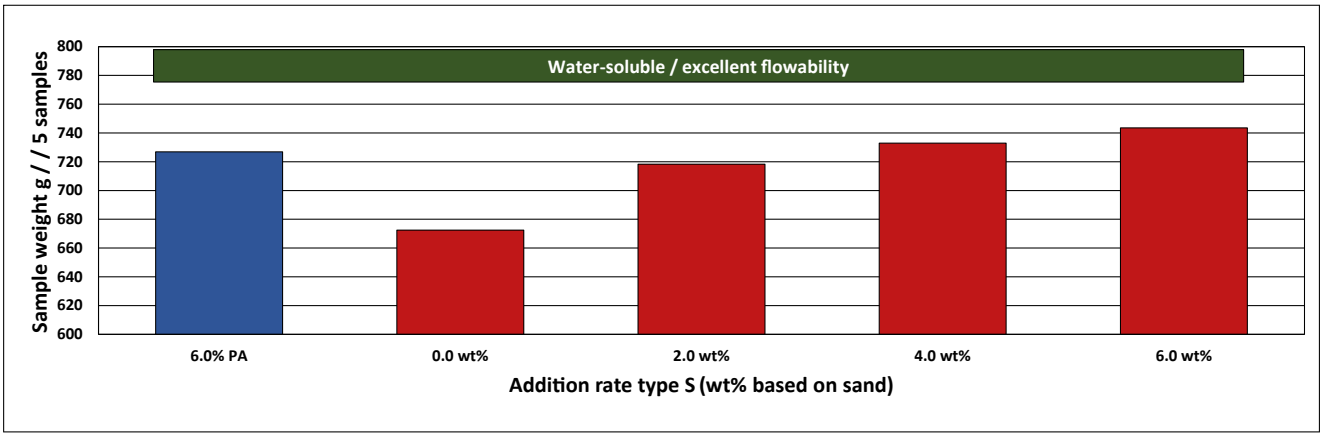


Fig. 6: Sample weight of sand cores (quartz sand H33) as a function of the addition rate of the additive S. The liquid binder (6.0 wt%) LB_A/LB_D ratio was set at 30/70.

temperature range, the viscosity of the modified WASCO water-soluble binder system is always significantly lower than that of the standard WASCO water-soluble binder system. Figure 8 shows the flowability curves, one corresponds with the reference sample prepared with the standard-type of organic-based water-soluble binder system (black curve), the second one with the modified organic binder including a shorter chain length (green curve), and the third with the standard cold box system. Clear is that the flowability of the sand mixture with the modified organic-based water-soluble binder is significantly higher.

The influence of the modified WASCO water-soluble binder system was further investigated with a series of core manufacturing, in this case transverse bars. The shooting parameters with the L1 Laempe core shooter were 4 bar shooting pressure and 0.4 s shooting time. The prepared sand mixture was first stored under various temperatures, here between 10 °C and 25 °C and with steps of 5 °C. Results from these tests are visualized in figure 9. With the standard WASCO water-soluble binder system and under relatively cold conditions, no complete sand cores could be produced. Due to the high vis-

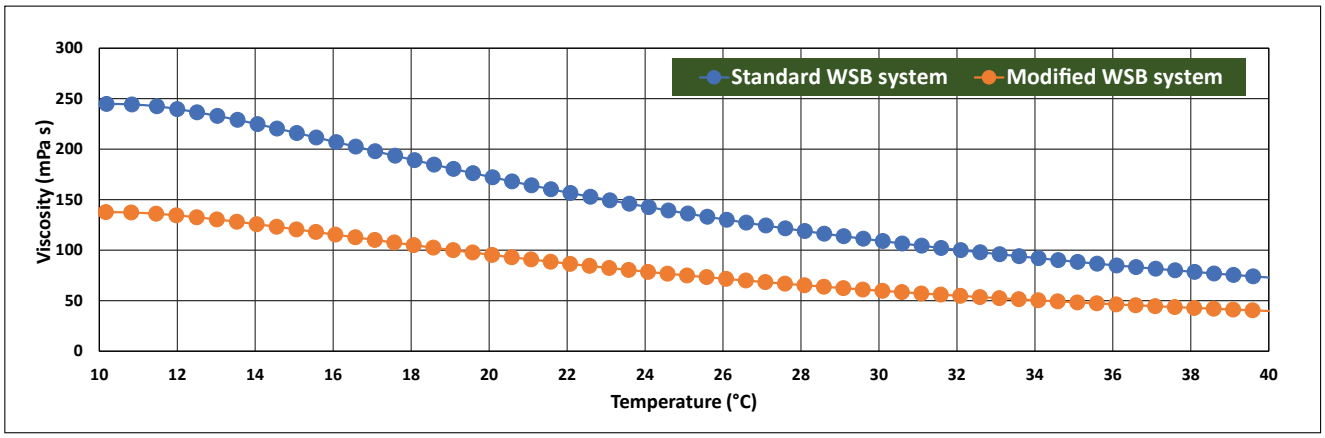


Fig. 7: Viscosity of the standard WASCO system (blue) and the modified WASCO system (orange) as a function of the temperature.

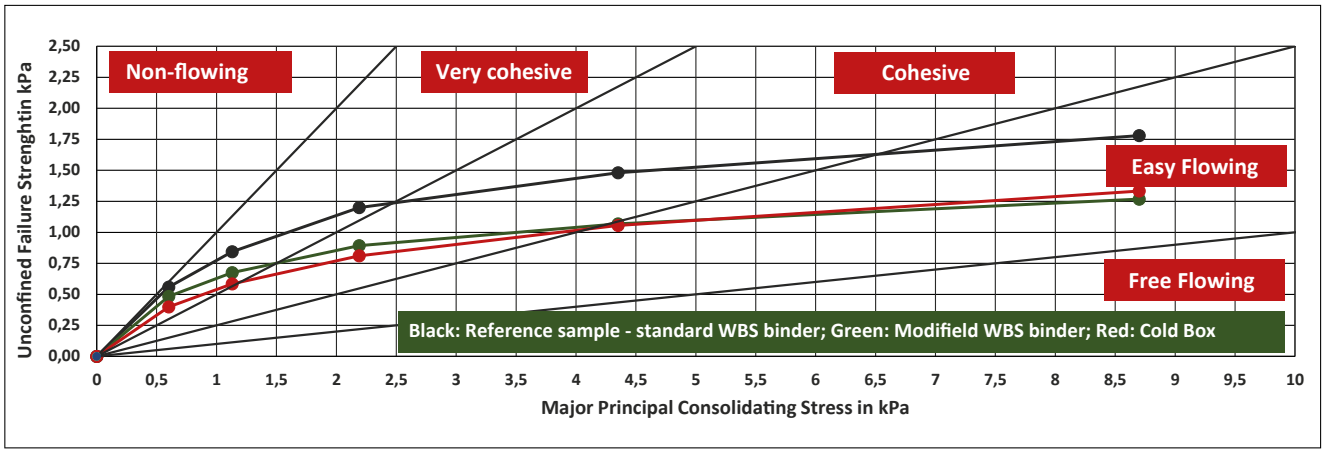


Fig. 8: Unconfined failure strength versus major principal consolidating stress for three various sand mixtures: black: standard-type of the WASCO water-soluble binder system; green: modified WASCO water-soluble binder system with shorter chain length; red: PU cold box system.

cosity of the liquid binder, in particular at 10 °C and 15 °C, flowability is too low to completely fill the cavities of the core box. Only at higher temperatures, here 20 °C or 25 °C, complete cores could be produced. In case of the modified WASCO water-soluble binder system, characterized by a significantly lower viscosity, even at 10 °C, complete sand cores could be produced, even at the lowest test temperature. Generally, a lower viscosity will result in defectfree sand cores with high compaction.

Trials on site

Housing components

This chapter is dealing with a project aiming to manufacture explosion-proof instrument housings. Figure 10 shows a schematic view of this housings with the designed sand core. First step in this was to start with a non-coated or unsealed sand core, this to investigate in more detail the surface quality of the castings.

After the casting process all castings were immersed in cold water. Within a very short time, all sand cores could easily be removed due to the high solubility of the binder.

Figure 11 shows the inner surface of the casting in case a non-coated sand core was used. The surface shows high roughness with severe sand adhesion, this due to metal penetration into the pores of the sand core. Even with a Kärcher pressure washer, the adhered sand grains could not be removed. To avoid metal penetration finally resulting in severe sand adhesion, a special type of waterborne coating was developed. Such a coating could be applied by the dipping process, followed by furnace drying at 120 °C. Figure 12 shows 3 sand cores with the waterborne coating, after dipping and after furnace drying at 120 °C for 1 h.

With the application of a coating to avoid metal penetration a smooth and sand-free casting surface was achieved. Figure 13 shows the final product fulfilling the following main requirements: good flowability of the sand mixture resulting in defect-free sand cores, high mechanical strength, easy to apply a waterborne coating, fast solubility of the binder after the casting process, smooth and sand-free casting surface.

Structural components

The second series of sand cores manufactured with the WASCO water-soluble binder system is dealing with an example of potential automotive applications for HPDC. In particular the production of light-weight hollow parts is key in this project.

As already mentioned, the presence of a coating is needed, this to avoid metal penetration and sand adhesion. Sand cores could be dipped or the coating could be applied by spraying. In both cases, a dense and compact coating layer was applied (see figure 14). After solidification, the castings were ejected from the mould and directly immersed in a water bath. All castings were collected followed by a further cleaning of the inner surface.

After cross sectioning the castings, it was obvious that the use of sand cores

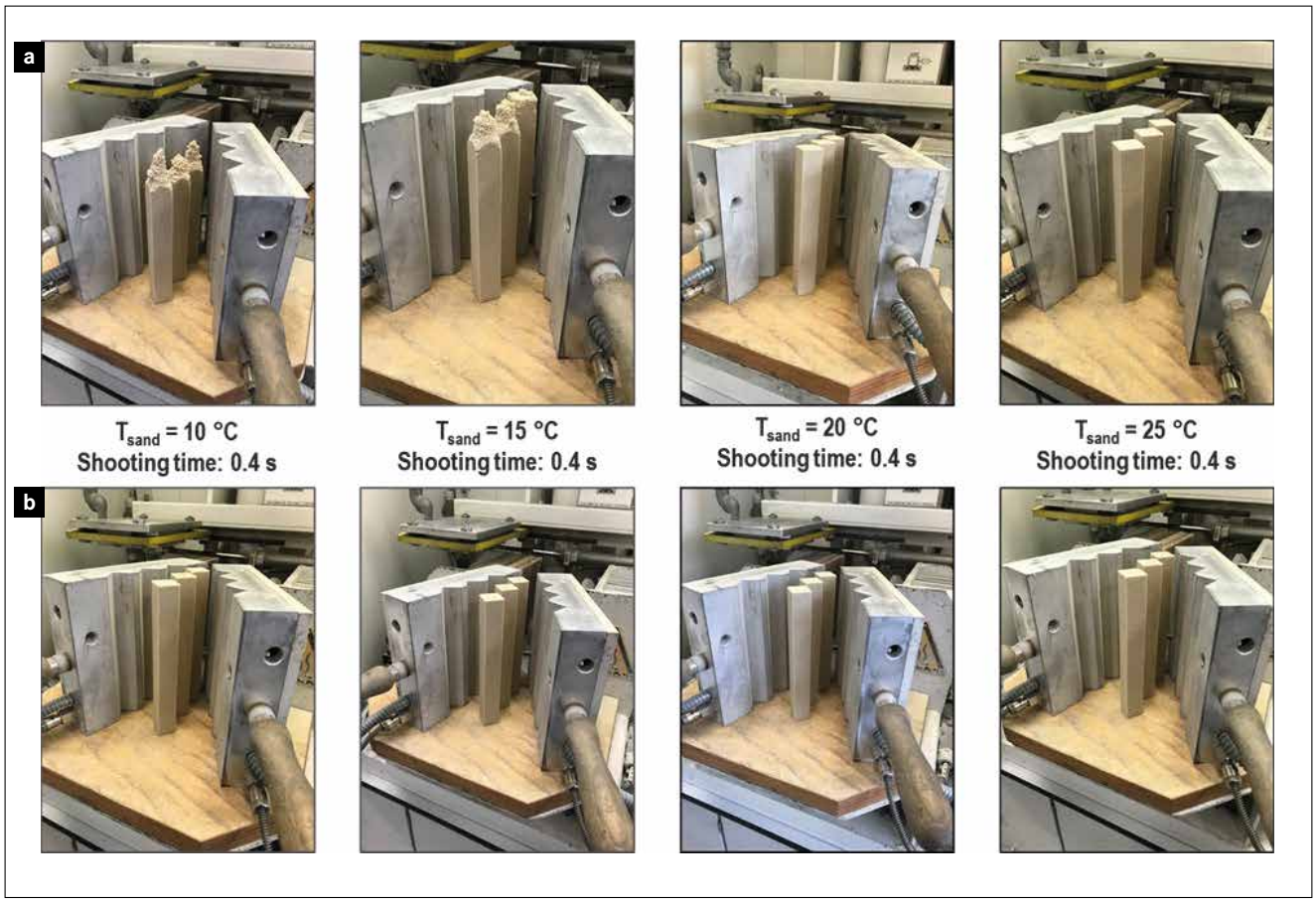


Fig. 9: Core manufacturing (transverse bars) with the standard-type WASCO water-soluble binder system (upper pictures) and with the modified WASCO water-soluble binder system (bottom pictures). In all cases, the shooting time was set at 0.4 s. The addition rate of the liquid binder was set at 6.0 wt% and of the additive at 4.0 wt%.

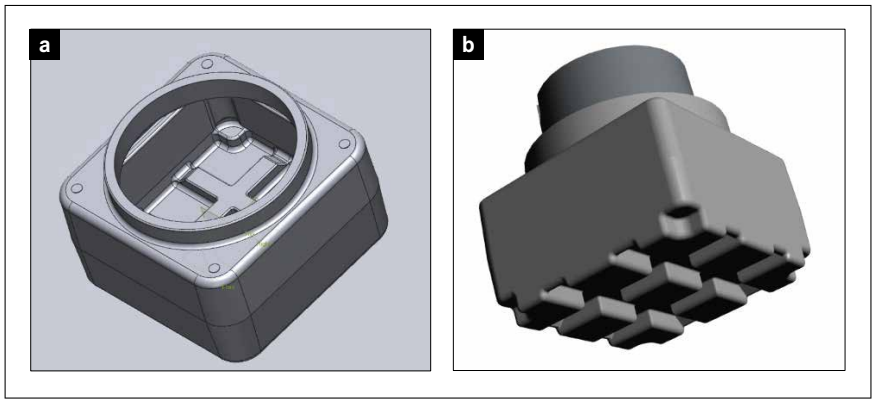


Fig. 10: left: schematic view of an explosion-proof instrument housings; right: drawing of the developed core (courtesy Limatherm S.A. Poland).

Fig. 11: Left: non-coated sand core; middle and right: inner casting surface with significant sand adhesion.

without a coating resulted in severe sand adhesion, as can be observed from figure 15.

With the presence of a coating, no sand adhesion occurred and the inner casting surface showed an acceptable surface quality (see fig. 16).

In some specific complex regions of the core surface, a secondary process using a Kärcher pressure jet wash enabled a completely sand-free casting surface.

Figure 16 shows the casting on the left and on the right part of the inner surface. Surface roughness of both casting pieces, non-coated and coated, was also determined by a 3D image of the surface, measured with the Keyence surface profilometer (fig. 17). Clear is the high smoothness of the surface in case a coated sand core was used.

Conclusions

The new and innovative WASCO water-soluble binder system developed by the Foseco has demonstrated their high strength in severe processing conditions, such as HPDC. With the use of an appropriate and compatible coating,

these innovative sand cores can withstand high pressures and temperatures whilst facilitating easy core removal from internal cavities by flushing water, leaving a smooth and sand-free surface.

This WASCO system demonstrated the strong potential and can meet a wide range of customer requirements, showing very promising results not only for liquid HPDC, but also for Semi-solid processes. Main advantages of the new WASCO system are:

> Strength values exceeding 1000 N/cm² are achievable
> Core residue is easy to remove and without use of mechanical force
> Use of cost-effective materials
> High flexibility in the use of additives
> Core manufacturing uses only standard hot box core
> shooters with hot air purge

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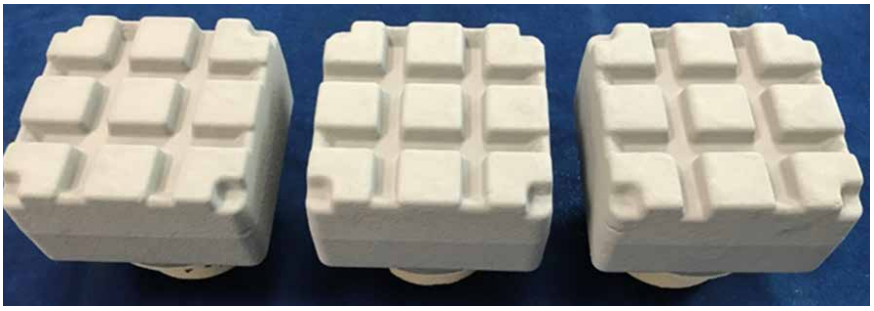

Fig. 12: Sand cores with a coating applied by dipping. The coating was furnace dried at 120 °C for 1 h.

Fig. 13: Inner surface of the casting (explosion-proof instrument housing) after removing the coated sand core. (courtesy Limatherm S.A. Poland).

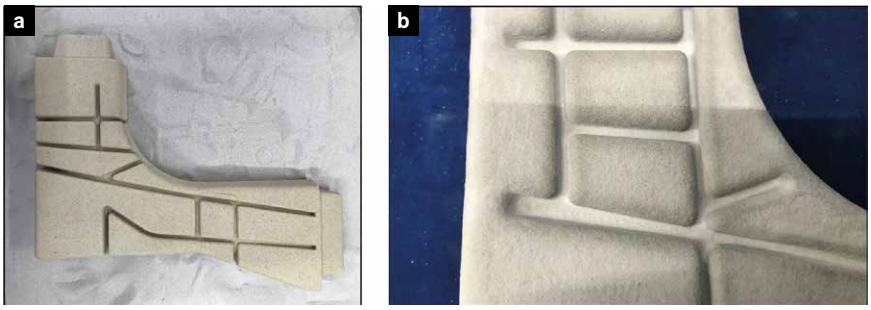

Fig. 14: Left: uncoated sand core; Right: higher magnification of the surface with an applied waterborne coating.

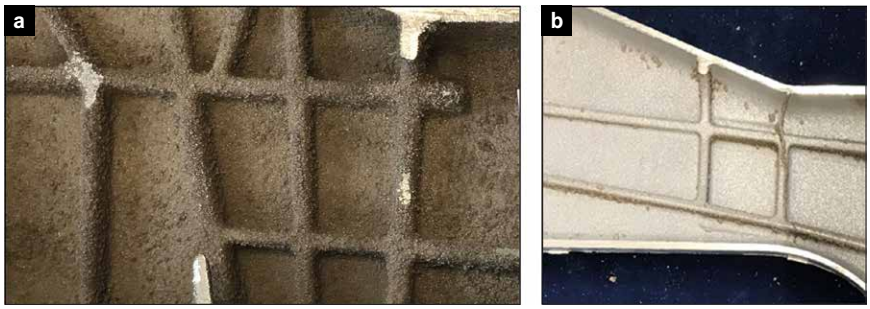

Fig. 15: Inner casting surface after cross sectioning of the castings. Left: after removing a non-coated sand core; right: after removing a coated sand core.

References

[1] Haga, T., Kapranos, P., Simple rheocasting processes, Journal of Materials Processing Technology 130-131, 2002, pp. 594-598.
[2] Bührig-Polaczek, A., Heiner, M., Bünck, M., Suitability of lost cores in rheocasting process, In Proceedings of the 11th International Conference on Semi-Solid Processing of Alloy and Composites : September 16 - 18, 2010, Beijing, China/S. J. Luo; W. C. Keung; Y. L. Kang.
[3] Winklhofer, J., Semi-Solid Casting of Aluminium from an Industrial Point of View, Solid State Phenomena 285, 2019, pp. 24-30.
[4] Payandeh, M., Rheocasting of aluminium alloys: Process and Components Characteristics, Dissertation 2016, Jönköping University, Jönköping, Sweden.
[5] Ming Fan Qi, Yong Lin Kang, Quan Quan Qiu, Industrialized Application of Rheo-HPDC Process for the Production of Large Thin-Walled Aluminum Alloy Parts, Solid State Phenomena 285, 2019, pp. 453-458.
[6] Jelinek, P., Adámková, E., Lost cores for high pressure die casting, Archives of Foundry Engineering, 14(2), 2014, pp. 101-104.
[7] Casarotto, F., Franke, A.J., Franke, R. - High-pressure die-cast (HPDC) aluminium alloys for automotive applications, Advanced Materials in Automotive Engineering, 2012, pp. 109-149.
[8] Jelínek, P., Adámková, E., Lost Cores

Fig. 16: Sand cores with a coating applied by dipping. The coating was furnace dried at 120 °C for 1 h.

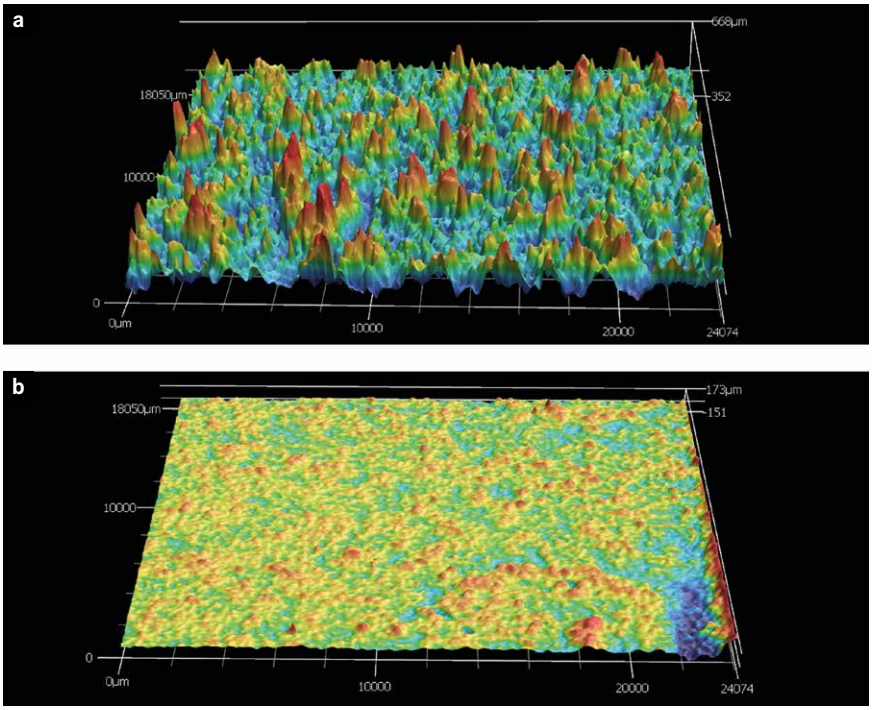

Fig. 17: Inner surface of the casting (explosion-proof instrument housing) after removing the coated sand core.

for High-Pressure Die Casting, Archives of Foundry Engineering DOI: 10.2478/afe-2014-0045, 14, 2014/2, pp. 101 – 104.
[9] Fuchs, B., Eibisch, H., Körner, C., Core Viability Simulation for Salt Core Technology in High-Pressure Die Casting, International Journal of Metalcasting, 7, 2013, pp. 39 – 45.
[10] Cantas, C., Baksan, B., Effects of Composition on the Physical Properties of Water-Soluble Salt Cores, International Journal of Metalcasting, 15, 2021, pp. 839 – 851.
[11] Schulze, D., Powders and Bulk Solids - Behavior, Characterization, Storage and Flow. Berlin, Heidelberg, Germany: Springer-Verlag; 2008. DOI: 10.1007/978-3-540-73768-1. Available from: https://www.dietmar-schulze.de/pdf/ flowproperties.pdf.
[12] Song, L., Liu, W., Xin, F., Li, Y., Effect of Silica Fume on Humidity Resistance of Sodium Silicate Binder for Core-making Process, International Journal of Metal Casting, 14, 2020, pp. 977 – 986. 2020, DOI:10.1007/s40962-019-00405-1.
[13] EP 2 359 957 A1, Method and composition for the preparation of foundry moulds and cores - European Patent Office, FOSECO INTERNATIONAL LIMITED, Central Park, Barlborough Links, Derbyshire S43 4XA (GB)).
[14] Haanappel, V., Methods to determine, influence and improve the flowability of sand mixtures, in Casting Processes, ed. T.R. Vijayaram, IntechOpen, United Kingdom, 2022, pp. 47-66. ISBN 978-1-80355-495-2.

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Permanent mold materials

Determining the main factors of fatigue and durability

The operating conditions, damage mechanisms and the requirements for the permanent mold materials used to manufacture cast rolls are described. The main reasons responsible for permanent mold damage, are the complex thermo-chemical processes in the permanent mold material caused by cyclic heating and cooling. These phenomena lead to thermal fatigue of the permanent mold material, which manifests itself in the formation of fire cracks on the inner surface of the permanent mold. The main factors determining the durability of permanent molds are the morphology, size, distribution, and amount of graphite precipitates, as well as the structure of the matrix.

BY VYACHESLAV GORYANY

1 Introduction

In this work the permanent molds used in the manufacture of cast rolls are considered. Due to a very high heat storage capacity, the permanent mold determines a faster heat dissipation from the roll barrel surface, in order to achieve a required wear-resistant microstructure in the working layer of the cast roll [1]. The rolls are used in various branches of industry such as metal forming technology, the plastics and rubber industry, paper and cardboard production, food industry etc. Their finished weight can range from 150 kg to 265 tons [2, 3]. Figure 1 shows a permanent mold for the casting of rolls, using the static casting process. A casting mold consists of several sections that are assembled in a casting pit. The total weight of a casting mold used to cast a roll with a gross weight of 50 tons can be around 150 tons and a height of 7,000 mm [4].

2 Conditions of use

The characteristics of permanent mold operation include a cyclical operation, which involves pouring the melt into the casting mold, heating the permanent mold and, afterwards cooling it down. From the start of casting until demolding, there is a continuous exchange of heat between the casting and the casting mold. The casting is continuously cooled, and the casting mold absorbs its heat and partially releases it into the environment. The heat storage coefficient (b) of the casting mold can be determine by the equation (1) [5]:

$$b = \sqrt{c \cdot \rho \cdot \lambda} \quad (1)$$

With: c = heat capacity, ρ = density, λ = thermal conductivity

The intensity of heat transfer depends on the geometrical, technological, physical, and other properties of the casting and the casting mold. The heating temperature of a permanent mold depends on the pouring temperature of the melt, which can be between 1320 °C and 1340 °C for cast iron and 1430-1460 °C for alloyed or 1520-1540 °C for unalloyed steel.

The mold filling is carried out in the rising way, starting from below. The lower permanent mold area therefor is in contact with the hot melt and heated for the entire filling time. As the permanent mold fills, the temperature of the poured melt is constantly lowered since the heat is dissipating from the melt through the inner wall of the mold. A rotating rise of the melt in the permanent mold is a further factor that leads to a sharp temperature drop of the melt. As a result, the upper areas of the permanent mold are exposed to a melt, which has a significantly lower temperature. In this regard, it is of great practical interest to experimentally study the temperatures of various zones of the permanent mold, which is constantly circulated by melts and heated under the action of a moving temperature field. Practical experience and the investigations [6, 7] carried out show that after the permanent mold has been filled, the highest heating temperature is reached in the lower area and in the middle of the permanent mold. In the case of the Infinite-Chill rolls with a diameter of 800 mm and a barrel length of 2,000 mm, the temperature gradient between the lower and the upper permanent mold area can exceed 100 °C [7]. At a temperature difference of 150-200 °C, a crack with a length of 1500 mm forms in the roll [7]. In the case of rolls with longer barrel lengths, the temperature differences can become even higher. With a filled permanent mold, however, there is a temperature difference in the melt not only in the longitudinal but also in the transverse direction. This can cause thermal stresses and cracks in the roll. After 3-5 hours from the start of shape contact from Infinite-Chill rolls (diameter 800 mm, barrel length 2000 mm), the highest temperature of about 500-525 °C was registered on the lower and middle outer permanent mold surface [6, 7]. The highest temperature on the top surface of the permanent mold was about 425-430 °C. The permanent mold wall thickness was 250-280 mm. The temperature of the permanent mold before casting was around 165 °C [6].

The lower the temperature of the permanent mold before casting, the quicker its surface heats up. After 3-5 hours, the temperature of the middle and lower parts of the permanent mold remained at the same level for an hour and then gradually decreased, while the temperature of the upper part of the permanent mold reached its maximum and remained the same for about one hour. After 7-8 hours the permanent mold cooled down in all three measured areas (lower, middle and upper), with the temperature gradually levelling off. After 70-80 hours, the permanent mold temperature was almost the same, only 1-2 °C higher in the middle and upper permanent mold areas [6].

The nature of the change in the temperature field is the determining factor in the formation of thermal stresses inspatial the permanent mold. The temporal and spatial temperature gradient is the most important parameter for characterizing the stresses occurring in the permanent mold. The strongest temperature gradient in the wall occurs immediately after casting [8]. With the heating of the working surface, the temperature gradient in the permanent mold wall increases, which reaches its maximum, just when the working surface reaches the contact temperature. It must be considered, that the permanent mold wall is heated unevenly, both in cross-section and in height. This leads to the appearance of an inhomogeneous stress field that changes with the temperature in the permanent mold wall and causes its elastic and plastic deformations. The thermally stressed-deformed state of the permanent mold largely determines its durability [9]. The magnitude of the resulting thermal stresses depends on the pouring temperature of the melt, the thickness of the permanent mold wall, the heating temperature of the permanent mold and the dimensions of the rolls. The larger the barrel diameter of a roll, the more time is required for solidification and cooling of the casting and subsequently, the longer the permanent mold is under the effect of the thermal stresses. For example, the cooling time of a steel roll with a gross weight of 290 tons (diameter 2,150 mm, body length 4,250 mm, total length 11,675 mm, finished weight 210 tons) is about three weeks [2].

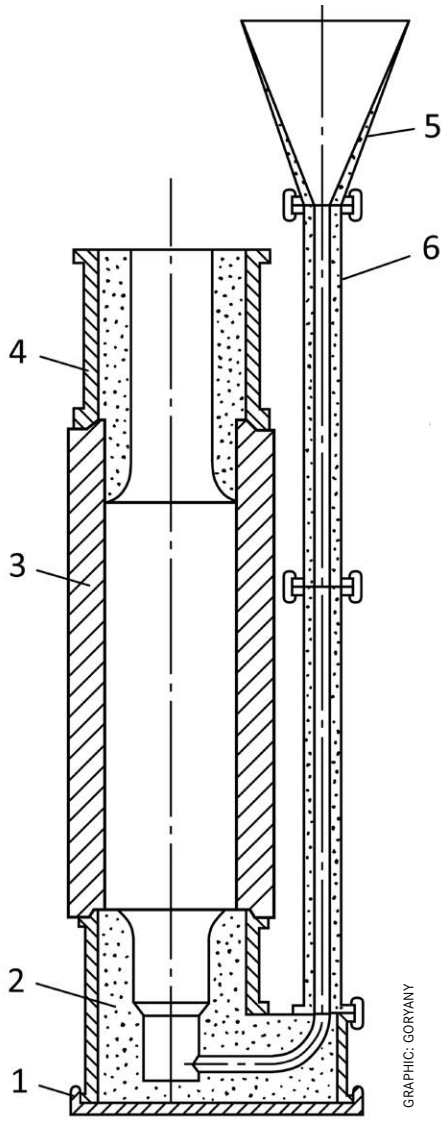

Figure 1: Casting mold for production of rolls: 1: bottom board; 2: form for bottom neck; 3: permanent mold; 4: form for top neck; 5: sprue cup; 6: sprue pipe.

With increasing temperature gradients in the working surface of the permanent mold, the compressive stresses only increase up to a certain limit. This limit is the boundary between the elastic and plastic states of cast iron. Further heating of the permanent mold (even if the temperature gradient in its wall does not decrease) leads to a decrease in compressive stresses due to the plastic deformation of cast iron. After the permanent mold has cooled down, internal tensile stresses appear in its plastically deformed layer.

The resistance of the permanent mold depends on its stress state and the frequency of thermal load cycles. The longer the permanent mold is in non-stationary mode during operation, the higher is the thermal load it is subjected to [10]. A cyclic change in the stress sign, as well as temporal and spatial temperature gradients, lead to the formation of residual stresses and consequently to fatigue of the permanent mold material, e. g. the formation of microcracks in the working layer, that grow with each further cycle and finally lead to the failure of the permanent mold.

The decisive impact on this type of damage have tensile stresses, which even have an effect when the mold is not in operation. The stresses on the inner surface can be calculated using the following equation (2) [9]:

$$\sigma = \frac{\alpha \cdot E}{1 - v} \lambda_{T_2} \left[\frac{3 + m}{6(1 + m)} - 1 \right] \quad (2)$$

With: α: coefficient of thermal expansion; E: Modulus of elasticity; v: Poisson's ratio; λT2: temperature gradient in the permanent mold wall; m = R_2/R_1 (R_1 inner and R_2 outer mold radius)

Determining the optimal permanent mold wall thicknesses is of great importance to achieve the required heat removal rate to ensure the optimal solidification rate of the casting and to increase the life of the permanent mold. Too thick permanent mold walls lower the heat dissipation from the casting, which impairs the formation of the desired microstructure in the working layer of the roll. Although thin-walled permanent molds have lower thermal stresses than thick-walled ones, they heat up more and can quickly fail due to fire cracking, growth, and corrosion. Therefore, the calculation of the wall thickness must take into account two interconnected causes of its damage: high-temperature heating of the working surfaces and cyclic exposure to thermal stresses. The thickness of a permanent mold (δ_K) depends on the diameter of the roll barrel (D_B) and the required technological allowance for regrinding (Δh) which is in the range of 80-120 mm, equation (3), [11]:

$$\delta_K = 0.18 D_B + \Delta h \quad (3)$$

3 Permanent molds materials

The lifetime of a permanent mold is up to thirty castings. The choice of the permanent mold material is based on the general principle of ensuring its maximum durability. The main reasons for permanent mold damage are complex thermo-chemical processes in the material caused by cyclic heating and cooling. The damage begins with the formation and growth of submicron cracks. With a further increase of cycles,

an increase in the number, size and opening angle of the cracks can be observed. Due to the cyclic temperature change, which leads to thermal fatigue, a network of fire cracks forms on the inner surface of the permanent mold.

The ability of a permanent mold to withstand thermal loads depends on the thermo-physical and mechanical properties of the material at the operating temperatures. Due to the specific loading conditions, the permanent mold materials must have high tensile strength (R_m) and thermal conductivity (λ), as well as low modulus of elasticity (E) and coefficient of thermal expansion (α). The possibility of relaxation of the resulting stresses due to the work of plastic deformation does not have to be excluded. The increased elongation of the alloy (δ) should be considered as a factor that reduces the likelihood of cracking. Therefore, the relation of the material's resistance to the formation of thermal fatigue cracks can be described by equation (4) [12]:

$$B = f\left(\frac{R_m \cdot \lambda \cdot \delta}{E \cdot \alpha}\right) \quad (4)$$

The required properties can be achieved by using nodular cast iron and lamellar graphite cast iron. The quality of the permanent mold and its durability is determined by the chemical composition and structure of cast iron, the cleanliness of the inner surface and the accuracy of machining [13]. The microstructure and phase composition are the main impact factors on the resistance of cast iron to thermal fatigue and corrosive effects at high temperatures. A strong matrix helps to slow down the process of crack development, therefore it is typical for permanent molds that 55-75 % of the total time of their operation is the period of increase in size and number of macro and micro cracks [14]. The pearlitic-ferritic matrix shows the highest resistance to thermal fatigue [15]. The presence of free cementite in the matrix is not allowed, because when heated, it will decompose with a change in volume. This obviously will create internal stresses in the permanent mold, which will contribute to a decrease in the resistance to fire cracking network formation.

A characteristic feature in the behavior of cast iron at high temperatures is its growth. This means an irreversible increase in volume that occurs at high temperatures and especially at cyclic temperature changes. Reasons for this are graphitization during heating and the release of dissolved carbon at new graphitization centers during cooling, as well as the penetration of oxygen into the interior of the casting, which leads to oxidation of the matrix, especially along the boundaries of graphite precipitates or along grain boundaries [16]. This leads to volume changes that generate compressive and tensile stresses that cause microcracks. Microcracks themselves increase the volume of cast iron and serve as additional channels for the oxidation of the matrix by aggressive gases. The internal oxidation of cast iron is going along with a significant increase in volume since the density of the produced oxides is lower than the density of the oxidized elements. The role of internal oxidation can be identified with a wedge expanding the metal matrix of cast iron. The phenomenon of cast iron growth also includes a sharp reduction of mechanical properties.

If the melt is in contact with the inner surface of the permanent mold, the heat dissipation in the direction of the outer surface will proportionally grow with the thermal conductivity of the mold material. The classic role of graphite in the basic structure of cast iron is to improve thermal conductivity, which leads to a reduction in temperature gradients and thermal stresses in the permanent mold and reduces fire cracking on the inner surface. Since graphite is a structural component with the lowest breaking strength (R_m = 3-20 MPa) and modulus of elasticity (E = 5000-15000 MPa) [17], its morphology, size, quantity, and distribution have a decisive impact on the damage rate and durability of permanent molds under thermal cycling. The thermal conductivity of cast iron primarily depends on the formation of graphite. In the case of lamellar graphite, the thermal conductivity increases with the quantity of graphite, although the basic structure still has a strong influence.

A negative effect of the lamellar graphite in the heterogeneous structure is the internal notch effect, which greatly impairs the strength properties of the cast iron. The weakening effect of graphite precipitates is more pronounced in cast iron with lamellar graphite than in cast iron with nodular graphite due to the larger ratio of the surface area of the lamellas to their volume [17].

If the morphology of the graphite precipitates remains constant and only their size or the distance between them decreases, the maximum stresses near the precipitates increase [18]. The large graphite precipitations will contribute to the intensification of the oxidation and growth processes in the surface layer of the permanent mold damage [16, 19, 20]. Due to the considerable length of the graphite lamellas, the destruction processes easily migrate from the surface deep into the metal. Gas filtration in the cast iron structure takes place along the graphite precipitations. Randomly arranged and interconnected graphite precipitates can form an infinite cluster with a through channel at a certain concentration [16, 18, 21]. The loss of tightness is already observed in the presence of a boundary channel in the structure of the casting, and with its increase, the power of the infinite cluster increases. Through the destruction of bridges in the matrix between the graphite precipitations, new through pores can develop [18, 21].

Nodular graphite formation counteracts the propagation of cracks and doubles the level of mechanical properties of cast iron. The decisive influence on the fracture-mechanical properties derives primarily from the graphite morphology and secondarily from the size and distribution. Due to the high plasticity (elongation) of ductile iron, the risk of penetration cracks is reduced and its lower disposition to grow helps to slow down the formation of a fire crack network. With ductile iron, there is no contact between its precipitates, which hinders deeper oxidation and erosion. At the same time, relatively large graphite nodules can contribute to the formation of deep cavities on the surface of the casting, which adversely affects the surface roughness and facilitates its erosion destruction [15].

The chemical composition, which determines the structure of the matrix, the amount and morphology of graphite, has a decisive influence on the resistance of cast iron to thermal fatigue and corrosion resistance. For the manufacture of permanent molds, it is recommended to use cast iron with a degree of saturation in the range of 0.97-1.05 without the silicon content exceeding 2 % [12, 22]. Silicon, which dissolves in ferrite, reduces the thermal conductivity of cast iron, and increases its brittleness. Practical experience proves the positive effect of manganese up to 0.75 % on the durability of permanent molds. Phosphorus and sulfur are undesirable

impurities, as their levels should be minimal. The typical permanent mold materials used in roll manufacture contain 3.1-3.4 % C, 1.4-1.6 % Si, 0.3-0.5 % Mn, ≤ 0.15 % P, ≤ 0.15 % S. The cast iron is inoculated (e. g. with 65 % FeSiBa) and poured into the casting mold at 1300 ± 10 °C. The matrix contains up to 35 % ferrite.

Permanent molds made of nodular graphite cast iron are characterized by a longer service life than gray iron (1.5-2 times) in the production of small and medium-sized castings. However, the durability of cast iron permanent molds with lamellar graphite for large castings (over 50 tons in weight) hardly differs from the durability of the same permanent molds made of nodular graphite cast iron [12]. To protect the permanent mold from the influence of the melt:

> prevent possible welding of the casting and the permanent mold,
> reduce thermal stress and thereby increase its durability,
> the permanent mold working surface is coated with a coating whose composition is suitable for a certain group of alloys.

The coating has a high thermal resistance compared to the permanent mold, so that a change in the thermophysical properties of the coating or the coating thickness leads to a significant change in the solidification rate of the casting and temperature gradients in the permanent mold [5, 23, 24]. The higher the thermal conductivity of the coating, the faster the permanent mold heats up and the higher are the temperature gradients that can develop in it. Increasing the thickness of the sizing contributes to slowing down the heat dissipation from the casting to the permanent mold. The temperature of the coating and the temperature of the melt are of secondary importance [20]. The thickness of the coating not only has a decisive influence on the solidification rate of the casting, but also on the temperature change in the permanent mold.

All types of local insulation or cooling of the surface of the roll barrel in the casting permanent mold, which can lead to uneven heat dissipation, play an important role. The presence of thermal nodes greatly increases the risk of cracking and permanent mold failure. A cavity in the permanent mold can also lead to local insulation and cracking in the rolls. The thickness of the coating not only has a significant influence on the solidification rate of the casting, but also on the temperature change of the permanent mold under the coating layer. Local insulation can be formed when the sizing collects in a crack on the inner surface of the mold, forming an insulated longitudinal strip. This leads to uneven heat dissipation from the roll surface. A local temperature increase leads to a decrease in the yield point and localization of deformations [9]. Practical experience shows that the use of permanent molds with mechanically or thermally damaged inner surfaces (e. g. deep scratches, fire cracks, etc.) can lead to the formation of casting defects such as hot or cold cracking in the roll barrel. Because of this, the inner surfaces of the permanent mold are constantly checked and, if necessary, mechanically processed (turned).

4 Conclusions

The main reasons for permanent mold damage are complex thermo-chemical processes in permanent mold material caused by cyclic heating and cooling. These phenomena lead to thermal fatigue of cast iron, which manifests itself in the formation of fire cracks on the inner surface of the permanent mold. The main factors that determine the durability of permanent molds are the morphology, distribution and amount of graphite precipitates, as well as the structure of the matrix. The graphite precipitations in the pearlitic-ferritic matrix enable the successful use of both nodular graphite cast iron and cast iron with lamellar graphite for permanent molds of various sizes.

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References:

[1] Giesserei 94 (2007), [No.7], pp.32-51.
[2] Giesserei 87 (2000), [No. 3], pp.103-104.
[3] Giesserei Praxis (2011), [No. 9], p.410.
[4] International Journal of Cast Metals Research 19 (2006), [No. 1], pp.66-71.
[5] News of Higher Educational Institutions. Ferrous Metallurgy 63 (2020), [No. 5], pp.327-334.
[6] Ferrous Metallurgy Bulletin (2002), [No. 6], pp.24-26.
[7] News of Higher Educational Institutions. Ferrous Metallurgy 66 (2003), [No. 1], pp.48-52.
[8] Scoular, T.; McPate W.A. Manufacture of Cast Steel Rolls. In: Rolls for the Metalworking Industries. R.B. Corbett (Ed.). A Publication of the Iron and Steel Society, Warrendale, PA, USA, (1990), pp.95-111.
[9] Foundry Production and Metallurgy (2004), [No. 2], pp.19-21.
[10] Foundry Production and Metallurgy (2007), [No. 2], pp.102-109.
[11] Krivosheyev, A.E.; Rudnitsky, L.S. Casting of cast iron rolls and shafts. In: Handbook of Iron Casting. 3rd Edition, N.G. Girshovich (Ed.), Mechanical Engineering, Leningrad, (1978).
[12] Mikhailov, A.M.; Bauman, B.V.; Blagov, B.N. etc. Foundry, 2nd Edition, Mechanical Engineering, Moscow, (1987).
[13] Budagyants, N.A.; Karssky, V.E. Cast rolling rolls. Metallurgy, Moscow, (1983).
[14] Foundry (1991), [No. 2], pp.15-17.
[15] Volchok, I.P. Fracture resistance of steel and cast iron. Metallurgy, Moscow, (1993).
[16] Baranov, A.A. Phase transformations and thermal cycling of metals. Scientific Thought, Kiev, (1974).
[17] Litovka, V.I.; Snezhko, A.A.; Yakovlev, A.P.; Voloshchenko, M.V.; Luzan, P.P. The cyclic viscosity of cast iron. Scientific Thought, Kiev, (1973).
[18] Casting processes (1996), [No. 3], pp.35-40.
[19] Mogilev, V.K.; Lev, O.I. Increasing the life of permanent molds and rolling mill rolls. Metallurgy, Moscow, (1986).
[20] Foundry Production and Metallurgy (2010), [No. 1-2], pp.88-94.
[21] Foundry (1997), [No. 2], pp.7-9.
[22] Casting Processes (2006), [No. 4], pp.71-77.
[23] Foundry Production and Metallurgy (2005), [No. 2], pp.52-56.
[24] Foundry Production and Metallurgy (2003), [No. 1], pp.92-93.

Scrap that is more organically contaminated is not yet optimally recyclable.

Decarbonization

Recycling of organically contaminated aluminum scrap

For melting down organically contaminated, mostly finely divided aluminum scrap, the current state of the art is to use conventional salt bath rotary drum furnaces as well as fossil-fired two-chamber hearth furnaces. The separation of pyrolysis and melting is advantageous in terms of process technology. In order to achieve the decarbonization targets, Otto Junker also suggests using crucible induction furnaces powered by green electricity as a melting unit. Compared to a hearth furnace, these also offer advantages in terms of metal loss.

By Daniel Rader, Wilfried Schmitz, Christof Dahmen, Peter Uerlichs, Tobias Mertens

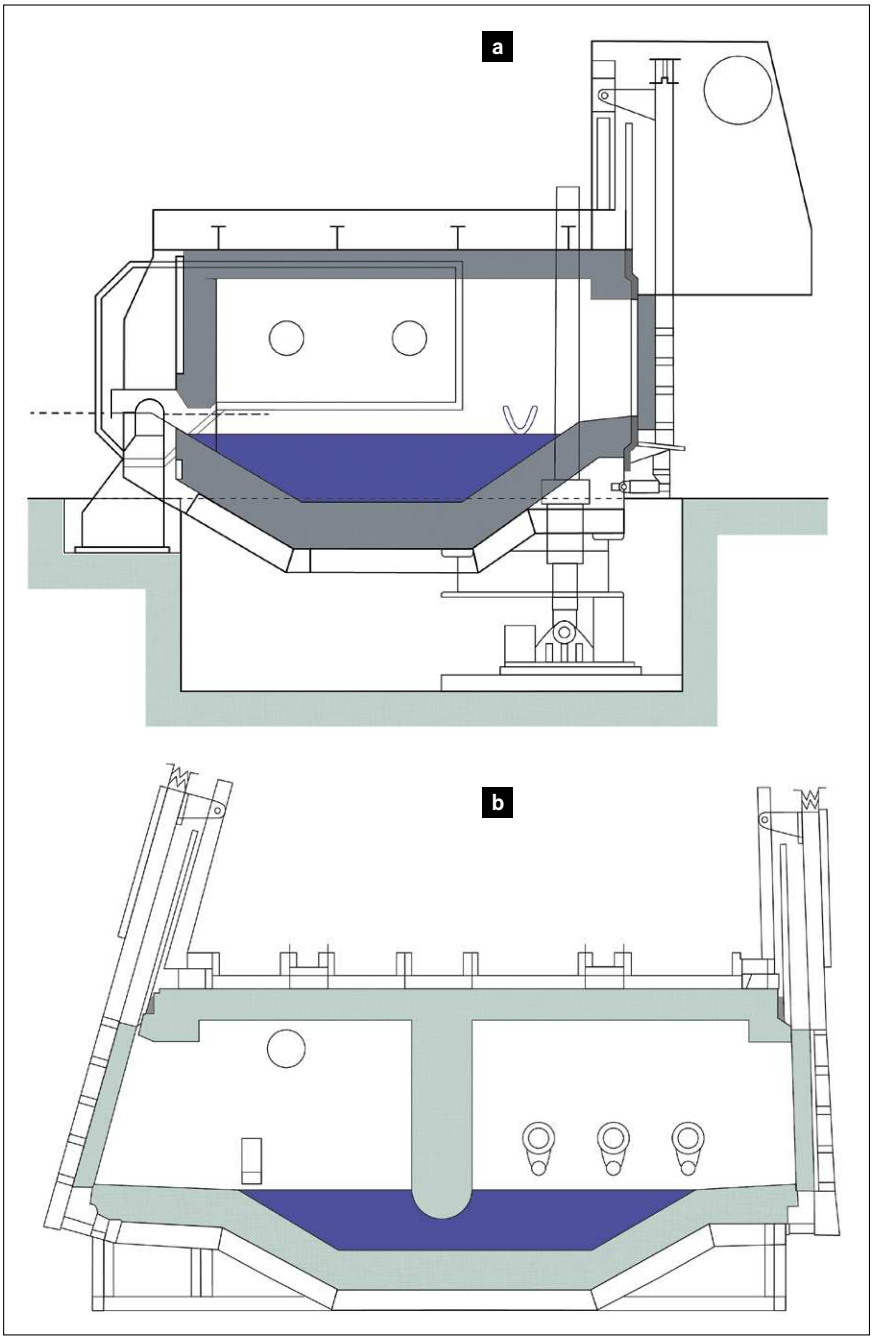
State of the art

In recent years, the global demand for aluminum and its production has risen steadily. 1.2 million tons of aluminum were produced in Germany in 2019, with approx. 53 % scrap being used in the process [3]. Products with a short lifespan (production waste, single-use products) account for a considerable proportion of scrap. A fundamental problem encountered when recycling (remelting) aluminum scrap is metal loss. Therefore, an increase in aluminum yield of 1 % through more efficient recycling processes corresponds to 10 million per year at a price of about 1,600/t for secondary aluminum production in Germany.

PHOTO: ADOBESTOCK

Table 1: Organic content of various types of scrap in % (according to [4]).

Scrap	Organic content in %	Scrap	Organic content in %
Painted sheet metal	3	Packaging foils	50-90
New litho plates	<4	ISO window profiles	21
UBC	4	Bottle caps	30
Conductor material	<20		



PHOTOS AND GRAPHICS: OTTO JUNKER

Fig. 1: a) Tiltable single chamber hearth furnace, b) Dual chamber hearth furnace.

Aluminum scrap is often contaminated with organic substances (paints, lubricants), see table 1. A method has yet to be found to effectively recycle scrap containing higher levels of organic contamination, such as used beverage cans (UBC), printed packaging foils or aluminum profiles with thermal insulation materials. Based on current knowledge, the direct introduction of such contaminated scrap into single-chamber melting furnaces (fig. 1a) results in an uncontrolled release of gaseous hydrocarbons combined with an insufficient utilization of the energy of such gas in the melting process as well as increased metal loss (dross formation). As a rule, using today's technology, organically contaminated scrap is melted down in a dual chamber melting furnace with volatile organics being released in the process, as shown in figure 1b.

The scrap, which is usually pressed into bales, is first conveyed to the bridge of the scrap chamber to be preheated and to gasify the adhering organic matter. Due to the throughput rate of the melting furnace, the scrap remains here for approx. 20 to 30 minutes and is exposed to hat flue gas during this period. As it heats up, part of the organic content is gasified at temperatures between 350 and 550 °C (near the surface and not in the core). Same of the resulting gases bum off already at the scrap surface, and same after transfer to the heating chamber. Thermal post-combustion of the exhaust gases is mandatory in order to avoid dioxins and similar pollutants.

The energy from the pyrolysis gases can be better utilized and metal losses reduced by optimizing the pretreatment, which is accomplished by decoupling the processes into ‚thermal pretreatment' and ‚melting'. This approach calls for integrated energy management for both process units. Besides the positive impact on material efficiency (yield) as well as on process stability, a further advantage is that a separate process unit for thermal pretreatment can be arranged upstream of today's single-chamber furnaces, which means that the operators of such plants can also process low-grade organically-contaminated scrap.

One problem in recycling aluminum scrap is the adherence of organic, i.e. carbonaceous, materials. If this organically contaminated scrap is melted down without pretreatment, the organic material will thermally decompose in the molten bath and the aluminum, which has an affinity for oxygen, will react with the escaping species of pyrolysis gas. In such cases, the aluminum melt acts as a catalyst to a certain extent during the decomposition of species in the gas phase [5].

Furthermore, less CO_2 is emitted, causing the aluminum to oxidize, and thus reducing the yield. To avoid these undesirable metal losses, the scrap is thermally pre-treated before the actual melting process. When exposed to heat, the organic compounds decompose to form combustible gaseous hydrocarbons, liquid tar, and a solid carbon resi-

due on the aluminum. In the case of contaminated aluminum scrap, the process takes place at temperatures above 350 °C but below the melting point.

The most common melting concepts for producing secondary aluminum are to melt down lightly-contaminated scrap in a hearthtype melting furnace and to melt down thin walled and heavily-contaminated scrap in a rotary drum furnace with the addition of salt. To melt finely divided scrap, such as chips, induction furnaces are particularly suitable. The problem with in-situ ‚pyrolysis' of the scrap in the furnace chamber is the uncontrolled release of hydrocarbons. Therefore, to ensure the efficient combustion of these uncontrolled released hydrocarbons, a high excess air factor is required (too much air, lower efficiency) as well as measurement of the O_2 content in the flue gas duct so that the supplementary air supply can be corrected accordingly (using slow control action).

As already mentioned, one concept for processing scrap contaminated with up to 5 wt% adhering organic material is to melt it in a dual chamber furnace. This modified chamber furnace consists of a scrap chamber and a heating chamber separated by a wall. The scrap, which is usually pressed into bales, is first conveyed to the bridge of the scrap chamber to be preheated and to gasify the adhering organic components, as mentioned above. However, the short dwell time on the charging bridge is not sufficient to heat the bales right to the core. The bales of scrap, still partially contaminated with organic matter, are pushed from the bridge by the newly charged bales into the melting bath, where they start to melt (melting time approx. 2 h). In doing so, the residual organic matter remaining in the core of the bales is decomposed and pyrolysis gases are released in an uncontrolled manner. This in particular leads to higher dross quantities (poorer yield).

The bumer in the scrap chamber is operated at a slightly substoichiometric level; this is to prevent the escaping pyrolysis gases from being burned off directly by the oxygen introduced during charging. The main problem with this furnace design is the limitation that, at most, scrap with 5 % contamination can be processed and that the melting capacity is strictly limited by the amount of organically contaminated scrap that can be charged per unit of time. With a separate thermal pretreatment of the material, there is no such limitation on the melting capacity in the chamber furnace. This also makes it easier to process the growing volumes of scrap with an organic content of >5 %.

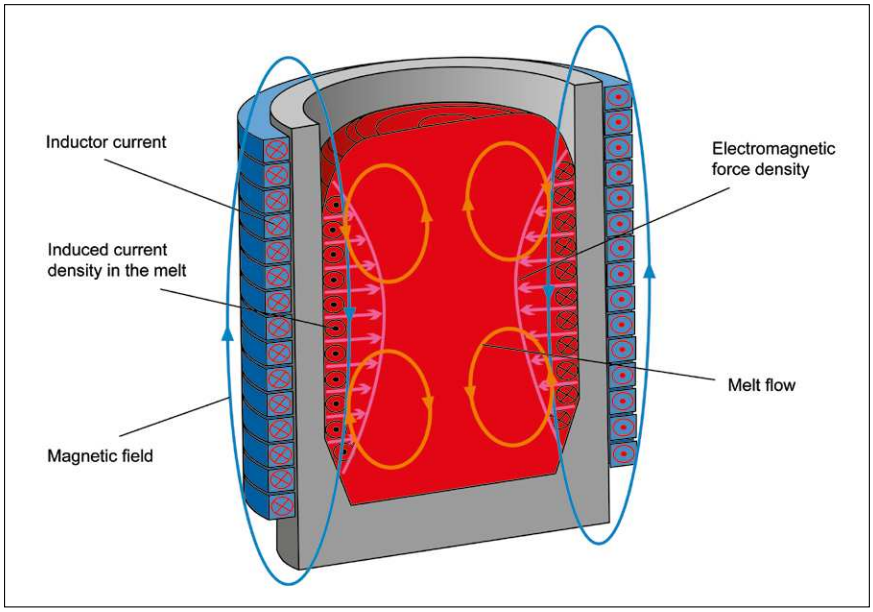


Fig. 2: Bath movement in a coreless induction furnace.

A reduction in metal losses through optimized pretreatment can be achieved by decoupling the thermal pretreatment and the melting process. Besides the positive effects on material efficiency (yield) and process stability, there is also the advantage that a separate process unit for thermal pretreatment can be arranged upstream of any of today's single-chamber melting furnaces in operation. A dedicated process unit can minimize production losses and thus offers cost-saving optimization potential.

For the thermal pretreatment, which is completely separate from the melting process, a rotating, slightly inclined rotary furnace is used. In this way, types of scrap with a high organic content of up to 10 % can be processed. The material is heated by the circulating flow of hot gas. The gas used to heat the material can flow co-current or counter-current to material flow. The temperature in the furnace is 500-550 °C and the oxygen content is 1-5 %, whereby the volatile components are removed and the remaining carbon is incinerated. The pyrolysis gases released are subsequently burned either in a connected post-combustion chamber or in the melting chamber itself, and the hat exhaust gas is fed into the rotary furnace to heat the scrap. The scrap, which is now free of organic material, is then transferred to the melting furnace while still hot.

Besides ensuring a higher metal yield, a separate gasification step prior to the actual melting process has the advantage of reducing or excluding the introduction of possible impurities into the melt, as the organic content can be effectively removed from the scrap.

Greenhouse gases and melting with electricity

At present, secondary aluminum is almost exclusively produced using melting and holding furnaces as well as rotary salt bath furnaces which are fired by fossil fuels, mostly natural gas. On average, about 300-500 kg of CO_2 are generated per ton of secondary aluminum produced from scrap (without addition of primary aluminum) [1]. The combustion of fossil fuels accounts for a large proportion of this CO_2 generation. It should be noted that the data from a large number of older plants with suboptimal efficiency are also included here. The quality of the scrap and the mode of operation also play a role. However, it is obvious that this situation must change fundamentally in order to achieve the climate targets set by governments. This is only possible if the consumption of fossil fuels and thus of natural gas is drastically reduced, a need reinforced by the Ukraine crisis existing at the time this paper was written. A seemingly simple way would be to replace the natural gas burners deployed for the furnaces by hydrogen burners, with the necessary hydrogen being produced on site from ‚green'

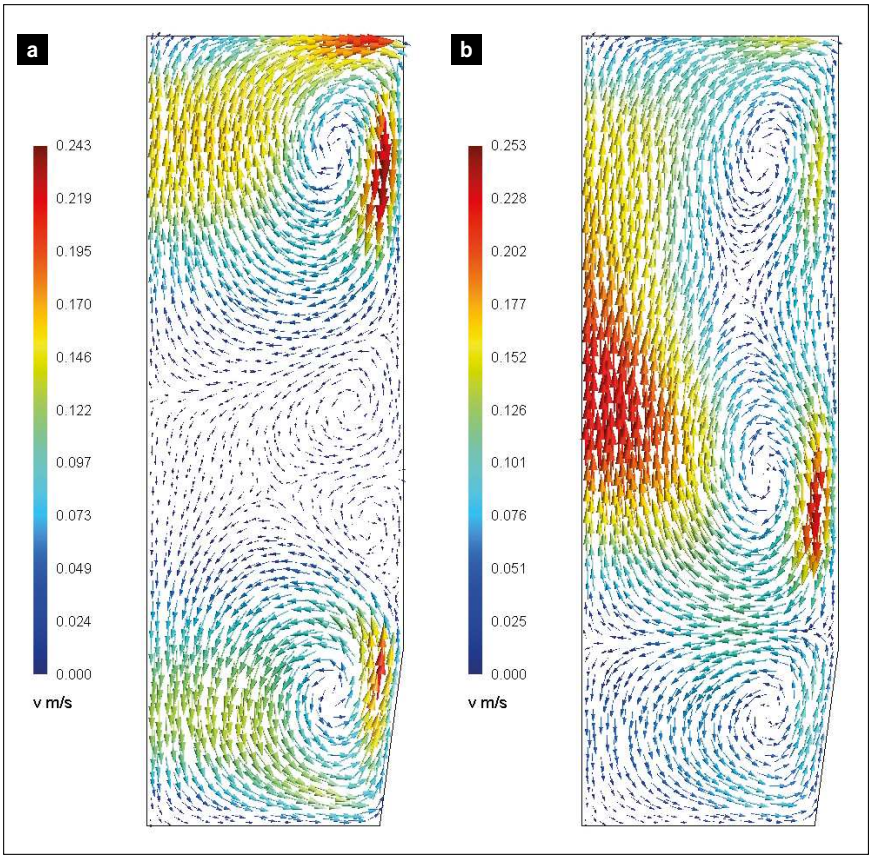


Fig. 3: Bath movement with phase-shifted operation of coil sections; 0° phase shift on left and 60° on right.

electrical energy. However, given the poor efficiency of hydrogen production, it seems to make more sense to use this green electrical energy directly for the melting process. In view of the specific melting rates in question here, only the coreless induction furnace or variations thereof are suitable. Furthermore, the coreless furnace has a number of additional advantages when it comes to melting scrap, especially finely divided.

Principle and characteristics of coreless induction furnace

One key feature of the coreless induction furnace, distinguishing it fundamentally from all other melting sources, is the movement of the metal bath created by electromagnetic forces. This is illustrated in same detail in fig. 2, which depicts the current-carrying water-cooled induction coil and symbolically indicates the direction of the current flow. It also shows the refractory crucible which contains the melt and is placed inside the coil. The inductor current produces a magnetic field which in turn induces ring currents in the molten metal. It should be noted here that the current density is highest, due to the skin effect, in the rim zone of the melt directly adjoining the crucible wall.

Because the currents are short-circuited, Joulean heat is generated in the melt, mainly in the boundary layer dose to the crucible wall. In addition, these currents – extending in a direction opposed to that of the inductor current – produce a secondary magnetic field. Due to this effect, the coil exerts repelling forces on the melt. With a coil of infinite length, the magnitude of these forces would be the same at all places aver the coil height. In a finite coil as encountered in practice, the electromagnetic force density is variable aver the height of the coil (fig. 2). Hence, melt volumes situated at the center of the coil encounter a more intense repellent force and hence, are accelerated more strongly in the direction of the coil axis than melt regions located near the edge of the coil.

One consequence of this Situation is that a flow pattern resembling two rotational toroids will form in the melt. In a high-power furnace, the local flow velocity may amount to as much as 1-2 m/s. Moreover, a so-called bath meniscus will form at the surface of the melt due to the equilibrium between the repelling electromagnetic force and the force resulting from the metallostatic pressure.

The intensity of this bath movement firstly depends on the furnace power; the higher the power input, the more vigorous the bath movement will be. In addition, the melt flow intensity varies with the frequency of the a.c. current feeding the coil: the lower this frequency, the more vigorous the bath movement. It follows, first of all, that for a given fixed frequency the heat input into the melt and the intensity of the bath movement are always correlated. Furthermore, bath movement intensity can be selectively controlled at a given required furnace output by selecting the proper operating frequency.

Finally, at a given power and frequency, the intensity of the bath movement depends on the furnace filling level; and this is particularly true for the melt flow in the bath surface region. The higher the filling level at a given power and frequency, the less vigorous will be the bath movement.

In the above considerations we have assumed laminar flow conditions for reasons of descriptive simplicity. In reality, however, a substantial turbulent flow portion will be superimposed over the laminar flow. This will be the more pronounced the lower the furnace's operating frequency.

Bath movement is very important from a technological viewpoint since it facilitates optimum melt homogenization and stir-down of constituents and thus ensures a uniform melt composition and temperature at the same time. Also, without this forced convection, the coreless induction furnace simply wouldn't work because most of the heat input takes place via a boundary layer situated dose to the crucible, as explained earlier. If there were no bath movement to distribute this heat to the entire charge, strong overheating of the melt dose to the furnace wall would inevitably occur within a very short time, causing a failure of the refractory lining.

Finally, it is important to remember that for induction furnaces which are operated at a fixed nominal frequency, which is the majority of furnaces so far, heat input into the melt and the intensity of bath movement are always correlated.

From a metallurgical viewpoint, the ideal induction melting process is one in which both the input of thermal power and the melt flow can be controlled to match given technological needs. Therefore, it is desirable to decouple

heat power input and bath movement from each other, i.e., the desired melt movement in the furnace should be adjustable independently of the respective heat input. While controlling electrical power – and hence, the input of thermal energy into the melt – poses no major problem to the furnace engineer, it takes very special circuit technology to control the melt movement independently of the power input.

To achieve this objective, Otto Junker had initially developed the special circuit variants known as Power Focus Technology and Multi-Frequency Technology, both of which have been successfully deployed in a large number of furnace systems.

Power Focus Technology permits an automatic or freely selectable concentration of power in the coil region where it is most needed (i. e., the upper or lower section of the coil). Thus, on a half-filled furnace, the power input can be focused in the lower crucible area to make more energy available there. On the other hand, when the furnace is filled to capacity, the operator can raise the power input in the upper coil section to agitate the bath more intensely and thus improve stir-down, e.g., of metal chips.

Multi-Frequency Technology provides a means of changing the operating frequency either manually or automatically during the melting process. With cast iron, for instance, a suitable frequency of 250 Hz is used for melting down the charge materials. A lower frequency – e.g., 125 Hz – is then selected for introduction of the carburizing agents and alloying additives. Practice has shown that this changeover to a reduced frequency can greatly accelerate the carbon pick-up in cast iron analysis adjustment. At the same time, melting loss of carburizing agent is reduced.

It should be noted here that these two circuit technologies can also be combined for even greater effect. This approach has proven its merits, e. g., in melting furnaces used for the recycling of aluminum chips, which are always molten with a liquid heel. Here, on the one hand, the filling-level-related surface bath movement must be reduced as far as possible in order to minimize oxidation and melting loss, while on the other hand it must always remain sufficient to ensure a rapid stir-down of the chip material. This is achieved via an automatic use of Power Focus and Multi-Frequency Technology functions.

Fig. 4: Rotary furnace – pilot System at Otto Junker GmbH.

These options are substantially expanded by the newest developments relying on the special technical advantages of IGBT converter technology: Apart from proven thyristor-based frequency converters, the successful development of special IGET Converter technology has gained increasing importance in electrothermal processes. These systems involve the use of Insulated Gate Bipolar Transistors (IGBTs) instead of thyristors in the inverter.

A special design of the IGBT Converter with two separate inverters and a system providing n phase-shifted power supply to two furnace coil sections creates the technical prerequisites for an even broader control of the bath movement. In the charge melt-down phase a furnace can thus be operated at an appropriate nominal frequency of, e.g., 250 Hz, and to increase the bath agitation at low power the frequency can be controlled steplessly below 100 Hz. The amount of phase offset between the two coil sections is likewise adjustable to provide a more selective control of the flow pattern (i. e., direction of rotation and velocity), as illustrated in figure 3. In this example, illustrating a 0° offset vs. a +60° offset, the second offset section permits the region of maximum flow velocity to be moved to the center of the molten metal bath to obtain more effective intermixing of the entire melt. In addition, the turbulent portion of the melt flow is increased substantially with this circuit technology, especially at low frequencies, so that the mixing effect can be maximized with minimum heat input.

The technical options available for influencing bath movement in a coreless induction furnace can be implemented and combined in manifold ways to address specific metallurgical tasks. The decisive factor is that the development of said circuit technologies (stepless frequency variation, phase shift) has made it possible for the first time to largely decouple heat input from the intensity and pattern of bath movement.

Coreless induction furnace combined with rotary furnace for recycling of aluminum scrap contaminated with organic materials with lower CO_2 emissions

Provided that the coreless induction furnace used for melting is powered with electricity from renewable sources, no greenhouse gases are generated by the melting process. As described above, the stirring properties of the furnace guarantee minimal metal loss, thus further improving the eco-balance. This presupposes that the scrap is free of organic materials and has therefore been treated beforehand by pyrolysis or thermolysis. In addition to the induction furnace, Otto Junker can also provide the necessary rotary furnace technology. A corresponding pilot plant, specially designed for treating organically contaminated aluminum scrap, was developed, designed and erected at Otto Junker (fig. 4). In the future, it will mainly be used to study the properties of specific types of scrap in cooperation with customers in order to determine the parameters and design

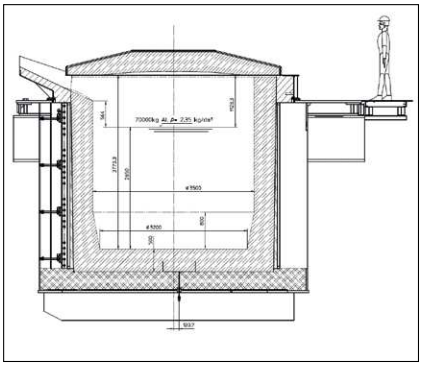


Fig. 5: **Concept study for a coreless induction furnace for aluminum with a capacity of 70 tons.**

data for appropriately upscaled production plants.

If this rotary furnace is fired with natural gas, the following CO_2 balance compared with the state of the art (dual chamber furnace fired by fossil fuels) is achieved:

> Conventional technology: natural gas-fired dual chamber furnace, only the quantity of CO_2 generated by the combustion gases is considered [2]
> With external thermal incineration: approx. 750 kWh/t, equating to 150 kg CO_2/t
> With internal thermal incineration: approx. 580 kWh/t, equating to 116 kg CO_2/t

These figures apply to furnaces of the latest design operated under optimum conditions using high-quality scrap, see section ‚greenhouse gases and melting with electricity'.

> Natural gas-fired rotary furnace for pyrolysis combined with coreless induction furnace powered by renewable energy: approx. 165 kWh/t, equating to 33 kg CO_2/t.

This means that by combining a rotary furnace with a coreless induction furnace, a reduction in CO_2 emissions of 70 % can be achieved relative to the state of the art, even when the rotary furnace is fired by natural gas.

In the future, it is conceivable that such rotary furnaces could be operated using hydrogen generated from renewable energy, provided this is available in sufficient quantities. This would mean that such a combined system, consisting of rotary furnace and coreless induction furnace powered by renewable energy, could be operated with zero GHG emissions, except for those generated through the combustion of organic matter adhering to the scrap.

General aspects of decarbonizing melting operations in the semifinished aluminum product industry

The primary focus of same factories manufacturing semi-finished products is on retrofitting burner systems so that they can be used with hydrogen, as this seems to be the simplest solution in terms of effort and plant engineering. However, on closer examination, it does not appear to make much sense to produce hydrogen with poor efficiency using (renewable) electricity if this electricity can also be used directly for the melting process. As far as the electrical heating processes are concerned, only induction can be considered in most cases because of the high energy density required. In this scenario, it is self-evident that renewable energy is used. Although coreless induction furnaces for melting aluminum are already on the market, the largest capacity realized to date is 16 tons with an output of 4,000 kW. Conventional gas furnaces in factories where semi-finished aluminum products are manufactured can hold up to 100 tons or more. In a first step, Otto Junker therefore carried out concept studies and made calculations for a coreless induction furnace with a capacity of 70 t (fig. 5). The respective data are shown below:

> Capacity: 70,000 kg
> Melt rate 16 t/h
> Efficiency: 55-58 %
> Wall thickness of refractory lining: 500 mm.

Taking design aspects into account, it appears feasible to upscale the existing technology accordingly with an acceptable risk.

As an alternative, concept studies were carried out with a view to converting existing hearth-type melting furnaces with one or two chambers to induction heating. Figure 6, for example, shows a schematic of a conventional dual chamber furnace in which the liquid aluminum is circulated via an external channel by an electromagnetic pump (EMP); the arrows show the direction of flow. Instead of the burners used in a main hearth, in this case the thermal energy is generated based on the channel induction principle by means of an inductor arranged around the channel.

Figure 7 shows the same arrangement, but here a coreless inductor is used. The difference between these two solutions is that the channel inductor arrangement is more efficient than the coreless inductor, but the latter can achieve a much higher energy density. Thus, the first arrangement would be primarily suitable for holding furnaces, while the second would be more suitable for melting furnaces. Furthermore, the electromagnetically-induced movement of the melt bath mentioned above significantly reduces burn-off when melting down finely divided stock. One variation of the channel inductor arrangement is shown in figure 8: In this case, the inductor is located between the furnace chambers. The melt could be circulated as required by a mechanical circulation pump, which is commercially available. Corresponding property rights have been registered for the aforementioned concepts.

In the examples shown, a dual chamber furnace was chosen as the starting

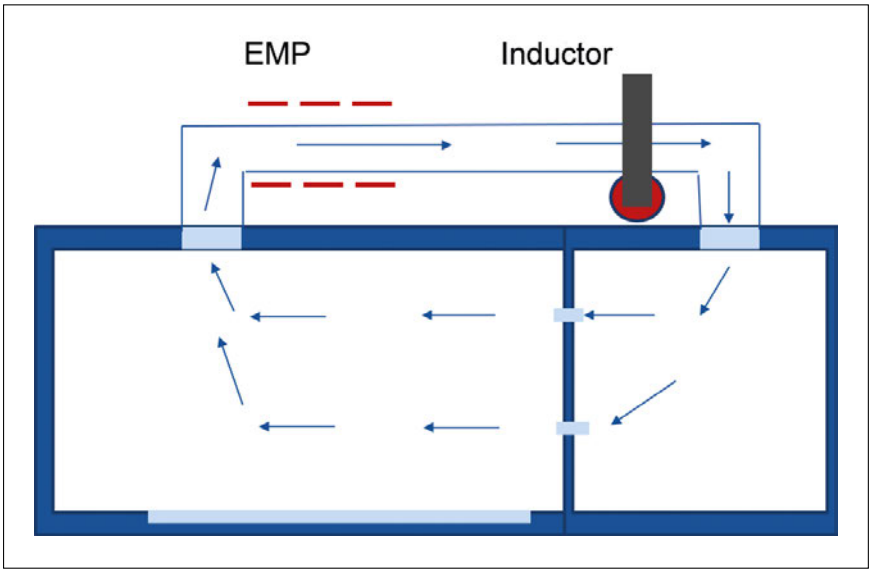


Fig. 6: **Dual chamber furnace with sidewell, circulating pump (EMP) and channel inductor heating.**

point for the considerations, because an external channel (sidewell) with pump circulation is a common feature in this type of furnace. In principle, however, the above arrangements can also be applied to a single-chamber hearth furnace. Finally, it should be mentioned that, in the case of a corresponding conversion, the original burners can still be used to start with. Thus, a hybrid melting furnace would be available for a transitional period, enabling the economically more favorable form of energy to be used in the event of strongly fluctuating gas or electricity prices.

Conclusion

In general, the vast majority of melting furnaces operated in German mills manufacturing semi-finished aluminum products are fired by fossil fuels and are therefore direct producers of greenhouse gases. It is clear that this situation must change fundamentally in order to achieve the climate targets set by the government. This is only possible if the consumption of fossil fuels and thus of natural gas is drastically reduced, one possibility would be to use burners powered by green hydrogen. However, since the production of hydrogen from electricity generated by renewable energies is only moderately efficient, it makes more sense to use this electrical energy directly for the melting process. In view of the melting rates in question here, only inductive melting can be considered. Corresponding concepts, also for retrofitting existing furnace vessels, were presented.

To melt down organically-contaminated, mostly finely divided aluminum scrap, the predominant current practice – in addition to conventional rotary salt bath furnaces – is to use dual chamber hearth furnaces fired by fossil fuels. With regard to dross formation and metal losses, this solution is known to be a compromise. In this respect, it is more advantageous to separate the pyrolysis and melting steps. This is already practiced on an industrial scale in same cases, with a rotary furnace fired by fossil fuels being used for pyrolysis and a hearth furnace fired by fossil fuels being used for melting. With reference to the preceding paragraph, a coreless induction furnace powered by green electricity is proposed as the melting unit here as well. This furnace also offers advantages over a hearth furnace as regards metal loss if the scrap to be melted is finely divided stock. If the upstream rotary furnace is additionally powered by green hydrogen, the said scrap could be recycled with zero fuel-related CO_2 emissions.

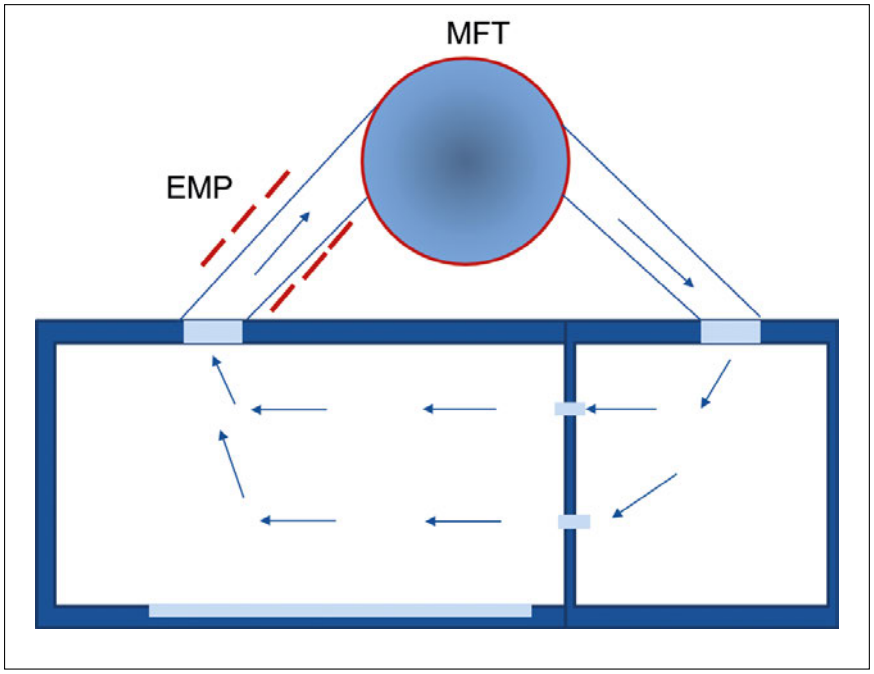


Fig. 7: Dual chamber furnace with sidewell, circulating pump (EMP) and coreless inductor heating (MFT).

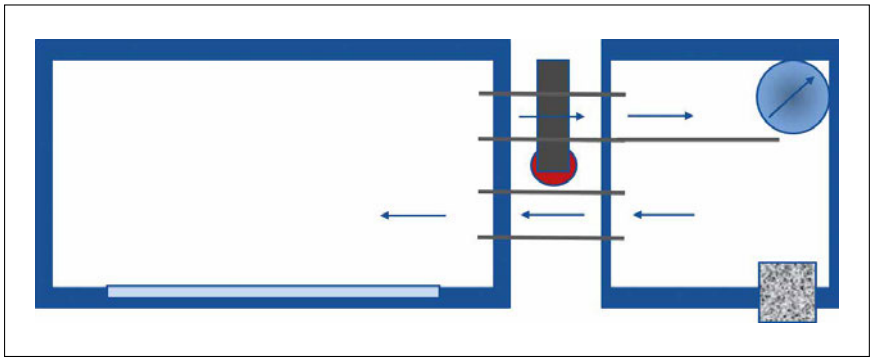


Fig. 8: Dual chamber furnace with circulating pump (e.g. mechanical pump, top right) channel inductor heating arranged between the chambers.

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Daniel Rader, Wilfried Schmitz, Christof Dahmen, Peter Uerlichs, Tobias Mertens; Otto Junker GmbH, Simmerath, Germany

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References

[1] http://www.international-aluminium.org/statistics/greenhouse-gas-emissions-aluminium-sector
[2] http://www.volker-quaschning.de/datserv/CO_2-spez/index_e.php
[3] http://de.statista.com/statistik/daten/studie/197960/umfrage/produktion-von-primaer-und-sekundaeraluminium-in-deutschland
[4] Schwalbe, M.: Grundlagen und Möglichkeiten der Verarbeitung von höher kontaminierten Aluminiumschrotten, Erzmetall (2011), Nr. 3, S. 157-162
[5] Dittrich, R., Friedrich, B., Rombach, G., Steglich, J., Pichat, A.: Understanding of Interactions Between Pyrolysis Gases and Liquid Aluminium and their Impact on Dross Formation, TMS 2017 – Light Metals, San Diego, USA, pp. 1457-1464

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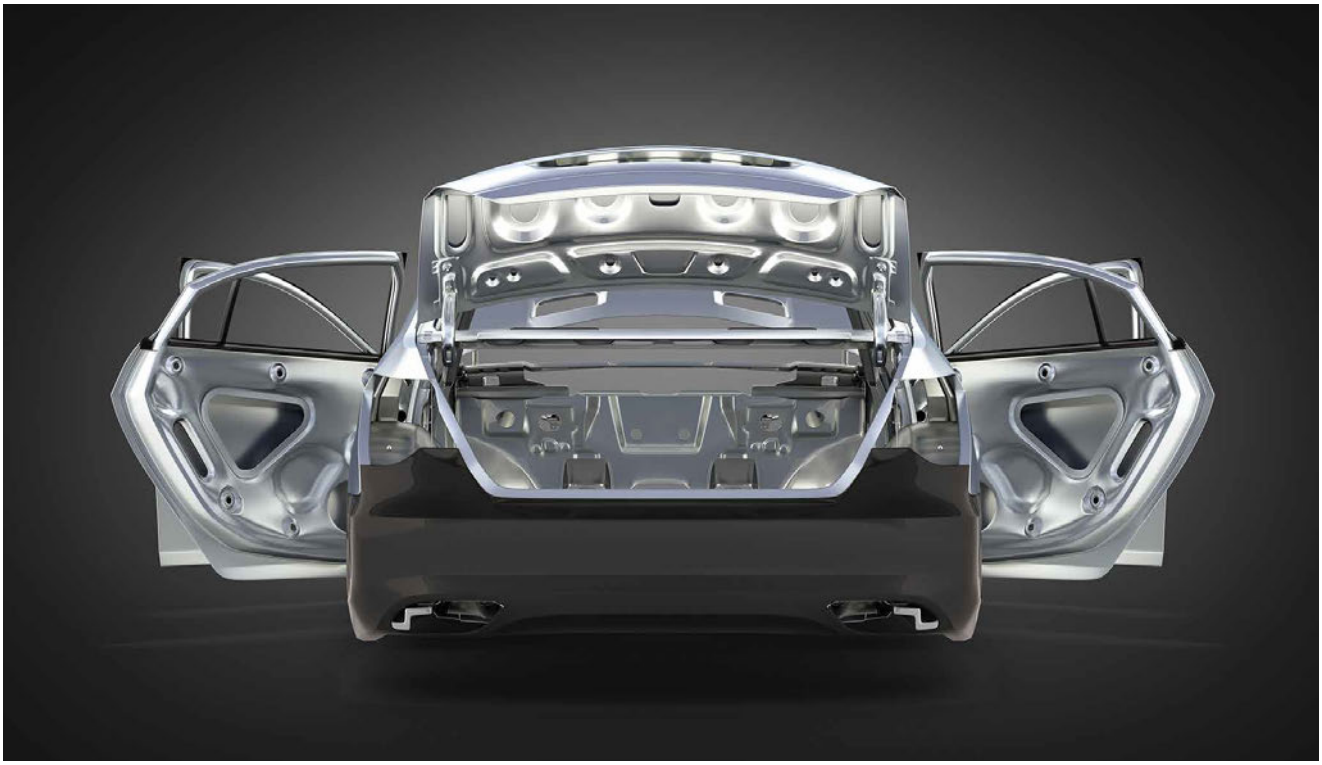


Photo: kv_san - stock.adobe.com

Shorter cycle times and improved sustainability in die casting are particularly important for automotive suppliers.

Sustainability in die casting

Minimum quantity lubrication with electrostatic application

As a direct continuation of our technical article from Edition 3-4/2023 CP&T, the presentation of the electrostatic application of mold release agents in minimum quantity lubrication (MQL) and its fundamental importance for the automotive industry, in this article we want to go into more technical detail about the sustainable advantages and differences to conventional standard processes. Maximizing process efficiency combined with significant reductions in energy, raw material and waste disposal costs are the declared goals of the die casting industry and should be implemented immediately, particularly in view of the tough global competition and environmental challenges. Minimum quantity lubrication (MQL) is an important step in this direction.

by JOCHEN CASTER

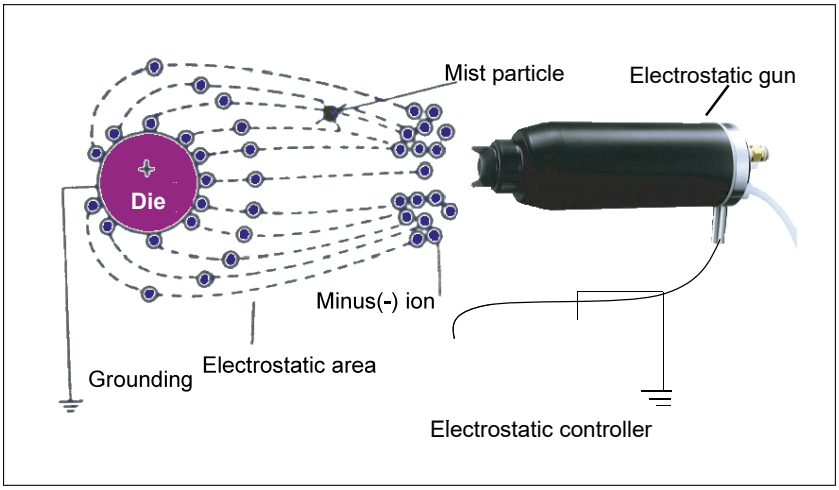
For many decades, it was standard practice to use diluted water-miscible mold release agents (wmFT) for die casting in the field of non-ferrous metals, i.e., Aluminum, Magnesium, Zinc, and their numerous alloys. This is still the most common release and cooling technology today.

Purpose of dierelease agent emulsions

> Cooling, i.e., removing the heat energy introduced by the melt from the mold surface; up to 80 % of the release agent emulsion is used for this purpose.
> Forming a surface separating layer that prevents the melt from sticking to the mold surface so that the finished castings can be easily removed from the mold.
> Lubrication of the moving mold parts (slides, ejectors, etc.) without the addition of further lubricants.
> High release effect / good demoldability of the cast parts.

PHOTO: QUAKER HOUGHTON

Fig 1: Effective minimum lubricant application with the Lubrolene spray head.



GRAPHIC: LUBROLENE

Fig. 2: System of the electrostatic spraying.

These requirements often lead to significant consumption of die release agent and, as a result, to long cycle times and large quantities of wastewater. However, the inevitable over-lubrication of the mold and the machine periphery in molds without internal cooling is usually accepted.

Over time, this leads to considerable deposits forming on the mold surface, the machine, and the spray nozzles due to residues of the wmFT ingredients:

> Oils: Mineral oils, Silicone oils (Siloxane, Polysiloxan), Ester oils, PAOs, etc.,
> Waxes: Montan waxes, Synthetic waxes, PE waxes, etc.,
> Additives: Emulsifiers, Corrosion Protection, Biocides/Fungicides, Defoamers, Wetting Agents.

The result is increased effort for cleaning and maintenance of the machine, combined with the corresponding machine downtimes.

Further basic requirements for a wmFT

> High stability of the emulsion: segregation stability,
> High corrosion protection: mold and die-casting machine,
> High bacterial stability: Microbial stability,
> Toxicological harmlessness: Occupational health and safety,
> Low tendency to form residues: Mold engraving and frame,
> Economic and ecological orientation,
> Compatibility with paints / coatings,
> Paintability of cast parts in subsequent operations.

Consequences for the DC process

> Short mold lifetimes: the strong thermal cycling stresses on the mold surface during intensive quenching with cold mold release emulsions from 700 °C to around 100 °C generate high residual tensile stresses in the surface layers and lead to the formation of fire cracks with a crack depth of fractions of a millimeter to well over 50 mm and a width of a few 1/1000 mm to over 2 mm and thus to premature failure of the die casting mold.
> Brown spots: Discoloration of the part surfaces due to burnt-in wax and oil residues.
> Corrosion: Due to the high water content of the wmFT used, there is corrosive attack on the die casting mold, the clamping plates, the machine environment and the container for the mold release agent.
> Porosity: The corrosion inhibitors used in wmFT are mostly substances based on Tolutriazoles, Phosphono-, Phosphino- and Polycarboxylic acids, Alkali Soaps, Sulphonates, Amines, Benzoic Acid derivatives and Boron compounds. Their decomposition during the casting process significantly increase the quantity and composition of gas development and thus the porosity in the cast parts.
> Leidenfrost effect: is a physical phenomenon in which an aqueous liquid, e.g. a drop of mold release agent (wmFT), which is in close contact with a mold surface that is significantly hotter than the boiling point of the water content, creates an insulating vapour layer. This prevents the surface from being wetted by the wmFT and the release agent droplet bounces off the vapour layer. Very hot molds therefore require very long cooling spray phases to be able to apply a sufficient release film, which significantly increases the cycle time .
> Maintenance costs for the spray system: Contamination caused by the build-up of release agent ingredients on mold surfaces, the mold frame and in the spray nozzles leads to heavy deposits and even partial spray system failures (blockages), which cause unplanned machine downtime.
> Bacteria (aerobic, anaerobic, facultative anaerobic) and Fungi: The existing heat and moisture strongly favor growth in the area of the die casting machines. This often causes malfunctions, but also poses health risks for personnel and high maintenance costs.
> Maintenance costs for large compressors: The application of mold release agents and the blowing off of mold surfaces to remove flakes and still-moist release agent residues requires the use of a large amount of compressed air.

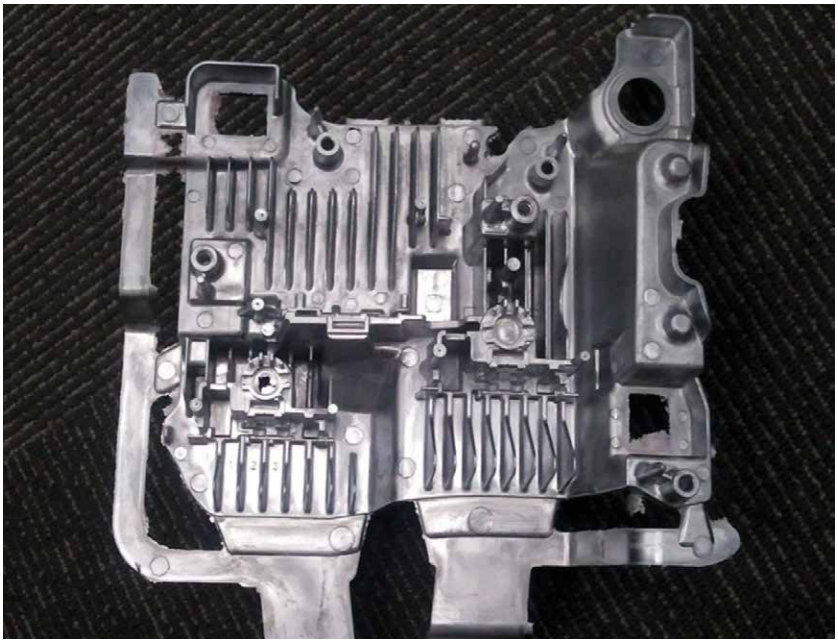


PHOTO: LUBROLENE

Fig. 3: **Deep, narrow ribs.**

> High consumption of release agent, water and energy: The usual application of release agent is carried out at a high spray pressure of approx. 2 - 4 bar and volumes of up to 12 liters and sometimes more. Up to 80 % of the actual mold release agents are "misused" as pure coolant.
> Wastewater is hazardous waste: Heavy over-spraying produces a large quantity of a mixture of mold release agent, hydraulic oil, thermal oil, wash-off from lubricating greases and lubricating pastes used and other substances from the machine environment.
> Health care for the workers: In accordance with the ever more stringent TA-Luft (Technical Instructions on Air Quality Control), large extraction systems must be financed to remove the significant quantities of water and release agent vapors produced. Otherwise, there would be a toxicological hazard for the workers at the machines due to inhalation of the alveolar aerosols / vapors formed. Direct skin contact must also be ruled out. A study by the German Employers' Liability Insurance Association for the Iron and Metal Industry found that 30% of serious and recurrent skin diseases are caused by emulsions.
> High noise level: Due to the high demand for compressed air for spraying and blowing off the mold release agents, noise levels of around 98 dB(A) with peaks of up to 110 dB(A) are present (noise level in a discotheque); with permanent exposure without hearing protection, levels > 85 dB(A) already cause incurable damage to the inner ear.

All of this means high costs and burdens as well as risks for people, machines and the environment, a significant consumption of raw materials and energy and above all: it contradicts the idea of sustainability!

In order to completely avoid these problems, it was necessary to fundamentally revise the entire production concept and at the same time reduce the consumption of release agents and energy to a minimum. The idea of minimum quantity lubrication (MQL) was born, but first the appropriate foundations had to be laid.

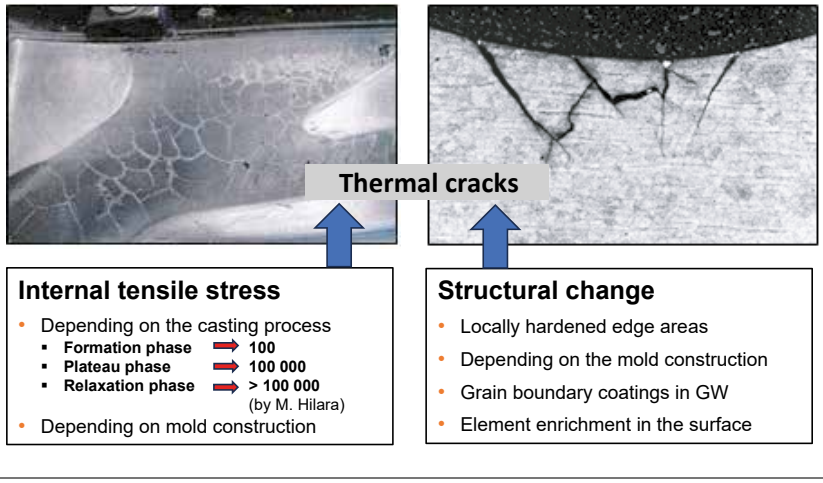
The turning point

Using energy profitably and without waste enables a comprehensive restructuring of the entire manufacturing and production process, resulting in maximum cost savings while at the same time maximizing protection of the environment and the working environment. The keys to improvement are a balanced energy balance in the molds, a clever conversion of the available thermal energy and the reduction of the electrical energy and compressed air used.

However, a number of prerequisites must first be created in the production process. As mold cooling was previously achieved by intensive spraying of the applied mold release agent, the production costs of the molds used could be kept quite low. In order to significantly reduce or even completely avoid external mold cooling, sufficient cooling channels must now be created inside the mold halves during production. This is an additional manufacturing cost and effort, but it is worth it in every respect.

Basics for minimum quantity lubrication

Thanks to "intelligently" designed temperature-regulated die casting molds, the required external cooling, i.e., mold temperature control, can be reduced to a minimum, so that minimum quantity lubrication (MQL) is possible without additional cooling:
> Suitable mold cooling channels distributed over the entire surface reach all mold areas,
> Cooling positioned close to the surface dissipates the heat energy directly,
> selective cooling of hot spots, e.g., through the use of jet streams,



GRAPHIC: H. PRIES ET AL. [1]

Fig. 4: **Development of residual tensile stresses and structural changes in die casting molds: Build-up and reduction of tensile stresses as a function of load cycles (number of shots).**

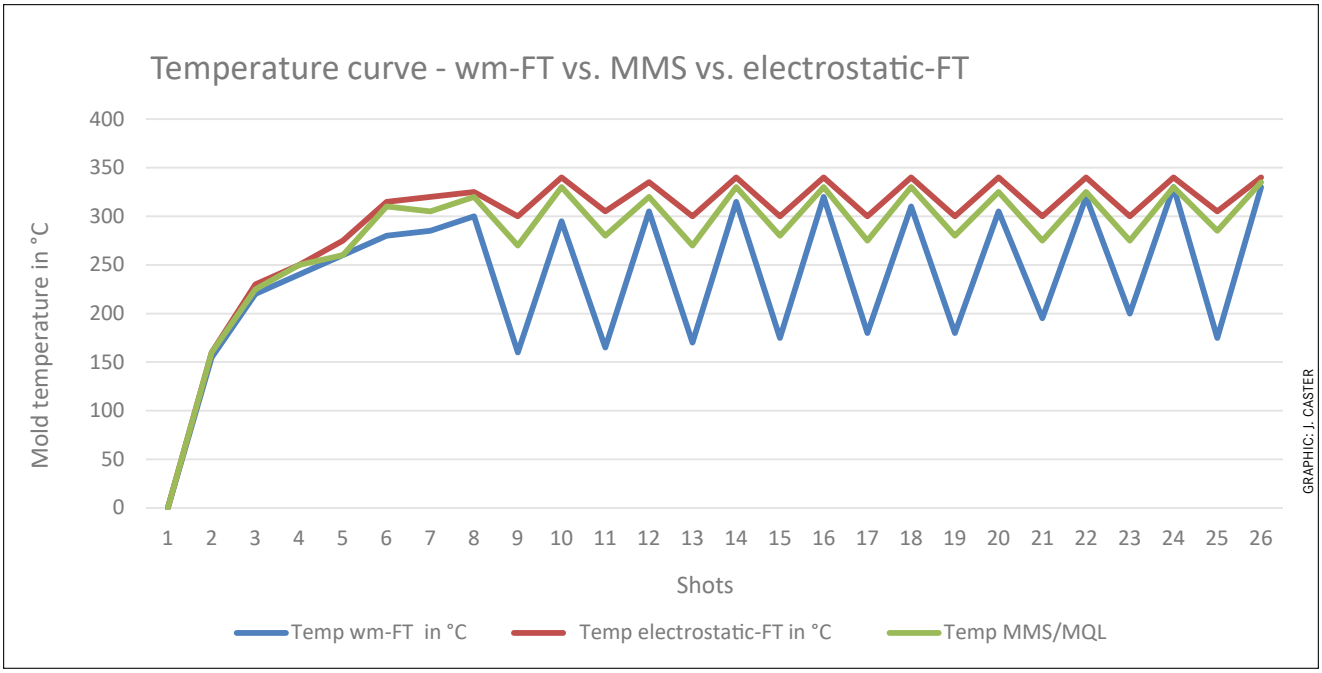


Fig. 5: Comparison of the temperature curves of the different spraying techniques.

> Use of sufficiently dimensioned heating / cooling units.

Additional cooling for die casting molds is achieved through the use of industrial heating/cooling units (HKG), which are placed next to the die casting machine. They use a heat transfer medium (oil/water) to dissipate the heat energy introduced into the mold by the molten metal in order to ensure rapid solidification of the cast parts and prevent general or partial overheating. Depending on the number of possible cooling channels and their cross-sections, heat transfer oils or pressurized water systems are used.

This also means that only as much mold release agent needs to be applied as is necessary for a sufficient release effect, as the required cooling is completely taken over by the internal mold temperature control. The mold release agent no longer has to be diluted to a mixing ratio of 1:50 - 1:120 and higher but can be applied undiluted and in minimal quantities using suitable spraying equipment. This not only reduces the freshwater requirement, but also the associated wastewater volume to a minimum, or even to zero. The result is known as minimum quantity lubrication (MQL) and has already been successfully implemented by several well-known manufacturers over the past 20 years.

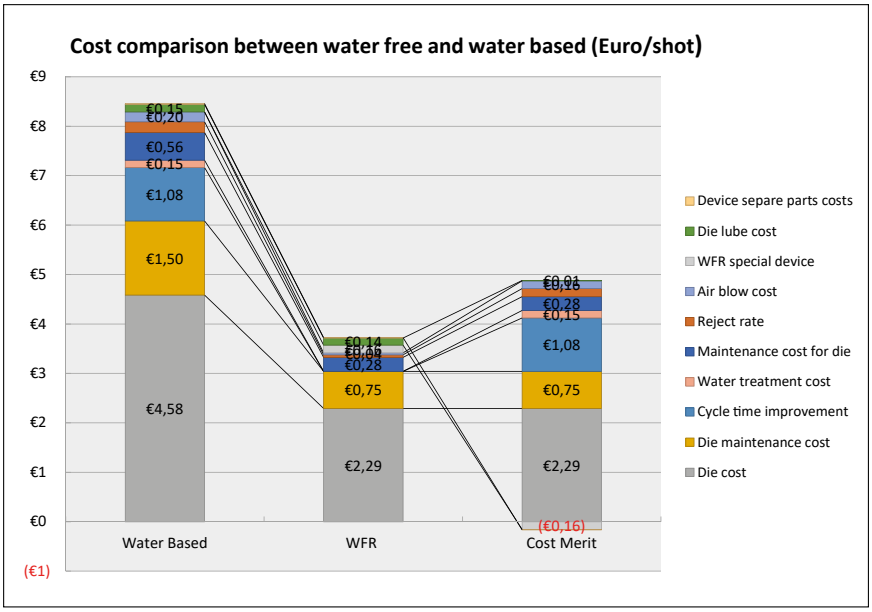
The electrostatic minimum quantity mold release agent application

Developments to perfect and maximize improvement of existing MQL application systems, particularly with regard to increased process sustainability, has led to another milestone. This is achieved through the use of patented, water-free release agents from Lubrolene in combination with Quaker Houghton's Fluidcast Electrostatic Spray Technology (fig. 1) for die-casting mold release agents (we reported on this in GIESSEREI 107 (2020), [No. 09], pp. 49-51 and GIESSEREI 108 (2021), [No. 09], pp. 60-61, the ed.).

It is currently the best available technical solution to deliver the desired maximum die casting performance improvements and production cost savings. Lubrolene has already proven this in numerous applications in recent years, not only in the automotive industry but also in other industrial sectors. The application of the required mold release agent is reduced to the technically feasible minimum, so that an "over spray" is almost zero. At the same time, this significantly reduces the issue of contamination and cleaning effort.

Procedure description

This spray system (fig. 2) is based on a non-water-miscible mold release agent (nwmFT), which means that water is no longer required. It is first atomized using specially developed spray nozzles and then electrostatically negatively charged in the nozzle at the start of the actual spraying process. An air jet with a delivery pressure of just 0.5 - 1 bar is used as the carrier medium. The charged, finely atomized, mold release agent particles (micro-droplets) are drawn to the metal surface by the potential difference and, aligned with the field lines, are distributed evenly on the earthed diecasting mold surface, both over the surface and in relation to the release film thickness. A longer spraying time produces greater layer thicknesses, but not indefinitely, as otherwise there is a risk of reionization, which can lead to faults during application. By means of the so-called "wrap-around effect", all undercuts of the mold geometry and the mold slides, up to deep and narrow cavity zones (Fig. 3), e.g. in the narrow rib area, are also reached. Empirically



GRAPHIC: J. CASTER

Fig. 6: Cost comparison between standard wmFT and electrostatic FT using an example.

determined limit value considerations have reproducibly shown an achievable depth of up to > 100 mm with a minimum width of 2 - 3 mm.

Advantages of electrostatic die release coating

The process of micro-spraying is already known to save considerable resources in terms of energy and raw materials, while at the same time significantly reducing the impact on the environment. Compared to MQL, the electrostatic application of mold release agents achieves even greater benefits:

> significantly extended mold service life: a considerable reduction in thermally induced surface stresses reduces the formation of fire cracks in particular.

> the savings in energy and release agent consumption of the die casting cells can be significantly exceeded.

> the complete avoidance of water consumption and thus reduction of the general volume of wastewater offers further considerable savings potential.

> the absence of water prevents bacterial or fungal infestation.

> the significantly reduced reject rate also substantially reduces the CO_2 footprint.

> the mold temperature application range lies in a wide interval of < 100 °C - >300 °C,

> the significant cycle time reduction is mainly achieved by the shorter cycle times for release agent application (no occurrence of the Leidenfrost phenomenon) and the elimination of the post-blowing or blow-off time required with water-miscible mold release agents in order to blow excess water out of the mold and avoid production disruptions.

> A single electrostatic spray nozzle from a single position can cover the front and rear surfaces simultaneously, achieving a more effective, full-coverage adhesion of the release agent. Conventional MQL usually requires spraying from three different angles with three or more nozzles or a spraying robot to achieve comparable, complete surface coverage.

Sustainability plus

The sum of all the savings, optimizations and simplifications associated with this new production strategy results in the efficient use of all raw materials and energy as well as the associated resources in terms of optimal sustainability of manufacturing and overall production.

Achievable cost savings

It sounds simple when it comes to saving raw materials and energy, but it is the sum of all the associated upstream and downstream actions and influences that produce the desired, optimum end result (fig. 6):

> Costs for mold release agent,
> Costs for compressed air,
> Disposal costs,
> Maintenance and repair costs,
> Spare parts costs,
> Scrap rate,
> Cleaning costs,
> Machine downtimes,
> Planned maintenance times,
> Tool costs (mold),
> Cycle time of the casting process.

A direct comparison of the costs of conventional production using water-miscible mold release agents and optimized production with the aid of electrostatic application clearly shows the enormous potential for improved sustainability.

Summary and outlook

Energy and raw materials are the cornerstones of any further development and improvement of our processes in order to achieve and further expand true sustainability. What we have achieved so far can only be the first step towards further developing the heat and energy flow within a production area, or even better within an entire production site, into an almost closed cycle and achieving the highest possible overall efficiency: a glimpse into a possible future!

If you have any further questions, please contact us directly

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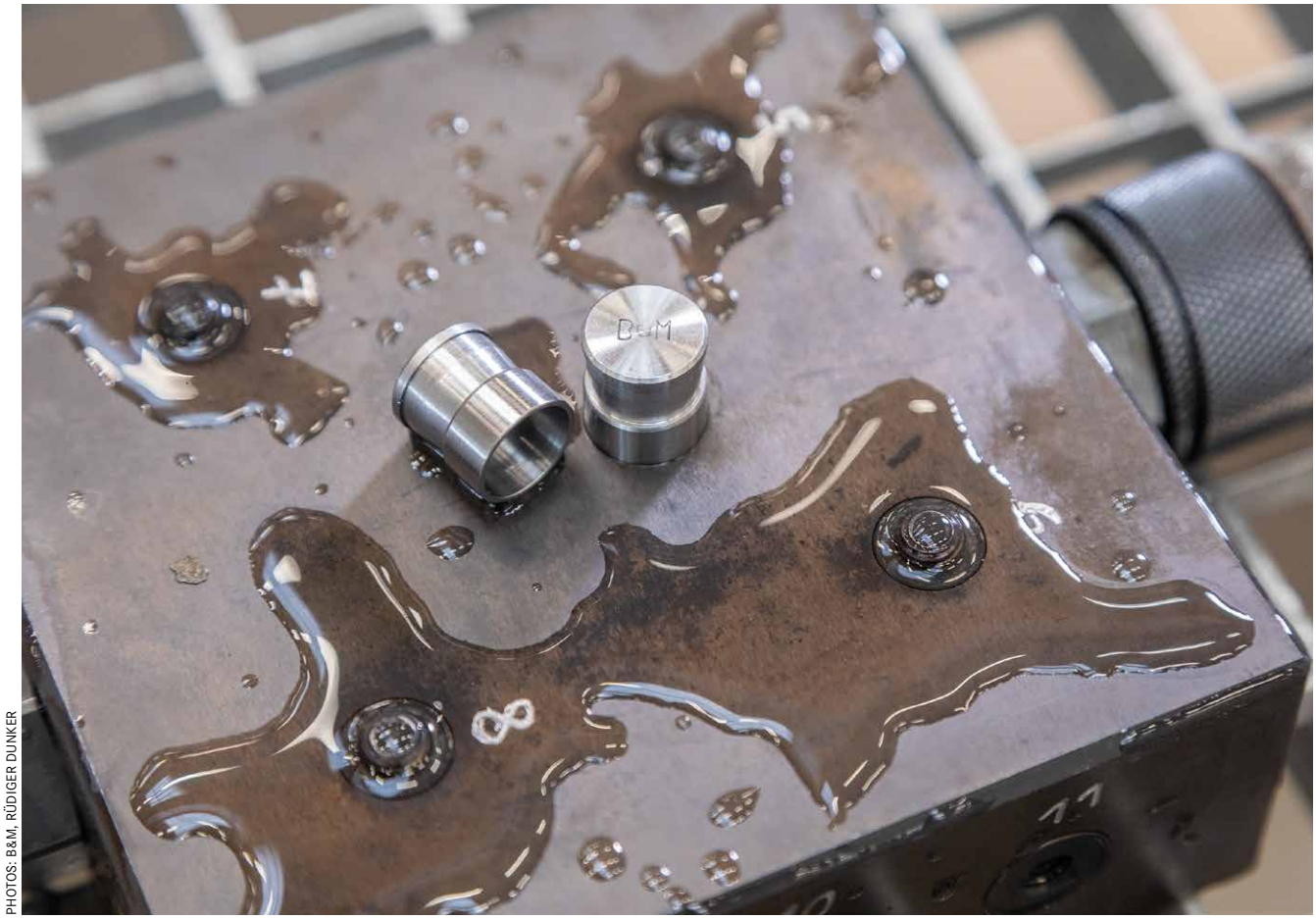


PHOTOS: B&M, RÜDIGER DUNKER

Easy installation, reliable sealing – pressure and temperature resistant b&m-KL Plugs

Freeze-fit plug vs. b&m-KL Plug

The art of sealing in large die-casting dies

There are good reasons to rethink the performance of cooling channels, especially if the aim is to improve casting part quality, cost efficiency, and ecological footprint. This is the case at Schaufler Tooling. The company uses an intelligent sealing system from baier & michels to overcome even complex challenges, whether in dies for mega and giga castings or for dies prepared for micro spray.

By Andreas Wollny

Leaks are some of the most annoying occurrences in the daily processes involving die casting and die making. They are the main drivers of unplanned downtime during the production process and can have different causes. Leaks on the outside of a die, for example on the connecting thread, are relatively easy to fix. Cracks between the die and a cooling channel occur less frequently but are often reducing the overall equipment effectiveness (OEE) significantly. And then there is the variant that prompted Siegfried Heinrich, Managing Director of die manufacturer Schaufler Tooling in Laichingen, Germany (fig. 1), and his team to search for the optimum solution: leaks on sealing plugs.

"For several years, we used freeze-fit plugs", reports Siegfried Heinrich. Heinrich explains that, while the key feature of these proven sealing elements is their effectiveness, "they are quite a burden in terms of material and energy consumption as well as working hours and safety". Schaufler was therefore open to new solutions that would meet the high sealing requirements while

Table 1: Effort comparison freeze-fit plugs and b&m-KL Plugs. Reference: cavity part with 15 plugs.

	Freeze-fit plug process step	Time [min]	b&m-KL Plug process step	Time [min]
Preparing the die insert	hard milling	75	drill to target diameter	10
	ream	5		
	re-machine to larger diameter, if necessary	15		
Preparing installation	measure the holes	30	check the holes	10
	turn the plugs	60		
	heating of cavity part (approx. 6 h)	15		
Installation	insert the plugs	30	install the KL Plugs	15
	leak test	10	leak test	10
	grind flat	30		
Reworking in the case of a leak	re-machine the hole	90	set 2nd plug	3
	measure the plug	3	or replace the plug	5
	turn the plug	5		
	heating of cavity part (approx. 6 h)	15		
	insert the plug	10		
	leak test	5		
	grind flat	3		
Total		**401**		**48-50**

substantially reducing the effort required for installation and removal.

Large dies = more closing and sealing elements

A look at a simple cavity insert with 15 openings illustrates just how important this challenge is. The four phases – preparing the insert, preparing installation, installation, and rework in case of a leak – take around 400 minutes on average when a freeze-fit plug is used at Schaufler (table 1). "Die-casting dies, for example for a shock tower or a transmission housing, can contain up to 150 plugs – that means 150 potential leaks", says Thomas Schwegler, Head of Design Engineering. "And in the project that we have been implementing recently, things are on a much larger scale than that".

One could also say: gigantic. This becomes evident when stepping into the new Schaufler production building in Laichingen. Dies with a total weight of up to 200 tons have been manufactured in this 1000 m² workshop since last summer – for die-casting machines with clamping forces between 6000 and 12 000 tons. This makes the company part of a very small group of pioneers worldwide who are able to supply the automotive industry with so-called mega and giga dies.

"Side members, for example, are considered very heavy and complex parts in conventional die casting of structural parts", explains Schwegler. "As a comparison: For mega and giga castings, two side members and up to three crossmembers, for example, can be produced in one die and therefore in a single casting". The increasing requirements for the geometry of the parts also have an impact on the number of cooling circuits. According to Thomas Schwegler, the Schaufler engineers need three to four times as many circuits as before. The number of required drilled holes and sealing elements also increases accordingly.

Other challenges

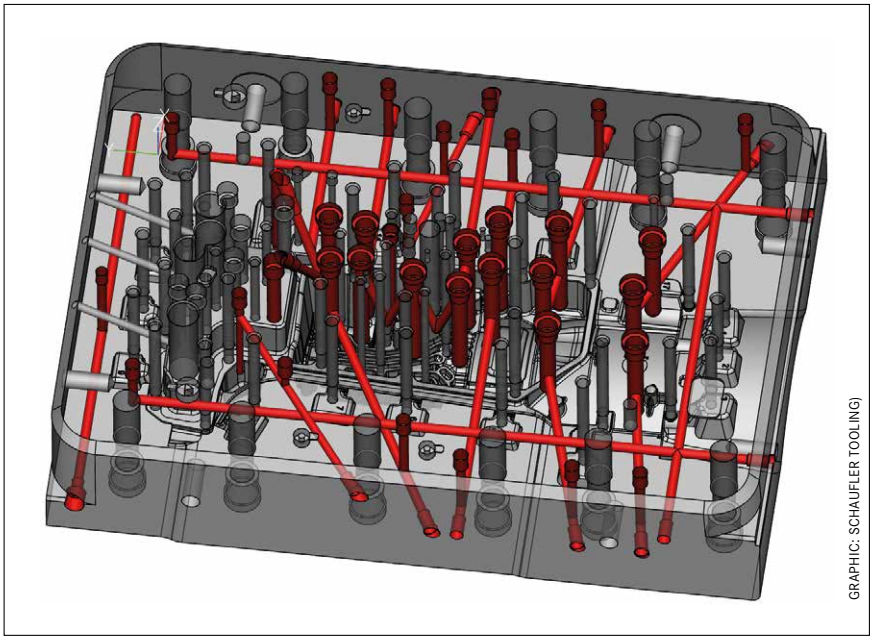
"And there is another innovation: micro spray", adds Managing Director Siegfried Heinrich. "This principle has proven to be an opportunity and a burden at the same time". In this process, minimal quantities of release agent emulsions or water-free release agents are sprayed onto the surface of the die. The background: With water-based spray, large and rapid temperature changes cause thermal fatigue cracking on the surface relatively early on. These enter the die insert and progress all the way to the cooling channels, allowing cooling water to get inside the die.

The same risk is also present inside the cavity parts. The driver for this is corrosion in the cooling channels. "This

Fig. 1: Siegfried Heinrich (left), Managing Director of Schaufler Tooling, with Constantin Egold, Technical Product Manager at b&m.

Table 2: Test procedure.

Parameter	Value
Temperature of the heat transfer oil	300 °C
Flow pressure	2.5 bar
Water volume for quenching	10 l
Water temperature	approx. 20 °C
Quenching cycle	2 min
Cycle duration	1 h
Cycles per day	2
Total duration	8 days
Tempering period	8 h
Tempering temperature	540 °C
Leak test	nitrogen
Sealing pressure	20 bar
Sealing period	60 min



GRAPHIC: SCHAUFLER TOOLING)

Fig. 2: 3D image of a conventional insert: The cooling channels are shown in red. For mega/giga die-casting dies, their number multiplies.

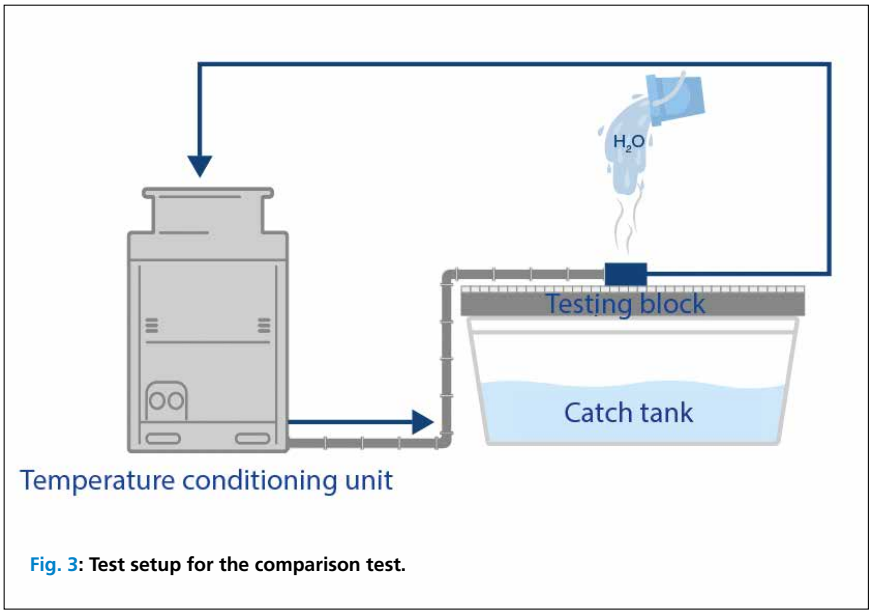


Fig. 3: Test setup for the comparison test.

is primarily caused by the free carbonic acid from softened water. We are currently trialing effective solutions for this issue", says Heinrich. "Micro spray enables our customers to achieve significantly increased die life. At the same time, it helps to reduce cycle times and to minimize wastewater quantities".

But even though micro spray opens new possibilities for reducing alternating thermal loads on the surface of the die, efficient heat removal should be ensured. And that can be achieved only by complex internal cooling with very strong performance. That means: even more changes of direction in the cooling channels and even more holes to be sealed.

It all comes down to sealing

"Mega and giga casting and trends like micro spray multiply the number of potential leakage points", says Siegfried Heinrich (fig. 2). "At the same time, minimizing the risk of leaks has always been a deciding factor in our daily business, even on traditional dies". But his company not only wanted to sell die-casting dies, but to also contribute to their customers' ability to manufacture successfully with optimized overall equipment effectiveness (OEE). Schaufler has now implemented a new sealing solution that, according to Heinrich, "significantly improves the interplay of quality, cost efficiency, and ecological footprint".

The solution, which is mostly replacing freeze-fit plugs and other common products, is called the b&m-KL Plug. The closing and sealing element is manufactured by baier & michels (b&m). The fastener technology specialists with headquarters in Ober-Ramstadt, Germany, are part of the Würth Group. Constantin Egold, Technical Product Manager at b&m, reports on the development: "Our aim was to create a completely new system that offers convincing performance in direct comparison with expander plugs, screw plugs, or press-fit balls".

New design idea in a comparison test

A radical idea paved the way: The design engineers at b&m integrated the principle of a blind rivet into that of a closed blind rivet nut. The result is a single-piece, weight-optimized closing and sealing element. The right material pairing is crucial here: The component and the b&m-KL Plug must have the same linear expansion coefficients.

An analysis conducted by Schaufler was crucial for the implementation: an eight-day direct comparison between a freeze-fit plug and the b&m-KL Plug that simulated the thermal stresses during a normal casting process and tested the service life of the sealing elements. A rectangular block made of hot work tool steel (1.2343) with a hardness between 43 and 46 HRC was used as the test part. Holes with 14 mm and 18 mm diameter were drilled into the block, into which several combinations of freeze-fit plug and b&m-KL Plug were then inserted.

Schaufler subjected the test part to two load cycles per day (table 2). Step one: The unit was heated to 300 °C with a temperature conditioning unit and a heat transfer oil (fig. 3). When the temperature had been reached, an employee quenched the block with 10 l of water (approx. 20 °C) every two minutes over a one-hour period (fig. 4). After a simulated maintenance break of two hours, the block was rotated 180°, moving the sealing plugs that had been on the underside to the top, and the load cycle was restarted. The test setup was based on a previous analysis of different sealing options that were implemented by Schaufler Tooling in 2005. At that time, the freeze-fit plug had been the most practical option and had remained in use despite continued new approaches.

Fig. 4: Miriam Groß, toolmaker in training at Schaufler Tooling, oversees the test for the comparison of the sealing plugs.

Positive conclusion

With a view to the current analysis, Thomas Schwegler, Head of Design Engineering at Schaufler, draws the following conclusion: "The b&m-KL Plugs offer great advantages already during drilling of the holes". This is because the hole can be out-of-round by up to 0.05 mm and the surface quality can have an Rz of up to 16 µm, both of which are easy to achieve with a pilot drill. The holes for the freeze-fit plugs, on the other hand, must not be out-of-round by more than 0.01 mm and the surface quality must not exceed an Rz of 4 µm. In addition, the personnel at Schaufler must make a customized hole for each freeze-fit plug.

"The b&m-KL Plugs", explains Schwegler, "are easy to install and adapt to the hole". Moreover, the freeze-fit plug must be cooled down to -196 °C with liquid nitrogen before installation and the workpiece has to be heated to +350 °C (fig. 5). The b&m-KL Plugs, on the other hand, can be installed quickly and easily with a rivet nut setting tool, without generating any waste. This makes it possible to install and remove the plugs directly at the place of use. To remove the b&m-KL Plugs, the adapter on the setting tool is changed and the plug can simply be pulled out. A slide hammer can also be used. The hole is not damaged during the process. "And the worker can then directly install a new b&m-KL Plug", adds Thomas Schwegler. "Freeze-fit plugs, however, have to be drilled or milled out, and the hole then has to be reworked and a new sealing plug has to be turned".

The conclusion from the Schaufler test: As a sealing element, b&m-KL Plug is fully equivalent to the previously used freeze-fit plug. But they are much easier to use, as a specific calculation illustrates: In the die insert mentioned above with 15 plugs, freeze-fit plugs consume 401 minutes of working time on average, whereas b&m-KL Plugs require a mere 48 to 50 minutes. "In certain applications, we still use freeze-fit plugs, though", says Thomas Schwegler. "Especially where the sealing element must be adapted to the geometry of the surface. This includes sealing faces where the aluminum comes into contact with the die". Schaufler also uses flanged plugs in some cases.

Recently, though, b&m-KL Plugs are used to seal 80 to 90 percent of all holes in the cooling systems at Schaufler. "That is because these plugs", explains Managing Director Siegfried Heinrich, "improve our process stability and that in turn is a crucial factor for our productivity."

Fig. 5: Before use, a freeze-fit plug must be cooled down to -196 °C with liquid nitrogen, while the corresponding die insert must be heated to 350 °C.

www.baier-michels.com

Andreas Wollny, Product Communications Manager, baier & michels GmbH & Co. KG, Ober-Ramstadt, Germany

Humtown Products in Ohio owns 13 sand 3D printers from ExOne.

PHOTOS AND GRAPHICS: EXONE

3D sand printing

The Benefits of hybrid mold and core production

Hybrid production combines traditional sand mold making with 3D printing of complex sand cores and can give your casting business competitive advantages. Learn how foundries are using this modern approach to quickly manufacture complex cores, offset labor challenges, improve part quality, and de-risk their supply chain – all while reducing production costs.

By Nonni Sri Athari

Foundries worldwide are increasingly adopting a hybrid production strategy that pairs conventional production of sand molds with 3D printed sand cores using binder jetting technology (fig. 1). The change is being driven by rapidly evolving global market conditions that are driving new levels of part complexity combined with the wide range of business and technical benefits offered by this modern approach. Despite the increasing adoption of this hybrid production strategy, many foundries may not be fully knowledgeable about the approach, how easy it is to integrate into conventional operations, and how the strategy helps their business remain competitive to thrive into the future.

ExOne, the pioneer and global leader in sand binder jet 3D printing technology, carried out an exploratory research which investigated the market drivers and benefits of a hybrid production strategy. The company interviewed several foundries that have implemented the strategy and reviewed scientific literature that documents the benefits of hybrid mold and core production. This article briefly outlines the findings of ExOne's exploratory work.

To get the complete report from ExOne, please scan the QR code at the end of the text.

A modern approach: hybrid mold and core production

It's unclear when hybrid production of conventional sand molds and 3D printed sand cores became a more widely adopted strategy in the marketplace, but its growing use has been documented for years. Slightly different terms, such as hybrid molding, hybrid production, and hybrid concept, are used to describe this modern approach. In ExOne's report, the term hybrid production strategy is defined as the pairing of a conventionally produced sand mold with a binder jet 3D printed sand core.

Virtually all sand 3D printing done today is executed with binder jet technology. Binder jetting is one of seven categories of additive manufacturing (AM) recognized by ASTM International. In binder jetting, an industrial printhead selectively deposits a liquid binding agent onto a thin layer of sand. After printing, another thin layer of sand is deposited in the build area. The process is repeated layer-by-layer using a map from a digital design file until the object is complete. The process is routinely used worldwide to build high-value and one-of-a-kind parts and tooling.

Drivers of the hybrid production strategy

ExOne discovered that the shift to this manufacturing approach is being driven by a number of changing market conditions, foundry challenges, and inherent efficiency and quality benefits such as:

1. Increasing complexity of cast components

Modern products with increasing requirements for performance, sustainability, and innovation are driving increased demand for complex castings that are only expected to grow further in the future. One of the strongest drivers is the push for more sustainability and performance from virtually all transportation and machinery that uses traditional CO_2-emitting fuel, which is leading to more complex designs (fig. 2).

2. Labor challenges

At the same time part complexity is growing, finding labor to reliably assemble traditionally produced core segments has become more challenging. ExOne identified that nearly 50 % of foundries worldwide reported chal-

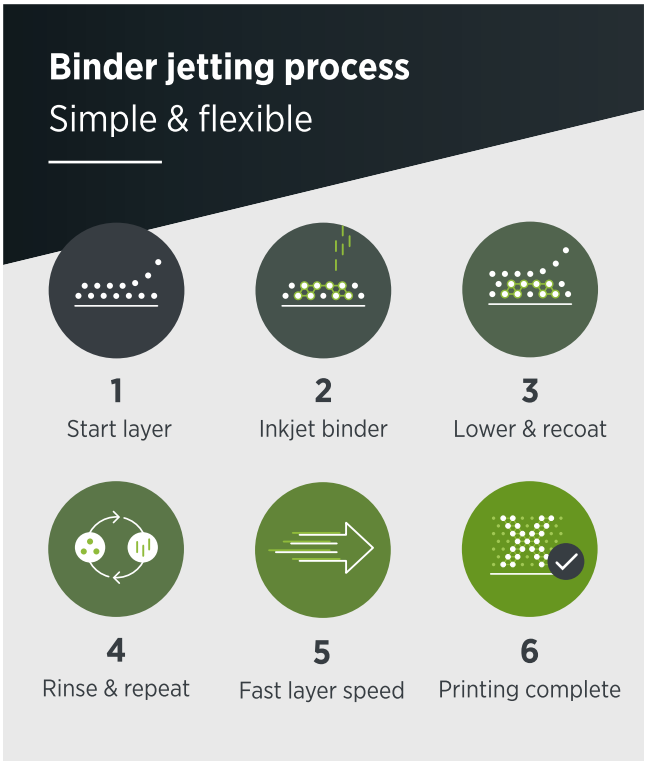


Fig. 1: **Binder jetting process.**

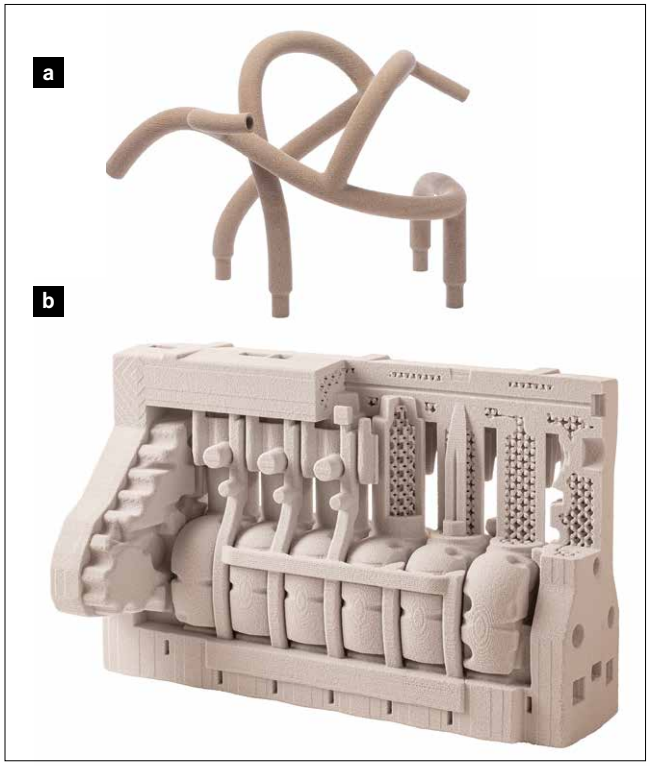


Fig. 2 **a+b: Complex cores.**

lenges finding and/or retaining workers who have the knowledge to assemble cores into quality sandcasting pieces. The high cost of labor is also a key consideration.

3. Demand for quality improvement with less scrap

Foundries strive to improve the quality of their complex cores. By eliminating hand assembly of complex core segments, quality improvements flow naturally as stackup errors are reduced or eliminated
and every core is produced virtually identical to the next.

4.Increasing demands for faster delivery

Time is money. For just about every foundry, promised delivery times can determine whether a job is won or lost. Speed matters for all types of volumes, too, from prototypes to the highest volumes. The speed advantage offered by sand 3D printing, especially with the hybrid core-printing approach, is often cited by users as a key justification for adoption.

5. Disrupted supply chains

Manufacturing supply chains can be fragile. Whether it's global pandemics, economic crises, wars, or even extreme weather events, complications for manufacturers can escalate and disrupt schedules quickly. Sand 3D printing can help de-risk the supply chain by enabling a decentralized manufacturing strategy. Indeed, several foundries reported that disruption in supply chains had accelerated its adoption of 3D printing.

6. Sustainability improvements

The foundry industry is an energy-intensive industry, which makes it a high-CO_2 emission industry as well. The challenges associated with this, coupled with rising energy and labor prices, require foundries worldwide to rethink their strategies. Both regulatory requirements and corporate responsibility make green foundry and sustainable manufacturing concepts indispensable.

7. Ease of integration into existing operations

Another significant driver of the hybrid approach for foundries is the ease with which it can be integrated into a conventional casting system. Foundries that have adopted sand 3D printing technology continue to operate normally, but simply send complex cores to the printer instead of through conventional processes.

The hybrid mold and core manufacturing processes

While traditional sandcasting requires permanent tooling for fabrications such as patterns or models, and core boxes, making cores via 3D printing is a digital process, thus eliminating the need for time-consuming designing and manufacturing of core boxes as well as for assembling cores. With the aid of 3D design software, a virtual model of the core can be designed and rapidly iterated when needed. The digital file is used to 3D print the core.

Foundries reported that the total time needed for the hybrid production processes varies and can be difficult to generalize, but it's undeniably faster. It can take a few days, one week, or a few weeks– depending on the size and complexity of the cast parts and the supply chain situation. However, the amount of time needed for the 3D printing process (right side of fig. 3) is generally really fast, given that several steps are eliminated, although it varies as well depending on factors like the size and complexity of the core, machine type, and filling level of the printer's job box.

Main benefits of hybrid mold and core production

Foundries adopting the hybrid production strategy and scientific studies alike have reported a number of benefits of the approach compared with conventional manufacturing alone. Moreover, it is found that one benefit leads to many other benefits, which are often interrelated.

1. Complex core consolidation

For complex cast parts that require several cores, the design and assembly of those cores required in the conventional process are time, labor, and

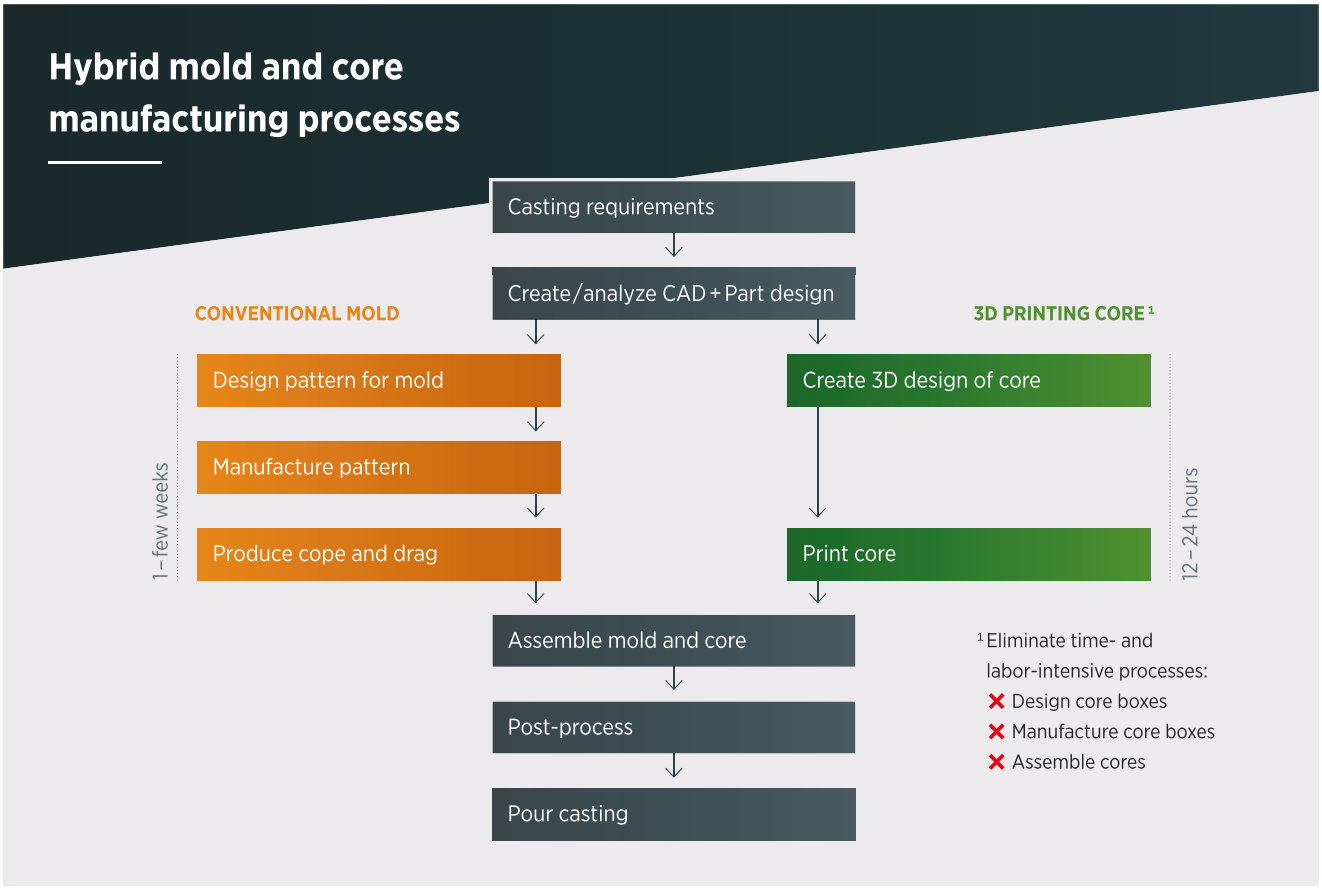


Fig. 3: Hybrid mold and core manufacturing processes.

cost-intensive. The more complex the cast part is, the more resources are needed in the production. Thanks to the freedom of design in 3D printing, foundries are now able to create a virtual design of the complex geometry and 3D print it as one piece – a monolithic core – instead of producing many cores as in the conventional core process. The integration or consolidation of cores through 3D printing eliminates the need for complex core boxes and assembly of cores, which is extensive post-processing requiring many resources. GF Casting Solutions Leipzig GmbH in Leipzig, Germany, produces complicated sand cores for hydraulic rotary transmissions (fig. 4). Conventionally produced, twelve partial cores were needed to form undercuts and thin channels. With the aid of the ExOne S-Max 3D printer, the iron foundry is able to produce the cores in one piece only. This core consolidation has significantly improved the quality of the cores for the hydraulic transmission as well as reducing laborious manual assembly and subsequent fettling work.

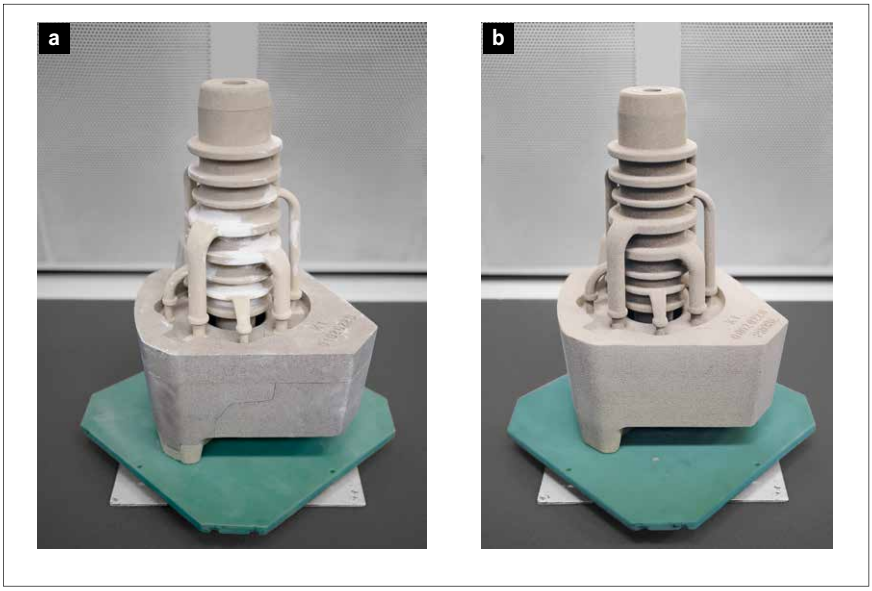


Fig. 4: GF Casting Solutions Leipzig's assembled core (left) and 3D printed core in one piece (right).

2. Faster delivery time/accelerated lead time

Sandcasting often suffers from high lead times due to many aspects such as the lengthy process of tool-making and disrupted supply chains. A significant benefit of the hybrid production strategy is a much faster delivery time of cast parts due to several factors:

> The elimination of hard tooling requirements
> Elimination or reduction of hand assembly and other post-processing
> The ability to consolidate core segments, oftentimes into just one piece
> Elimination or reduction of time-consuming and wasteful quality errors
> The use of high-speed binder jet 3D printing systems

With the hybrid production strategy, Eisengiesserei Mezger in Kallnach, Swit-

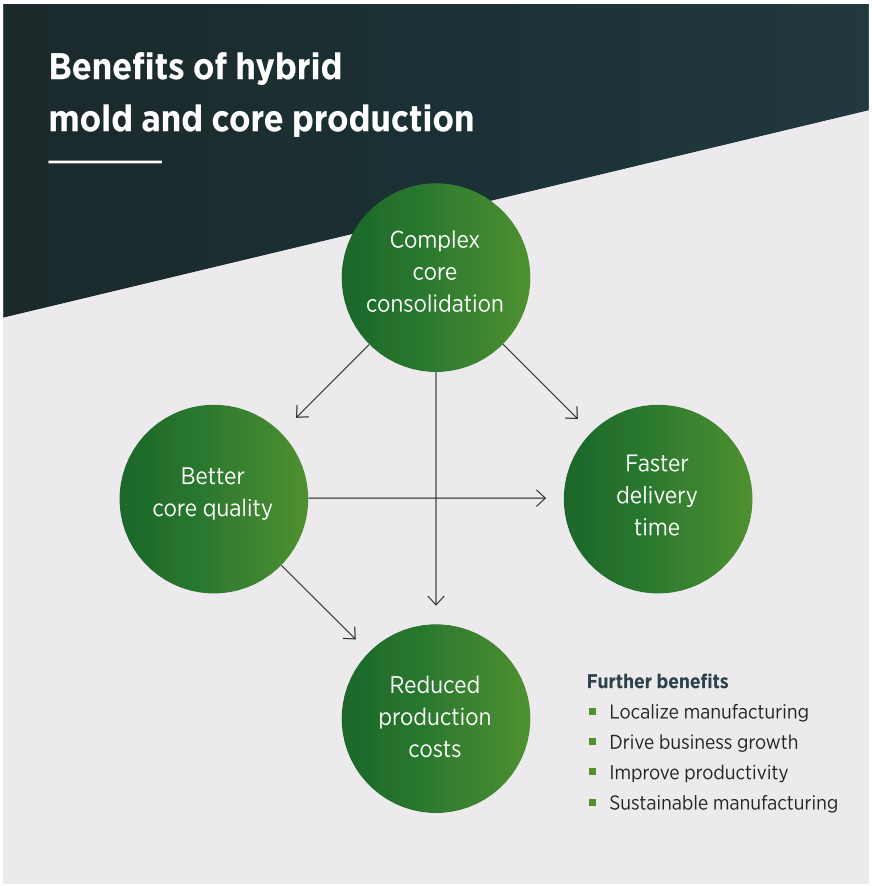


Fig. 5: **Benefits of hybrid mold and core production.**

zerland, pairs a conventionally produced mold with a monolithic core printed with the S-Max Pro. High-quality cores are completed in just 12 hours, while a raw cast part is completed in around three to five days. The speed of the digital workflow and the S-Max Pro allows the company to deliver cast parts to customers at top speeds. Saudi Mechanical Industries (SMI) in Riyadh, Saudi Arabia, delivers cast parts for pumps, valves, and automotive parts. The foundry shared that it can deliver the parts much faster with the hybrid approach as it saves a lot of time in its production through 3D printing. 50 % of the lead time is saved by 3D printing as the foundry doesn't have to make tooling anymore.

3. Reduced production costs

Given that 3D printing improves production time and eliminates expenses such as hard tooling and labor for core production, it stands to reason that it's a cost saver. While no clear academic work has been done on this topic, previous research has identified the economic opportunity for 3D sand printing in comparison with conventional manufacturing of molds and cores. Several foundries reported the process improves efficiency due to the following factors:

> The elimination of tooling (core boxes):
- No design and fabrication costs for core boxes
- No storage for core boxes
- Easy and rapid iteration of virtual core design

> Reduced labor needs through core consolidation
- Reduced assembly labor and associated cost
- Reduced post-processing
- Reduced scrap cost

Aldo Randazzo, who leads the customers' sand printing applications at ExOne GmbH pointed out: "The hybrid mold and core production has a huge potential to reduce overall production costs. But foundries must take into account the whole aspects and processes in the production, also the costs in the downstream processes, and not only count the production cost per core". Customers also save money. Not only do foundries reduce production costs through the hybrid approach, but ExOne's study also found that the foundries' customers can have the same benefit as well. According to Grede Iron Mountain in the USA, its customers save significant amounts of money by eliminating the capital cost for tooling, where some pours traditionally required multiple core boxes to be built.

4. Better core quality

High-quality cores contribute to high-quality castings. The foundries in ExOne's study and previous research have proven that the consolidation of multiple cores via binder jetting 3D printing technology enables better quality of cores in terms of scrap rates, surface quality, and precision or level of detail. GF Casting Solutions Leipzig GmbH prints the cores for the hydraulic rotary transmission with ceramic sand and a cold-hardening phenol (CHP) binder. The foundry exploits the good properties of the 3D printer's single component binder system, such as high-temperature resistance, good disintegration properties, and low core cleaning effort. Due to the long resistance at high temperatures compared to conventional cold box binders, high dimensional accuracy and clean interiors can be ensured for very thin channels.

Further benefits of hybrid mold and core production

Beyond the benefits specific to the hybrid production strategy, the foundries in ExOne's study reported that the integration of 3D printing technology into their traditional ways of manufacturing has also given them several further advantages such as driving business growth, localizing manufacturing, improving productivity, and sustainable manufacturing (fig. 5).

Download ExOne whitepaper to learn more about it:
teamdm.com/X1-hybrid-production.

To get the complete report from ExOne, please scan the QR code

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THE KEY to Casting Industry Suppliers

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🌍: www.keytocasting.com

08 Plants and Machines for Moulding and Coremaking Processes

08.02 Moulding and Coremaking Machines

▼ Multi-Stage Vacuum Process 3223

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35614 Asslar, Germany
☎ +49 6441 802-1190
E-Mail: andreas.wuerz@pfeiffer-vacuum.com
Internet: www.pfeiffer-vacuum.com

09 Moulding Sands

09.01 Basic Moulding Sands

▼ Chromite Sands 3630

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Internet: www.gtp-schaefer.com

▼ Ceramic Sands/Chamotte Sands 3645

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E-Mail: info@gtp-schaefer.de
Internet: www.gtp-schaefer.com

09.06 Moulding Sands Testing

▼ Moisture Testing Equipment for Moulding Sand 4410

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

▼ Moulding Sand Testing Equipment, in general 4420

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

10 Sand Conditioning and Reclamation

10.01 Moulding Sand Conditioning

▼ Aerators for Moulding Sand Ready-to-Use 4470

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

▼ Sand Preparation Plants and Machines 4480

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

▼ Mixers 4520

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

▼ Sand Mixers 4550

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
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▼ Aerators 4560

Maschinenfabrik Gustav Eirich GmbH & Co KG
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Internet: www.eirich.de

▼ Scales and Weighing Control 4590

Maschinenfabrik Gustav Eirich GmbH & Co KG
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10.04 Sand Reconditioning

▼ Sand Coolers 4720

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Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

12 Gating and Feeding

▼ Breaker Cores 5340

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▼ Exothermic Products 5360

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Internet: www.gtp-schaefer.com

▼ Insulating Sleeves 5375

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▼ Exothermic Mini-Feeders 5400

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▼ Exothermic Feeder Sleeves 5420

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▼ Exothermic Feeding Compounds 5430

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E-Mail: info@gtp-schaefer.de
Internet: www.gtp-schaefer.com

13 Casting Machines and Equipment

13.02 Die Casting and Accessories

▼ Multi-Stage Vacuum Process 5876

Pfeiffer Vacuum GmbH
35614 Asslar, Germany
☎ +49 6441 802-1190
E-Mail: andreas.wuerz@pfeiffer-vacuum.com
Internet: www.pfeiffer-vacuum.com

17 Surface Treatment and Drying

▼ Heat Treatment and Drying 7398

Gebr. Löcher Glüherei GmbH
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Internet: www.loecher-glueherei.de

18 Plant, Transport, Stock, and Handling Engineering

18.01 Continuous Conveyors and Accessories

▼ Vibratory Motors 7980

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E-Mail: info@friedrich-schwingtechnik.de
Internet: www.friedrich-schwingtechnik.de

20 Control Systems and Automation

20.01 Control and Adjustment Systems

▼ Automation and Control for Sand Preparation 9030

Maschinenfabrik Gustav Eirich GmbH & Co KG
Walldürner Str. 50, 74736 Hardheim, Germany
Internet: www.eirich.de

20.02 Measuring and Control Instruments

▼ Immersion Thermo Couples 9230

MINKON GmbH
Heinrich-Hertz-Str. 30-32, 40699 Erkrath, Germany
☎ +49 211 209908-0 🖷 +49 211 209908-90
E-Mail: info@minkon.de
Internet: www.minkon.de

▼ Laser Measurement Techniques 9310

POLYTEC GmbH
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E-Mail: Lm@polytec.de
Internet: www.polytec.de

▼ Positioning Control 9345

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▼ Temperature Measurement 9380

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E-Mail: info@minkon.de
Internet: www.minkon.de

▼ Thermal Analysis Equipment 9400

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E-Mail: info@minkon.de
Internet: www.minkon.de

▼ Thermo Couples 9410

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☎ +49 211 209908-0 🖷 +49 211 209908-90
E-Mail: info@minkon.de
Internet: www.minkon.de

20.03 Data Acquisition and Processing

▼ Numerical Solidification Analysis and Process Simulation 9500

MAGMA Giessereitechnologie GmbH
Kackertstr. 16-18, 52072 Aachen, Germany
☎ +49 241 88901-0
E-Mail: info@magmasoft.de
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▼ Numerical Solidification Simulation and Process Optimization 9502

MAGMA Giessereitechnologie GmbH
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E-Mail: info@magmasoft.de
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▼ Simulation Software 9522

MAGMA Giessereitechnologie GmbH
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Internet: www.magmasoft.com

22 Analysis Technique and Laboratory Equipment

▼ Sampling Systems 9970

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24 Environmental Protection and Disposal

▼ Waste Disposal, Repreparation, and Utilization 24.03

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Brunnenstraße 138 , 44536 Lünen
☎ +49 2306 106 8831
Internet: Germany
E-Mail: yannik.droste@remondis.de
Internet: www.legran.de

26 Other Products for Casting Industry

26.02 Industrial Commodities

▼ Joints, Asbestos-free 11120

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▼ Sealing and Insulating Products up to 1260 øC 11125

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27 Consulting and Service

▼ Simulation Services 11310

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▼ Heat Treatment 11345

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Internet: www.loecher-glueherei.de

28 Castings

▼ Aluminium Pressure Diecasting 11390

Schött Druckguß GmbH
Aluminium Die Casting
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Internet: www.schoett-druckguss.de

30 Data Processing Technology

▼ Mold Filling and Solidification Simulation 11700

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www.hannovermesse.de/en

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May, 19-21, 2024, Fukuoka, Japan
www.intlmag.org/event/annual-mg-conference-2024

CastForge 2024
June, 4-6, 2024, Stuttgart, Germany
www.messe-stuttgart.de/castforge/en

Intermold Die & Mold Asia
June, 26-28, 2024, Nagoya, Japan
www.intermold.jp/english

64th IFC PORTOROZ 2024
September, 18-20, 2024, Portoroz, Slovenia
www.drustvo-livarjev.si

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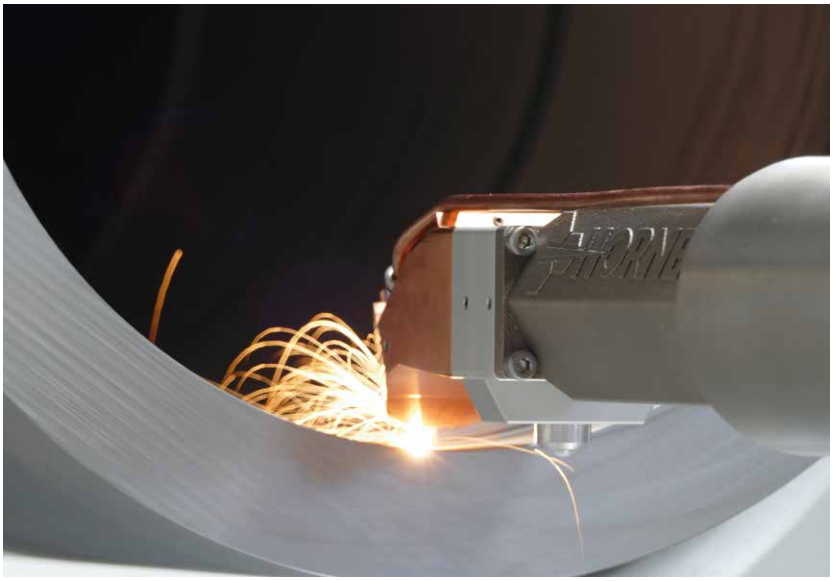

Photo: RWTH AACHEN

Repair of the inner surface of a casting container using laser cladding.

Preview of the next issue

Selection of topics:

Magnesium die casting: Additive manufacturing as a pioneering repair technology

A high cost factor in the die casting process is the wear and tear of the casting container with its its corresponding accessories. Special alloys are used to facilitate repair without changing the diameter and improve wear resistance and thus also increase the possible number of shots.

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The subject is a hot-air-curing inorganic core-making process, which works without an actively heated core making tool works.

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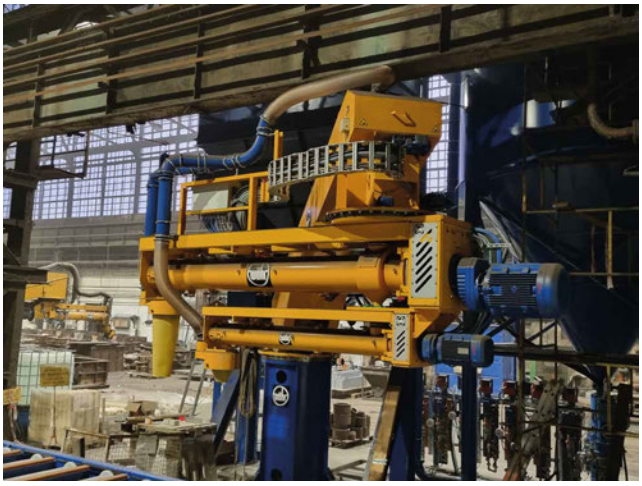
AAGM Aalener Gießereimaschinen GmbH

150 Jahre wöhr

> Continuous whirl mixers
for cold-resin-bonded mouldingsands

> Reclamation plants
> Moulding plants

Continuous whirl mixer 20-60t/h | 3-10t/h
Känguru, double joint, stationary



Technical data of the continuous whirl mixer

Version:	Känguru, double joint, stationary
Geometry:	Whirler SiO2 3,0m | Cr2O3 2,0m Band conveyor 4,5m
Performance:	SiO2 20-60t/h | Cr2O3 3-10t/h
Dischage height:	1,8m
Media:	Alphaset (3 components), 3 types of sand
Optionals:	Fully automatic flow control for binder, Temperature-dependent curing agent dosing, Dosing pressure monitoring, Dedusting unit, Radio remote control, Sand silo three types of sand 24to, Sand silo one type of sand 110to

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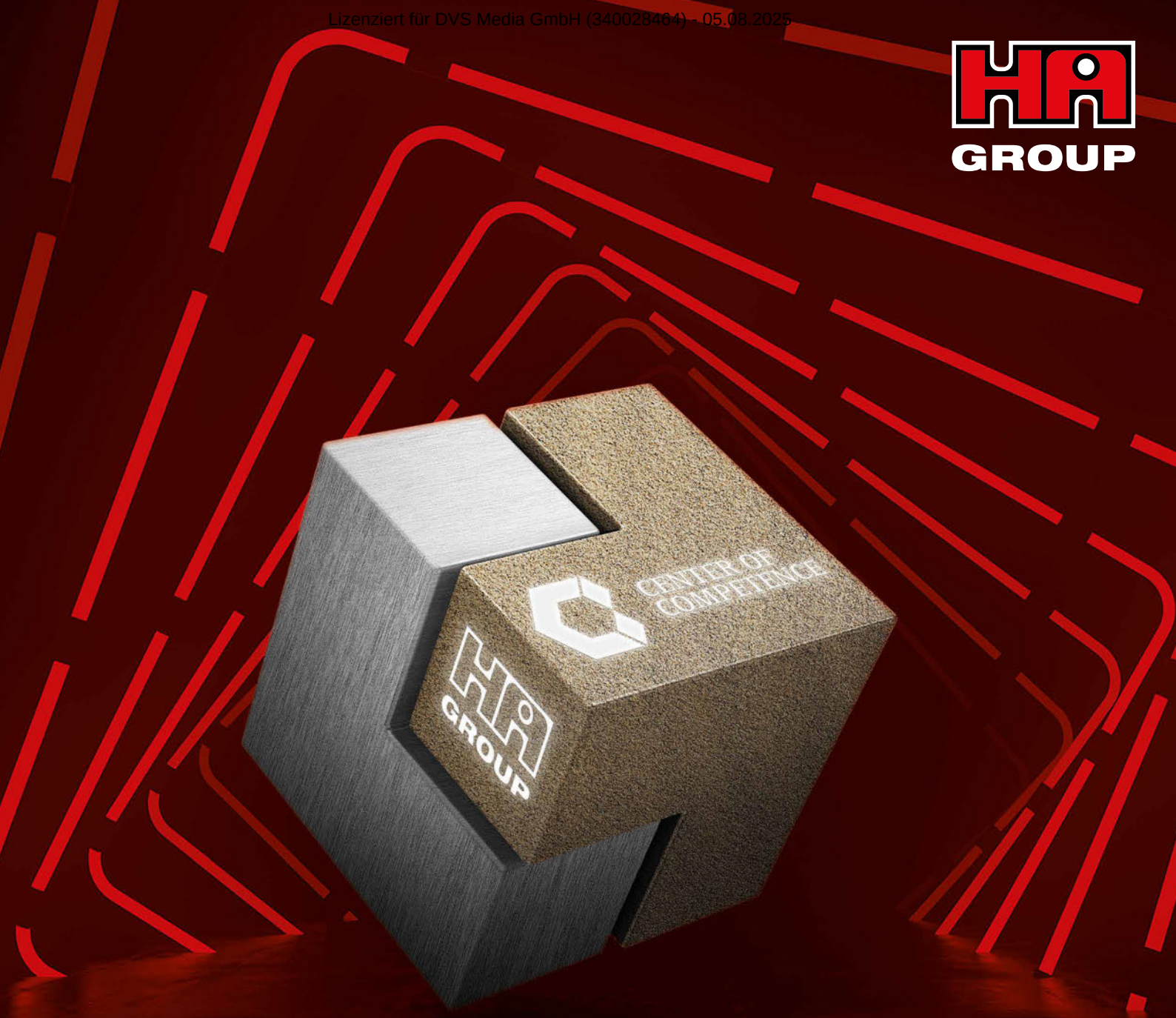

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