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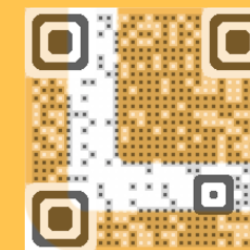
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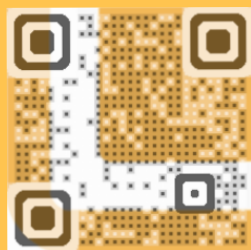


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Andrew Stack
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AFS RECASTING METALCASTING CONGRESS 2020

RECASTING METALCASTING
CONGRESS 2020

To Our Members and Friends,

Just a few months ago, this page was reserved to welcome you to the industrial city of Cleveland and to Metalcasting Congress 2020. Instead, I am writing to convey insightful technical and management information that was to have been presented at Congress.

Like you, the American Foundry Society was deeply disappointed by the cancellation of Metalcasting Congress. We know that many casting producers, buyers, and suppliers plan their yearly calendar around participating in this event. That's why we are striving to provide you with resources, such as this Recast Guide to Congress, that will provide some of the technical and management knowledge, industry intelligence, and supplier insight you expect from Metalcasting Congress.

In this Guide, you'll find abstracts and links to dozens of research papers and presentations, profiles of industry suppliers, contact information for companies across the supply chain, information about award-winners and other industry leaders, and much more. We hope this valuable information helps you keep a leg up on future opportunities and stay connected to our industry during this difficult period.

I want to express deep gratitude on behalf of the Society to our sponsors, exhibitors, and registrants. We are thankful for your unwavering support, and we are humbled by the many Continuity Contributors, listed on our website, who are helping AFS bridge the gap until next year's event by contributing back some portion of their registration or exhibit fees. Your support will help us continue our vital mission of advocacy, education, and innovation for metalcasters.

Metalcasting Congress is a proud tradition that dates back 124 years. It's also a resilient one, reflecting the indomitable spirit of our industry and the hard-working people who move it forward. We will all be back, stronger and more eager than ever to present new information and network with our peers. Next year, we'll celebrate the 125th anniversary of AFS at Metalcasting Congress 2021 on April 13-15, 2021, in Milwaukee. Now, more than ever, we look forward to seeing you there.



Sincerely,

Doug Kurkul
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2020 CONGRESS

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2020 PROCEEDINGS ABSTRACTS

ADDITIVE MANUFACTURING DIVISION

LARGE SCALE ADDITIVELY MANUFACTURED NOBAKE PATTERNS (2020-041)

Andrew Pike, Joel Busler, Alex Uchida, Mueller Co.,
Chattanooga, TN

Patterns for large nobake patterns have traditionally used wood as a material for making cavity impressions. This has posed challenges to producing consistent castings, as wood will swell and shrink under different levels of temperature and humidity, leading to a phenomenon of dimensional seasonality. As polymers are typically more resistant to these effects, so they have been used by patternmakers for some time. However, urethanes typically have been limited to small- and medium-sized work. There are challenges to using non-traditional materials for large nobake pattern impressions, but they can be overcome with careful planning and implementation.

Full Paper at www.afsinc.org/2020-041.

CHARACTERISTICS OF MATERIALS REQUIRED FOR HIGH SPEED SAND PRINTING (2020-056)

Jerry Thiel, University of Northern Iowa, Cedar Falls, IA;
Nathaniel Bryant, Imerys, Suwanee, GA; Kip Woods,
Emerson Automation Solutions, Marshalltown, IA

Extensive studies have been conducted to determine optimum characteristics of 3D sand printing materials. These studies have resulted in the development of many regionally available materials that both reduce the cost of sand printing while extending its capabilities. Lowering the operational cost while extending the capabilities has an indirect effect of increasing the rate of industry adoption. Understanding the characteristics of the materials used in sand printing will allow future increases in speed and efficiency, moving the technology from service centers to typical small business foundries.

Full Paper at www.afsinc.org/2020-056.

PORE NETWORK IN 3D SAND-PRINTED MOLDS: A COMPUTED TOMOGRAPHY SCANNING STUDY (2020-061)

Daniel Martinez, Philip King, Guha Manogharan,
Department of Mechanical Engineering, Pennsylvania
State University, University Park, PA;

Timothy Stecko, Center for Quantitative Imaging,
Pennsylvania State University, University Park,
PA

In sand casting, there is a need to critically balance mold strength and porosity to promote handling strength and outgassing respectively. The effect of binder concentration in 3D sand-printed molds for metalcasting applications is examined using Micro Computed Tomography (Micro-CT). Characterization of porosity and pore network are performed on sand molds with six different levels of binder concentration. Porosity is found to range between 39% and 43% which will influence outgassing during metal pouring. Air flow simulations are performed to examine its effects on permeability along different directions with respect to print direction. Results show an increase in tortuosity as well as a reduction in permeability along the direction orthogonal to the printing plane. Findings from this study can lead to fabricating sand molds via 3D Sand-printing by selectively engineering pore networks within the mold to increase degassing in critical sections.

Full Paper at www.afsinc.org/2020-061.

ALUMINUM DIVISION

ENHANCED MECHANICAL PROPERTIES OF HIGH-PRESSURE VACUUM DIE CASTINGS OF AL-SI-MG FOUNDRY ALLOYS BY ZR, V AND MO ADDITIONS (2020-005)

Zhan Zhang, Anil Arici, David Levasseur, University of
Quebec at Chicoutimi, Chicoutimi, QC; Francis Breton, Rio
Tinto, Saguenay, QC; X-Grant Chen, University of Quebec
at Chicoutimi, Chicoutimi, QC

The application of high-performance vacuum control has allowed production of structural parts in high pressure die-casting and promotes development of heat-treatable aluminum die cast alloys. In this study, the effects of Zr, V, and Mo on tensile properties in as-cast, T5 and T6 conditions for two AlSi8Mg and AlSi10Mg alloys cast by high pressure vacuum die casting process were investigated. The results revealed that the combined addition of Zr, V and Mo improved both strength and elongation, while combined addition of Zr and V enhanced tensile strength but not elongation under as-cast condition. T5 treatments strongly improved yield strength but had a negative impact on elongation. Meanwhile, T6 treatments increased the elongation while maintaining the highest level of strengths. The microstructure features, such as grain size, intermetallic phases, dispersoids and precipitates, were quantitatively analyzed to understand the effects of such transition elements on the mechanical properties.

Full Paper at www.afsinc.org/2020-005.

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MECHANICAL AND METALLURGICAL PROPERTIES OF ALUMINUM A356 ROTORS POURED IN PRINTED MOLDS (2020-006)

Franco Chiesa, Fabien Lanicot, David Levasseur, Jocelyn Baril, Gheorghe Marin, Quebec Metallurgy Center, Trois-Rivières, QC

Aluminum A356 compressor rotors were sand cast into printed molds; most were poured by low pressure and some by gravity. The casting was small (170mm in diameter, 1.2kg) and very intricate in shape, lending itself particularly well to 3D mold printing. Producing this casting by the traditional pattern-core box route would involve mounting 12 cores inside the mold with very stringent dimensional tolerance as the rotor blades are 2mm thick. The metallurgical quality of the low-pressure poured castings were compared via metallographic analyses in the hub and in the blades. The tensile properties of the hub and blades in the T6 conditions were also measured for low-pressure and gravity filled rotors.

Full Paper at www.afsinc.org/2020-006.

SIMULATION DRIVEN ANALYSIS OF SHOT END OPERATING PARAMETERS AND THEIR IMPACT ON THE FLUID DYNAMICAL EVOLUTION OF THE ALLOY IN A HORIZONTAL COLD CHAMBER HPDC PROCESS (2020-010)

Maximilian M. Rudack, Andreas Bührig-Polaczek, Uwe Vroomen, Foundry Institute RWTH Aachen University, Aachen, North Rhine-Westphalia, Germany

The fluid dynamical and thermal evolution of an A365 alloy during the dosing and filling sub cycle phases of a HPDC process is analyzed numerically in the shot sleeve as well as in the cavity. A shot curve that yielded minimal air entrainment when using a filled shot sleeve with a stationary, settled melt as the initial condition was determined. This shot curve was then exposed to initial melt conditions that were the result of a shot sleeve dosing process and therefore did include residual wave movement to varying degrees. A full factorial numerically driven design of experiments with 24 combinations and 4 distinct dosing times from 3 s to 6 s as well as 5 dwell times from 0 s to 2.5 s was calculated to gain insights into the interdependencies of these two process parameters. The qualitative change of wave dynamics and the resulting temperature field is assessed.

Full Paper at www.afsinc.org/2020-010.

HARDNESS TESTING METHODS AND THEIR APPLICABILITY (2020-012)

Devin Hess, Herbert Doty, General Motors, Pontiac, MI

Hardness is one of the most commonly specified requirements on automotive propulsion system engineering drawings. It is used as a process control check and as a proxy for strength, wear resistance, and machinability. It is commonly assumed harder means stronger, and while this is generally true, what are we really controlling when we measure hardness. Depending on the material and the manufacturing process, hardness can be used to verify that the material has been exposed to the appropriate thermal conditions and the proper microstructure is present. This session explores some of the issues that can arise when trying to compare between different scales within a given test method and when trying to convert from one test method to another and offers some rationale for these limitations. The focus of this paper is limited to cast iron and aluminum engine components and the Brinell, Rockwell, and Equotip test methods.

Full Paper at www.afsinc.org/2020-012.

DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL SETUP TO INVESTIGATE AND INFLUENCE COMPONENT DISTORTION IN GRAVITY DIE CASTING (2020-016)

Nino Wolff, Uwe Vroomen, Andreas Bührig-Polaczek, Foundry Institute of RWTH Aachen University, Aachen, Germany

Distortion, residual stresses and hot cracks can facilitate significant decreases in quality characteristics of casting products. Their reduction by a suitable component design and process control is therefore desirable. In the casting process, these characteristics are a result of the combination of solidification shrinkage paired with the local self-feeding and the geometric constraints imposed on the component by the mold. In permanent mold casting with thermally well conducting and rigid metal molds, the control of solidification through a localized adjustment of the heat balance appears to be a suitable approach to minimize these effects. The development of an experimental setup for the assessment of the interdependencies of the alloy, casting geometry and cooling are described in this work. Numerical simulations and a first series of experiments with aluminum are presented. Furthermore, the approach to improve the understanding of the underlying mechanisms is outlined and evaluated.

Full Paper at www.afsinc.org/2020-016.

EVALUATION OF NEW ALSI9CUMG CAST ALUMINUM ALLOYS FOR AUTOMOTIVE CYLINDER HEADS (2020-018)

Lei Pan, Francis Breton, Rio Tinto, Saguenay, QC

Application of foundry aluminum alloys in cylinder heads has been a significant lightweighting achievement in the automotive industry. Progress in fuel efficiency and performance of internal combustion engines have led to an increase in the engine operating temperature and pressure, thus leading the high drive for developing high temperature aluminum. This presentation reports a comparative property evaluation of a current commercial cylinder head alloy (A356+0.5Cu) and two new alloys (AlSi9Cu2 and AlSi9Cu3.5).

Full Paper at www.afsinc.org/2020-018.

PREDICTION OF ENTRAINED OXIDE INCLUSIONS AND OXIDE INDUCED DEFECTS DURING DIRECTIONAL FLOW IN ALUMINUM CASTING (2020-029)

Colin D. Ridgeway, The Ohio State University, Columbus, OH; Keith Ripplinger, Honda Engineering North America, Anna, OH; Duane Detwiler, Honda R&D Americas, Raymond, OH; Alan. A. Luo, The Ohio State University, Columbus, OH

It is well known that the entrainment of double oxide bifilms formed during flow and solidification has detrimental effects on the mechanical properties of cast aluminum products. Degassing, filtration and metal flow design are generally employed to reduce the presence of entrained defects, yet, oxide bifilms are still present in a majority of castings and their locations are often unknown, leading to severe quality issues. In this work, a new model, termed Oxide Entrainment Number (OEN), is proposed to predict the location and severity of bifilms and oxide induced defects in final cast structures. The model is developed by examining bifilms formation events and tracks newly formed bifilms via free surface tracking. Simple geometry patterns promoting directional flow were designed to compare the defect location and severity in optimal vs sub-optimal flow conditions. The proposed OEN model has been coupled with ProCAST (defined as Software 1 from this point on in this paper) and experimentally validated with aluminum A356 casting.

Full Paper at www.afsinc.org/2020-029.

QUANTIFYING CASTING QUALITY THROUGH FILLING CONDITIONS (2020-051)

Daniel Hoefert, Eck Industries, Inc., Manitowoc, WI

Focused concern and education related to filling damage and oxide inclusions has been widely promoted among the foundry industry in the past three decades, with special regards to aluminum. However, predicting the quantifiable damage that oxide film may cause to the quality of aluminum castings during the filling process remains largely theoretical, due to a lack of supporting data. The purpose of this experiment was to turn on and turn off turbulent filling conditions consistent with bifilm entrainment, in order to obtain the needed data required to predict the actual porosity and tensile damage these conditions may cause to aluminum castings. Filling conditions ranging from tranquil to turbulent were generated within a test casting by means of three different gravity-fill gating systems. Alloys trialed in the study were C355, A356, E357 and A206. Radiography and tensile testing were used to quantify the resulting damage with SEM analysis of fracture surfaces.

Full Paper at www.afsinc.org/2020-051.

INCLUSIONS IN ALUMINUM CASTINGS BY SEM CHARACTERIZATION (2020-052)

Rafael Gallo, Pyrotek Inc., Aurora, OH

Successful elimination of inclusion defects in castings requires proper collection and data analysis. Finding the root cause of inclusion defects poses great complexity because of the wide range of interdependent molten metal and casting process contributing factors. Statistical techniques can help correlate the effects of variables and establish priorities for problem solving. Yet, these techniques are inconsequential if a casting inclusion is improperly diagnosed. Having a notion of the level of molten cleanliness is just a part of a solution to eliminate inclusions related scrap in castings. Equally important parts of the solution are establishing a correlation between inclusions in the molten bath and in the castings, finding the root cause, implementing the proper corrective action, continuous monitoring of the solution, and understanding of the casting process. This session provides SEM characterization of inclusions in castings. It highlights the importance of proper inclusion identification and casting process knowledge.

Full Paper at www.afsinc.org/2020-052.

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EFFECT OF DEFECT SIZE ON TENSILE ELONGATION IN ALUMINUM CASTINGS (2020-085)

Anthony Koprowski, Qigui Wang, Peggy Jones, Thomas Gustafson, General Motors, Pontiac, MI

This presentation will study the effect of defect size (area) on percent elongation of tensile bars for various alloys, heat treatments, bar types, and bar sizes. Although this particular study will not take into account the effect of the type of defects, i.e. gas, shrink, intermetallic, etc., nor will it take into account as-cast skin on die cast tensile bars, irregular shapes of flat tensile bars cut from parts, it will look at the effect that total defect volume versus the fracture surface area has on the percent elongation of the test bar. It will show that there is good correlation to total defect size and the reduction of percent elongation on the samples.

Full Paper at www.afsinc.org/2020-085.

CASTING DESIGNERS & BUYERS

BENEFITING FROM LIFE CYCLE ANALYSES (2020-021)

Jeremy Lipshaw, Ferndale, MI

The casting supply chain has an opportunity to leverage the inherent strengths of its product into a competitive advantage by embracing sustainability assessments based on Life Cycle Analysis (LCA). While classical vehicle sustainability metrics primarily consider how materials affect fuel economy via lightweighting, LCA accounts for the entire lifecycle of the material or product, including the production, use, and end-of-life. Due to their recyclability and lower embodied energy, castings have the potential to be more sustainable in this framework. However, the casting industry is underprepared to compete in LCA-based evaluations. There is little data on the casting process to aid the development of LCAs. Furthermore, the well-documented and inaccurate perception problem within industry that castings are heavy and outdated discourages researchers from considering this line of study. This session talks about how the casting industry would benefit from LCA-based sustainability metrics.

Full Paper at www.afsinc.org/2020-021.

CAST IRON DIVISION

EFFECT OF ANTIMONY ON THE NUCLEATION PROCESS OF SPHEROIDAL GRAPHITE IRON (2020-004)

Gorka Alonso, Ramon Suarez, IK4-Azterlan, Durango, Bix Kaia, Spain; Dr. Doru Stefanescu, The Ohio State University and University of Alabama, Dublin, OH

To further understand the influence of the subversive elements on the nucleation process of spheroidal graphite, melts with antimony contents ranging from 0% to 0.0036% Sb were produced and poured into standard thermal analysis cups, which were quenched at increasing times. Two different inoculants rich in Ce and Al were used. Nucleation sites were characterized through spectrums, mapping and line scans of a FEG-SEM equipment. In most cases, Mg-Si-Al nitrides and Mg-Ca sulfides appeared to be the main nuclei, regardless of inoculation. The influence of these complex nitrides on the growth of graphite was determined. The presence of RE-inclusions in the nucleus of the graphite was very limited because of the lack of La and Ce in the Mg-treatment alloy. Sb can appear as inclusions in the matrix, spiky graphite or nucleation sites for ill-formed spheroidal graphite, depending on its content. Some dendritic graphite nucleating on Ca-inclusions was detected.

Full Paper at www.afsinc.org/2020-004.

FURTHER EVALUATING IRON FILTER PRINT DESIGNS USING QUANTITATIVE ANALYSES (2020-053)

Tony Midea, Foseco, Brookpark, OH

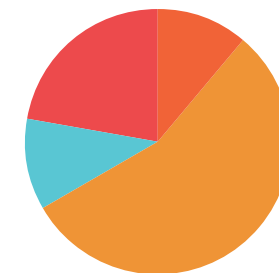
Properly filtering iron castings involves utilizing the most optimally engineered filter print and gating system designs to ensure delivery of the cleanest and least turbulent metal to the mold cavity. This session highlights a study that coupled quantitative analyses with qualitative analyses to ensure the best filter print designs were being recommended. Results from the quantitative analyses shown in this paper support the recommendations from a 2017 study and provide further insight on best practice filter print designs.

Full Paper at www.afsinc.org/2020-053.



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ENGINEERING DIVISION

DETERMINATION OF THE HEAT TRANSFER COEFFICIENT VIA INVERSE SIMULATION FOR AIR GAP AND CONTACT PRESSURE DOMINATED INTERFACES IN GRAVITY DIE CASTING PROCESSES (2020-023)

Thomas Vossel, Björn Pustal, Andreas Bührig-Polaczek, RWTH Aachen University, Aachen, Germany

A casting process is defined by its heat balance as the essential process characteristic. It describes the cooling and the resulting liquid-solid phase change inside the casting system. Investigating the heat transfer from the melt into the mold or core thus always has been a focus of foundry research. Especially for numerical simulations, modeling of the heat transfer coefficients at the respective interfaces is key for properly predicting the phenomena during a casting process. This paper evaluates the heat transfer when casting the aluminum alloy A356 in a gravity die casting process. Here a single description for the

development of the heat transfer coefficients cannot be applied as different boundary conditions can have a strong impact on their value and development. Hence an inverse simulation is applied to parametrize the heat transfer coefficients present in regions dominated by air gap and contact pressure formation respectively.

Full Paper at www.afsinc.org/2020-023.

PROPOSAL FOR AN ALTERNATIVE TRANSPARENT FLUID MODEL THAT CAN EMULATE OXIDE FILMS IN CASTINGS (2020-060)

Scott Giese, Mark McAllister, Andres Segura, University of Northern Iowa, Cedar Falls, IA

The goal of the research work was to explore the feasibility of using phenolic urethane as a transparent fluid material to investigate air entrainment mechanism. Use of the phenolic urethane cold box (PUCB) binder system allowed the liquid combined resin to develop viscosity properties within the range of viscous liquid and permitted a thin, solid film to form on the surface without completely catalyzing the resin. Through the observational tests, it was found that the amine and the binder solution react quickly to create thin films. Other observational tests explored the film's elasticity and mechanical characteristics for various resin and dilution ratios. Physical property tests showed that the formulation of the films can be altered to affect the strength and flexibility of the films. This could allow for the customization of the fluid and film to mimic a metal and oxide of choice.

Full Paper at www.afsinc.org/2020-060.

ENVIRONMENTAL, HEALTH, AND SAFETY DIVISION

ALTERNATE MATERIAL REPLACING N-METHYL-2-PYRROLIDONE AS A FOUNDRY TOOL CLEANER (2020-030)

Thuwarakai Kunanesam; Paula Vivas, Lee Horvath, ASK Chemicals LLC, Cuyahoga Heights, OH

N-Methyl-2-Pyrrolidone (NMP) has been in use in pure or blended form with other solvents in the foundry industry as a cleaner to remove resin build up on metal tooling. EPA has identified NMP as a high-priority chemical based on risks posed. On January 12, 2017, EPA proposed two approaches to manage risks of NMP in North America. One would be to prohibit import or restrict manufacture of formulations containing NMP and secondly to limit the amount to no more than 35 percent by weight. Based on how effective high levels of NMP has been in cleaning metal tools, it is evident that an alternate solvent in pure or as a mixture with other solvents had to be tested to replace NMP. A blended material is evaluated as a replacement for NMP.

Full Paper at www.afsinc.org/2020-030.

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MOLDING DIVISION

EVALUATION OF SOUTH AFRICAN CHROMITE SAND SINTERING BEHAVIOUR (2020-017)

Jonathan K Kabasele, Didier K Nyembwe, Onyeka F Ochonogor, University of Johannesburg, Johannesburg, Gauteng, South Africa

Research was conducted on six different types of South African chromite sand samples: Lil Sales, Insimbi, S11594, Rand York, Pentagon and Mineral Loy. The aim of the experiment was to determine foundry properties of chromite sand that affect its sintering temperature.

Three foundry properties of chromite sand were studied: turbidity, percentage of fine particles, and percentage of silica content. The approach selected to perform the sintering test was the VDG procedure 26 from the German foundry association. The test observed the sintering behavior of chromite sand over a range of temperature to identify its sintering temperature.

Using simple linear regression analysis, it was concluded that the presence of impurities, high silica content and fine particles decreases significantly the sintering temperature of chromite sand, which can contribute to an increase in the occurrence of casting defects.

Full Paper at www.afsinc.org/2020-017.

PREDICTION OF DOUBLE-SKIN METAL PENETRATION IN CHROMITE SAND USING PROCESS SIMULATION SOFTWARE (2020-040)

Nathaniel Bryant, Imerys, Suwanee, GA; **Sairam Ravi, Jerry Thiel**, University of Northern Iowa, Cedar Falls, IA

The University of Northern Iowa has completed the first stage of research into the development of an algorithm to predict double-skin penetration, a defect associated specifically with chromite sand. This algorithm was created based on a methodology used to measure the performance of chromite sand at elevated temperatures. Consequently, the methodology offers results as a function of temperature. By combining the temperature results generated by commercial process simulation software with the proposed user algorithm, several areas of concern on a casting design may be identified for the user.

Full Paper at www.afsinc.org/2020-040.

RECLAIMING ACTIVE CLAY AND CARBON: DETERMINING THE IMPACT OF PROCESSING VARIABLES (2020-048)

Liam Miller, American Colloid Co., Hoffman Estates, IL; **Elliot Halphen**, Minerals Technologies Inc., Broussard, LA; **Jerald Darlington**, Minerals Technologies Inc., Hoffman Estates, IL

Commercially available clay and carbon reclamation technologies from foundry streams show a common theme of hydrating and agitating the foundry solids in water. The goal is to separate the active clay and carbon from the degraded and dead clay, ash, and sand in order to return the active components to the green sand system in a slurry, called blackwater. A trial reclamation unit was used to model clay and carbon reclamation scenarios from foundry sources. Using a waste stream obtained from pneumatic sand reclamation of sand in a ferrous foundry, a factorial Design of Experiments was used to evaluate the impact of processing variables on active clay and carbon recovery. This study presents laboratory and trial test results used to model active clay and carbon recovery from this foundry stream. The results of this study show that changing process variables can dramatically impact the recovery of active components.

Full Paper at www.afsinc.org/2020-048.

SAND PROCESSING METHODS SHOW REDUCTION OF RESPIRABLE SILICA FOR THE FOUNDRY INDUSTRY (2020-057)

Jerry Thiel, Sairam Ravi, University of Northern Iowa, Cedar Falls, IA

Research into the breakdown of silica sand through mechanical attrition has led University of Northern Iowa researchers to information that could reduce the generation of respirable silica dust in the foundry. Although the results of the testing are preliminary, the information sheds new light at the current issue of meeting recent changes to the permissible exposure limit for respirable silica. This new information could allow some foundries that are at risk to meet the new regulations without extensive engineering solutions or material changes. The research demonstrates current technologies that can be used to reduce silica breakdown and control respirable silica.

Full Paper at www.afsinc.org/2020-057.

EVALUATION OF ALTERNATE AGGREGATES FOR USE IN GREEN SAND AND CORE SAND PROCESSES (2020-058)

Sairam Ravi, Jerry Thiel, University of Northern Iowa, Cedar Falls, IA

Commercially available ceramic sands were evaluated for the replacement of silica sand in chemically bonded and bentonite bonded sand systems. The bentonite bonded sand was reclaimed and reused in chemically bonded cores used in the testing. Since no new aggregate was introduced during the testing, the system was considered closed loop. The testing showed that the ceramic sands exhibited superior results in mechanical properties, break-down due to mechanical attrition, and casting quality performance.

Full Paper at www.afsinc.org/2020-058.

A NEW MEASURE FOR ACTIVE CLAY IN GREEN SAND (2020-062)

Andreas Decher, Andreas Decher, Minerals.Services, Wenden; Sam Ramrattan, Western Michigan University, Kalamazoo, MI

An alternative approach to measure active clay in green sand has been developed. The new technique is based on dye absorption and uses a spectrophotometer to detect the amount of active clay present in a green sand sample. This study investigated a commercially available, organic and nonhazardous dye. The test procedure can discriminate among various levels of sodium and calcium bentonite standards in silica sand. Results with the new approach shows repeatability with acceptable test-to test variability when measuring standard active clay levels from 2 to 12% and on samples of green sand from working foundries.

Full Paper at www.afsinc.org/2020-062.

USE OF MULL-TO-ENERGY STRATEGIES FOR IMPROVED CONTROL OF GREEN SAND SYSTEMS (2020-071)

Rose Torielli, Robert Voigt, Viraj Lele, Penn State University, University Park, PA; James Furness, Furness-Newburge Inc., Versailles, KY; Eric Nelson, Dotson Iron Castings, Mankato, MN; Frank Headington, American Foundry Society, Schaumburg, IL; Steve Lewallen, Clean Tech Partners, Middleton, WI

The control of production green sand systems in iron foundries has been improved by controlling batch-to-batch mulling energy instead of controlling batch mulling time. Before and after sand system control data from three production foundry green sand systems that have transitioned from mulling time control to mulling energy control will be presented. Unnecessary over-mulling can be eliminated, increasing miller throughput. Sand properties and sand related casting scrap are not impacted. Further research topics for extending this strategy are discussed including continuous mulling.

Full Paper at www.afsinc.org/2020-071.

QUALIFICATION CASE STUDY FOR CHEMICALLY BONDED SAND SYSTEM (2020-074)

Lee Wells, Sam Ramrattan, Prayag Patel, Western Michigan University, Kalamazoo, MI

In this study, two different resin coated sand-binder systems with the same binder type and binder level but different sand origin as the in-control system were considered as out-of-control systems. These sands are round grain silica sands with similar silica content, grain fineness number, and sand grain shape. Casting trials suggests that casting surface quality from these three sand-binder systems are significantly different for gray iron, but similar for aluminum. Therefore, with respect to this case study, the ability to detect this shift (for a gray iron system) would help prevent surface-quality related losses.

Full Paper at www.afsinc.org/2020-074.

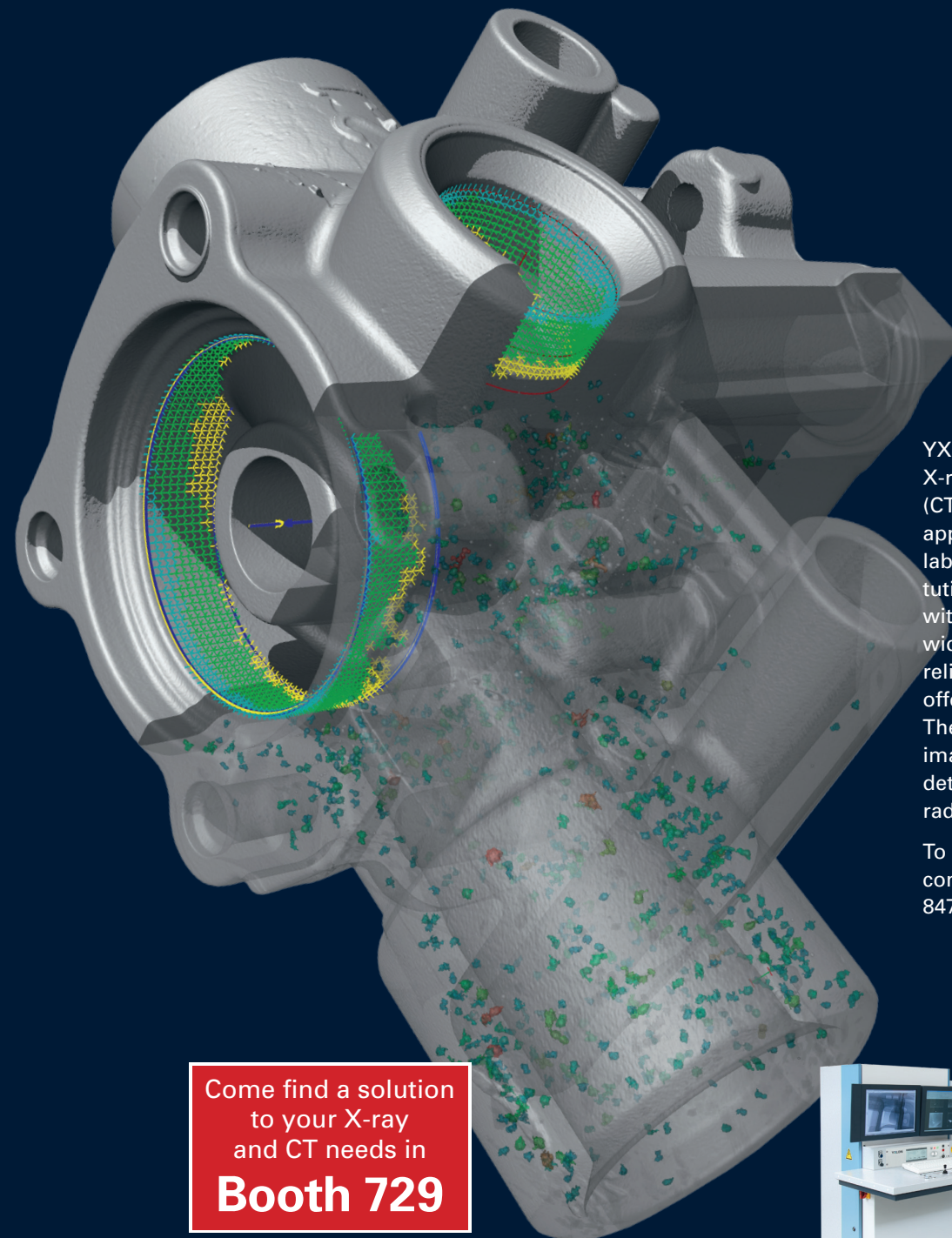
HYBRID SYSTEM FOR PRODUCING FUNCTIONAL CASTING PROTOTYPE (2020-075)

Pavel Ikononov, Sam Ramrattan, Western Michigan University, Kalamazoo, MI

A novel hybrid prototyping method using both additive and subtractive manufacturing techniques for cast metallic parts has been developed and implemented. It uses additive infrared light sintering (IRS) of a machinable mold material (MMM) and computer numerical control (CNC) machining methods. The hybrid approach is pattern-less and allows rapid mold development with complex geometry, high precision, and superior surface finish.

Full Paper at www.afsinc.org/2020-075.

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A CASTING TRIAL TO EVALUATE VARIOUS CHEMICALLY BONDED SAND DISC-SHAPED SPECIMENS FOR SURFACE FINISH AND EROSION DEFECTS (2020-076)

Milan Raval, Altair Engineering Inc., *Troy, MI*;
Sam Ramrattan, Western Michigan University, *Kalamazoo, MI*

Casting issues on thin wall surfaces and in complex geometry interface is not negligible and can result in costly defects. Foundries prefer chemically bonded sand mold over green sand when it comes to castings with thin-wall sections and complex internal dimensions. Still, interfacial defects in chemically bonded sand process are an issue. This paper addresses chemically bonded sand erosion and surface finish issues for aluminum and cast iron castings. Erosion in chemically bonded sand can occur when molten alloy dislodges grains of sand, resulting in a rough as-cast finish.

Based on a casting trial used to study the erosion in alternative green sand specimens; a new trial was developed to evaluate erosion on multiple chemically bonded sand specimens simultaneously. Gray cast iron and an aluminum alloy were delivered from controlled head pressures and temperatures to achieve a turbulent flow across chemically bonded sand specimens prior to solidification of the castings. Flow and solidification simulation of the casting trial model was conducted. The simulated predictions were evaluated along with results of aluminum and gray cast iron casting trials at two different head heights. Results show that in both alloys there are surface differences among the various chemically bonded sand systems studied.

Full Paper at www.afsinc.org/2020-076.

STEEL DIVISION

COMPARISON OF X80 PIPELINE STEEL MELTED UNDER ARGON ATMOSPHERE IN AIR INDUCTION AND VACUUM INDUCTION FURNACES (2020-046)

Kumar Sadayappan, **Delin Li**, **Colin Scott**,
CanmetMATERIALS, Natural Resources Canada,
Hamilton, ON, Canada

This session compares the cleanliness, microstructures and mechanical properties of X80 pipeline steel samples produced by air induction melting (AIM) versus vacuum induction melting (VIM).

Full Paper at www.afsinc.org/2020-046.

THERMAL ANALYSIS AND PROPERTIES OF 1030 WITH MG & TI ADDITIONS (2020-049)

Robert Tuttle, Saginaw Valley State University, *University Center, MI*

The work presented here examines additions of titanium and magnesium on their own and together in 1030. Mechanical testing, thermal analysis, and metallography were conducted on the heats. Additions of both magnesium and titanium produced the highest mechanical properties. The solidification structure was refined by all additions. Thermal analysis determined that magnesium increased the solidus.

Full Paper at www.afsinc.org/2020-049.

QUALITY

THE APPLICATION OF REASON'S GENERIC ERROR MODELING SYSTEM (GEMS) TO VISUAL INSPECTION: SUPPLEMENTARY INSIGHT INTO CATEGORIES, CAUSES AND PREVENTION OF ERRORS (2020-042)

Ted Schorn, Enkei America, Inc., *Columbus, IN*

In the 1980s, groundbreaking research was conducted in Denmark by Jens Rasmussen and in the U.S. by W.B. Rouse to formalize a more holistic understanding of the nature of human error leading to a model of human problem-solving and error categories. James Reason in the UK synthesized this earlier work into a generic error-modeling system (GEMS) in 1990. This model has wide applicability for the understanding of human error and has been applied to a variety of situations from piloting aircraft to surgeons in an operating room and operators in a nuclear powerplant control room. The presentation provides a description of the GEMS model with application to the performance of visual inspectors. Both decision-making and attentional errors are discussed using the GEMS model, providing new insights into both cause and prevention of human inspection errors.

Full Paper at www.afsinc.org/2020-042.

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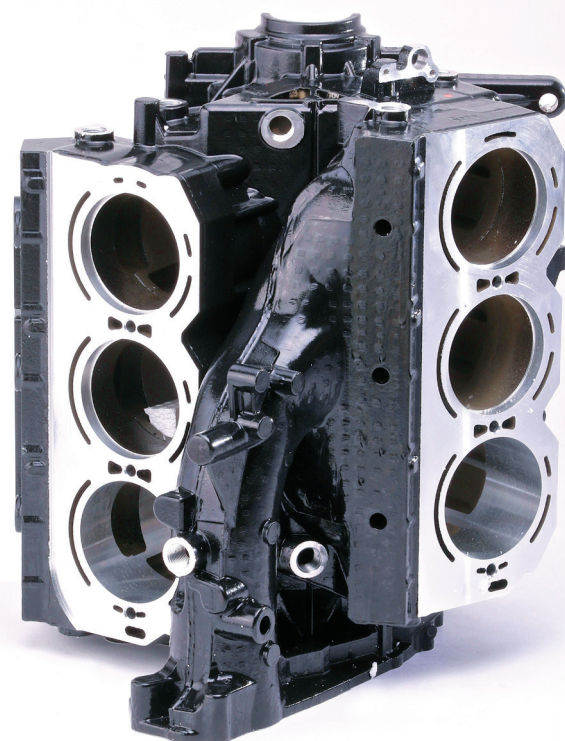
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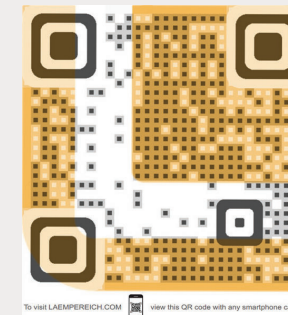
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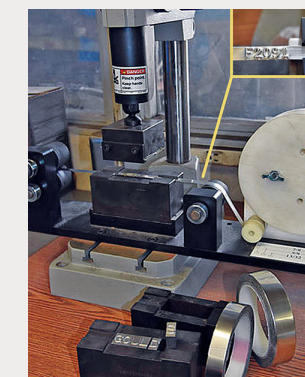


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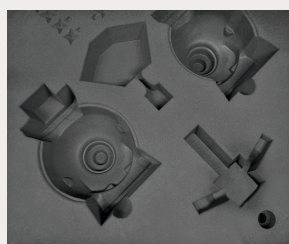
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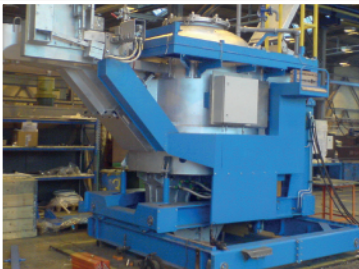
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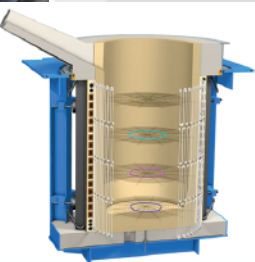
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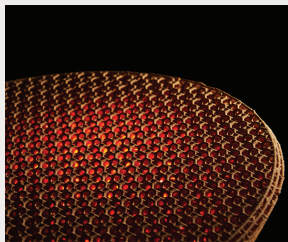
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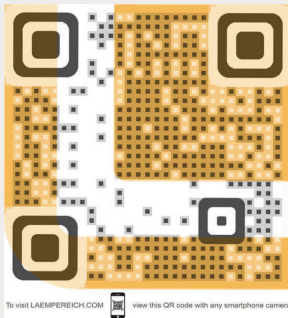
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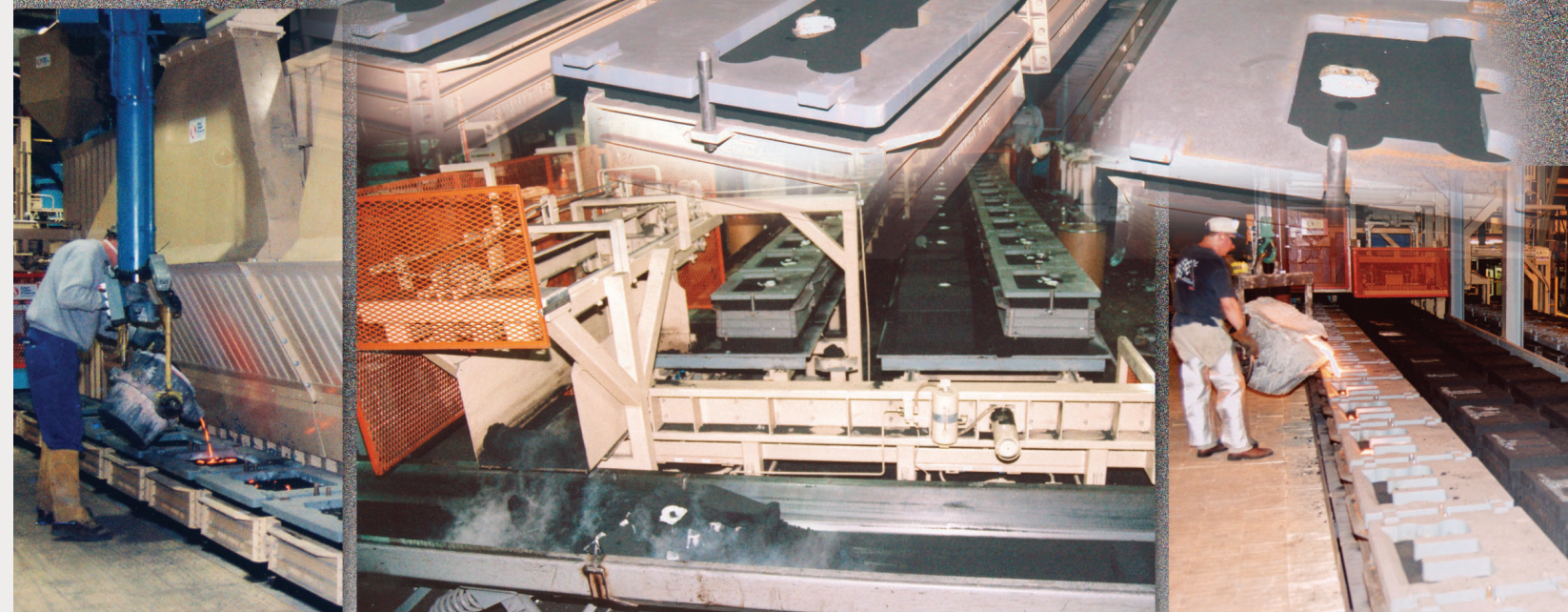
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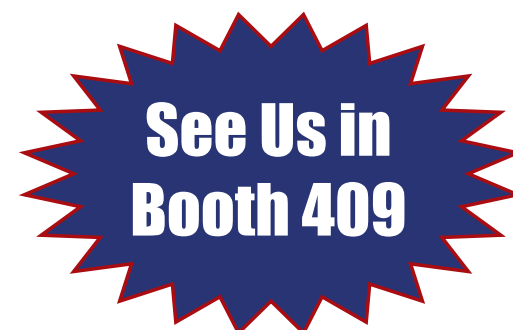
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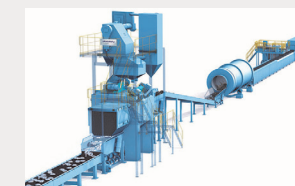


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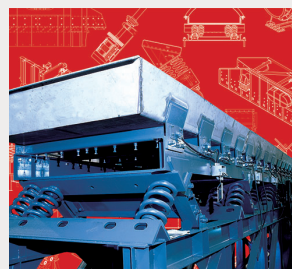
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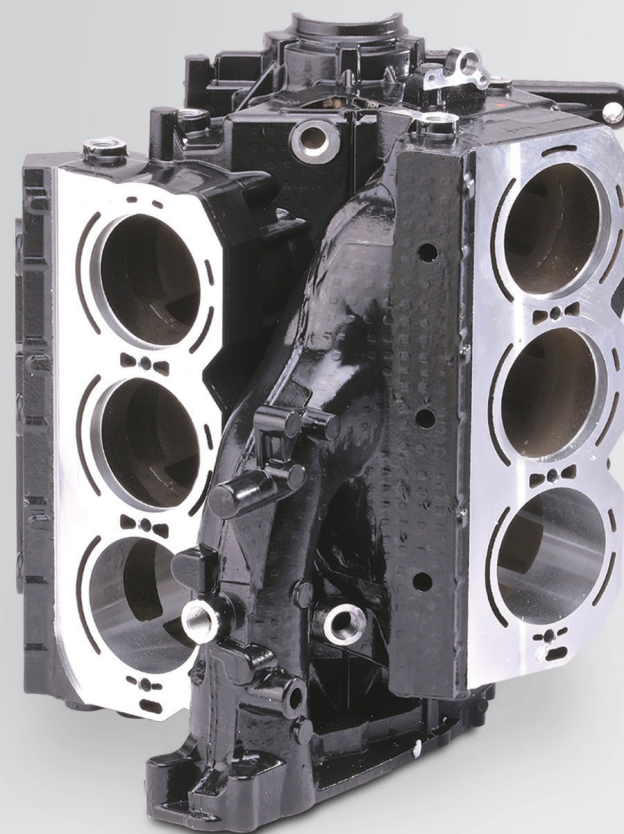
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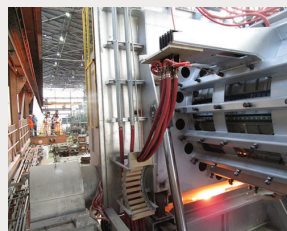
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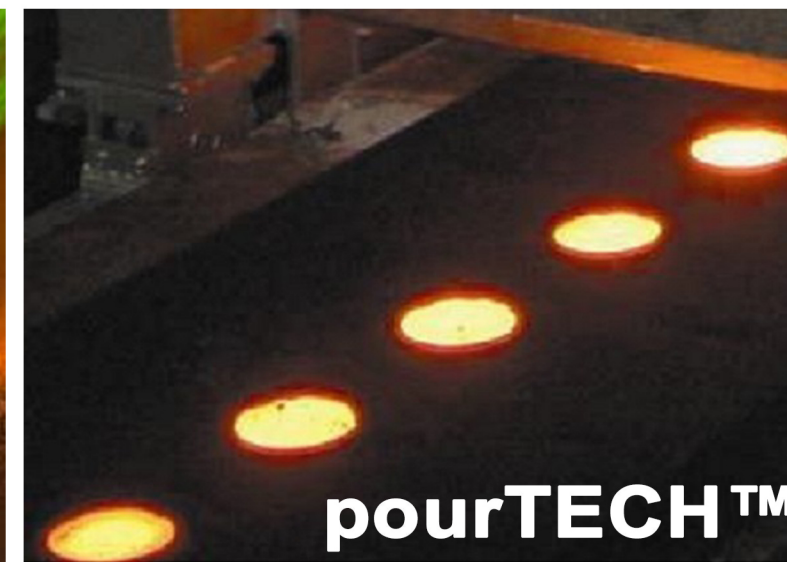
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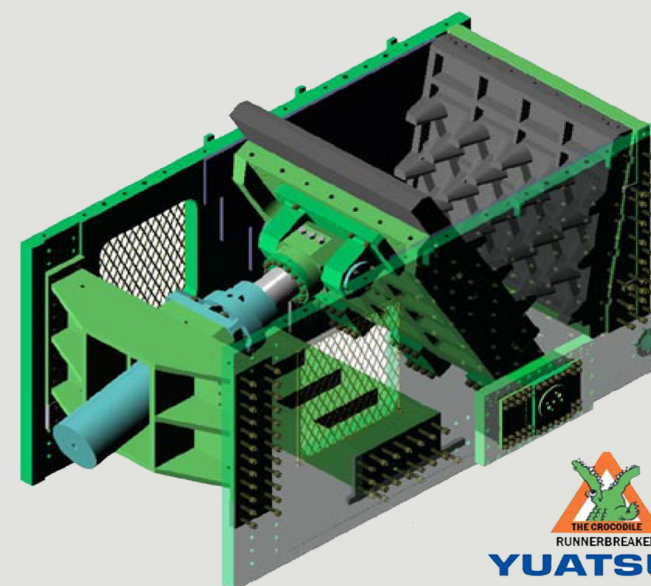
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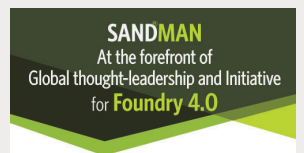
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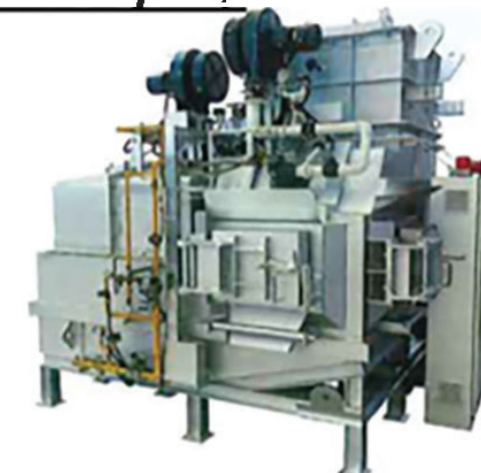
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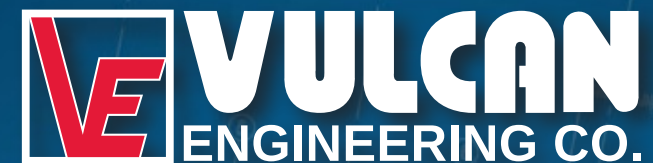
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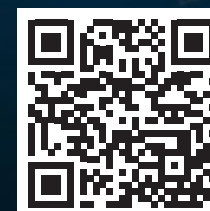
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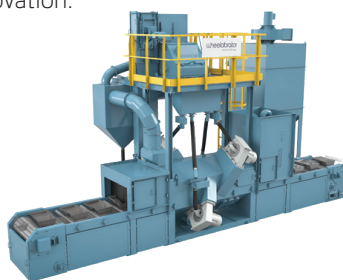
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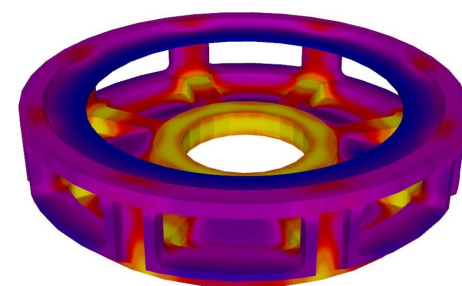
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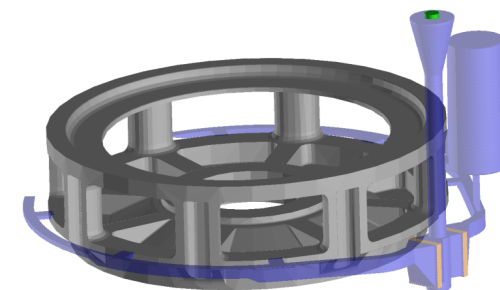
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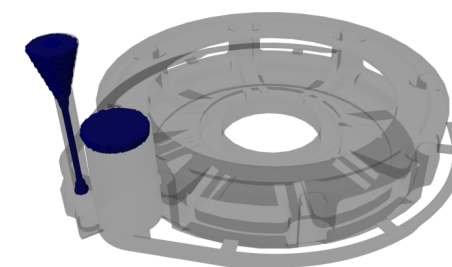
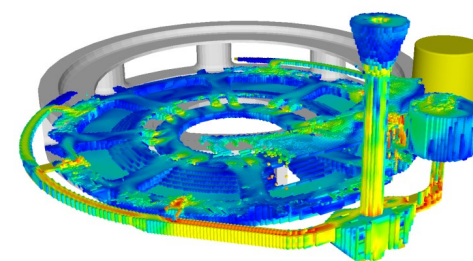


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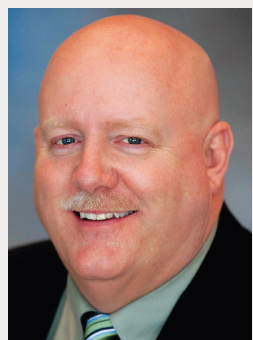
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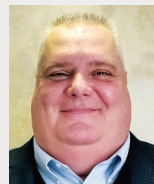


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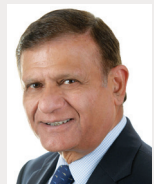
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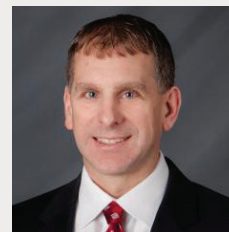
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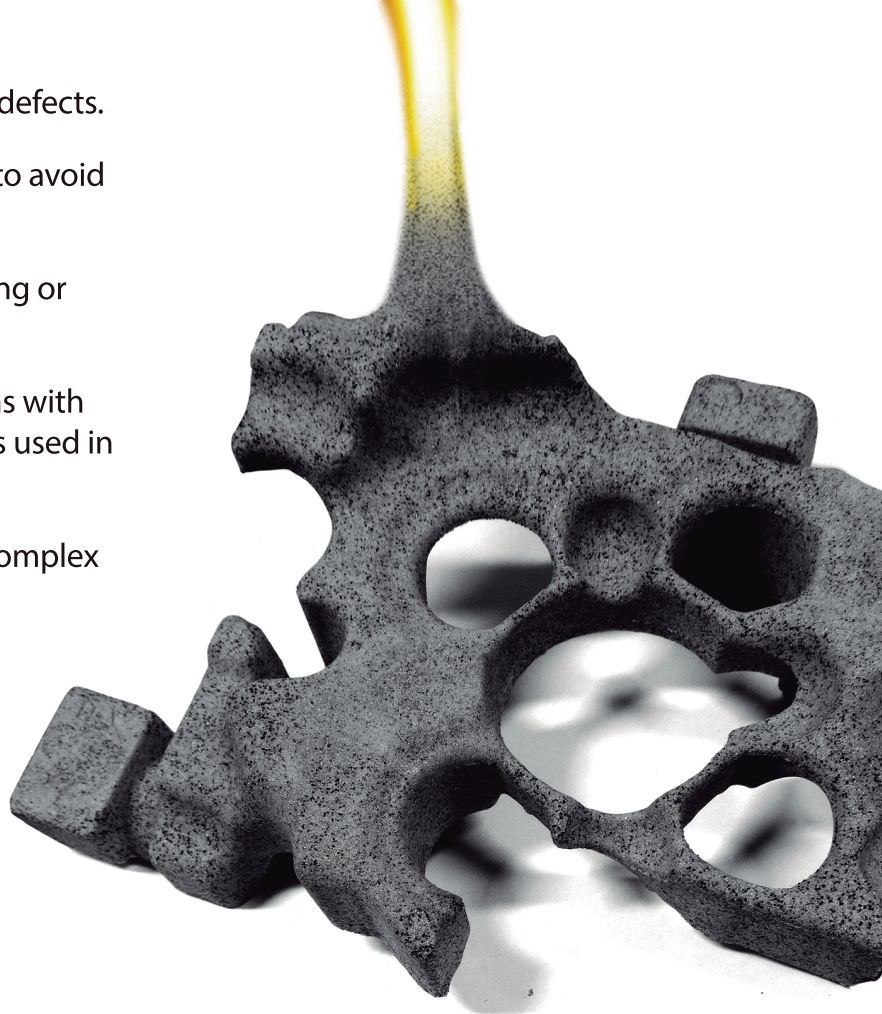
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The **PETER L. SIMPSON GOLD MEDAL** . . . for outstanding service and contributions in North America and abroad which reflects credit on the metalcasting industry.



DR. KUMAR SADAYAPPAN

Senior Research Scientist, CanmetMATERIALS, NRCAN, Hamilton, ON

The **JOHN A. PENTON GOLD MEDAL** . . . for his outstanding career achievements in non-ferrous casting technology, technology transfer to the casting industry and significant contributions to the AFS Copper Division, AFS Institute and local AFS Ontario Chapter.



THEODORE J. SCHORN

Vice President, Quality and Technology, Enkei America, Inc., Columbus, IN

The **THOMAS W. PANGBORN GOLD MEDAL** . . . for his contribution to the education of the cast metal industry in the field of quality, passionately advocating the application of quality improvement principles toward foundry management, and in the field of foundry safety and developing a practical system for the improvement of visual inspection operations.



AWARD OF SCIENTIFIC MERIT

CATHRINE HARTUNG

Senior R&D Engineer, Elkem AS, Foundry Products, Kristiansand, Norway

The **AFS AWARD OF SCIENTIFIC MERIT** . . . for scientific merit and technical excellence in the areas of cast iron molten metal processing, graphite shape, usage of rare earth elements, and other advanced topics relating to casting quality.



DR. JOHN CAMPBELL

Professor of Casting Technology, Campbell Technology Limited, Herefordshire, UK

The **AFS AWARD OF SCIENTIFIC MERIT** . . . for his knowledge, experience, and determination to move beyond the traditional methods of creating castings. From the development of the Cosworth, Baxi and Alotech casting processes, to his books and lectures, his work has changed the face of the metalcasting industry.



AFS SERVICE CITATION

DR. SAM NERONE RAMRATTAN

Professor, Western Michigan University, Kalamazoo, MI

The **AFS SERVICE CITATION** . . . for his numerous papers and presentations on both the core and green sand systems and his strong participation in technical committees, numerous articles in *Modern Casting* and presentations both at local Chapter and national levels at AFS Metalcasting Congresses.



JEFF SORENSON

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Continental Aluminum Corp. - New Hudson
Conveyor Dynamics Corp. - Saint Peters
Covia - Benton Harbor
Covia - Brentwood
Covia - Charlotte
Covia - Crystal City
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Covia - Rocklin
Covia - Troy Grove
Covia - Tuscaloosa
Covia - Wedron
CPP - Minneapolis Operation - Minneapolis
Craft Pattern & Mold Inc. - Montrose
C Reiss Coke - Latrobe
CR Onsrud Inc. - Troutman
CTP Sinto America LLC Lansing
Cumberland Foundry Co. Inc. - Cumberland
Curto-Ligonier Foundries Co. - Melrose Park
Custom Castings Limited - Winnipeg
Customized Energy Solutions - Philadelphia

D

D & L Foundry Inc. - Moses Lake
Dakota Foundry Inc. - Webster
DataProphet - Cape Town
David J Joseph Co. - Cincinnati
David J Joseph Co. - Houston
Decatur Foundry Inc. - Decatur
Decco Castings Inc. - El Cajon
Deere & Co. - East Moline
Deere & Co. - Davenport
Deere & Co. - Moline
Deere & Co. - Waterloo
Deeter Foundry Inc. - Lincoln
Denison Industries Inc. - Denison
De Pere Foundry Inc. - De Pere
DeZURIK - Cambridge
Didion International Inc. - Saint Peters
Dinamec Systems LLC - Acworth
DISA - Oswego
Dixon Group Canada Limited - Winnipeg
Dock Foundry LLC - Three Rivers
Dolphin Inc. - Phoenix
Donsco Inc. - Mount Joy
Donsco Inc. - Wrightsville
Dotson Iron Castings - Mankato
Dualtech Innovative Casting Tech Inc - Franklin
Durex Industries - Cary
Dustmaster Enviro Systems - Pewaukee
D W Clark Inc - East Bridgewater

E

Eagle Alloy Inc. - Muskegon
Eagle Aluminum Cast Products - Muskegon
Eagle Machined Products - Muskegon
Eagle Manufacturing Group - Hialeah
Eagle Precision Cast Parts Inc. - Muskegon
EBAA Iron Inc. - Albany
EBAA Iron Inc. - Cordele
EBAA Iron Inc. - Eastland
EBAA Iron Sales Inc. - Eastland
Eck Industries Inc. - Manitowoc
Eirich Machines Inc. - Gurnee
EJ - Ardmore
EJ - East Jordan
EJ - Elmira
Electric Controls & Systems Inc. - Birmingham
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Element Materials Technology - Wixom
Elkem Foundry Products - Pittsburgh
Elkem Materials Inc. - Boca Raton
Elkem Metal Canada Inc. - Hamilton
Elkhart Brass Mfg. Co. Inc. - Elkhart
Elyria Foundry Co. - Elyria
Emerson Automation Solutions
Appleton Group - South Milwaukee
EMSCO Inc. - Anniston
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ExOne - Houston
ExOne - Irwin
ExOne - Las Vegas
ExOne - Troy
EZG Manufacturing - Waterford
EZ Grout Corp. - Waterford

F
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Fairmount Foundry Inc. - Hamburg
Falcon Foundry Co. - Lowellville
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Farrar Corp. - Manhattan
Farrar Corp. - Norwich
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Ferroloy Inc. - Wichita
Finishing Associates - Warminster
Finite Solutions Inc. - Hamilton
Finite Solutions Inc. - Slinger
FISA North America Inc. - Elk Grove Village
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Flexovit USA Inc. - Angola
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Flow Science Inc. - Santa Fe
Flury Foundry Co. - Lancaster
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Fonderies Bibby Ste-Croix Inc. - Oakville
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Ford Meter Box Co. Inc. - Wabash
Forterra - Irving
Foseco - Cleveland
Foseco - Guelph
Foseco - Highland
Foseco Mexico - Guadalupe
Foseco - Pittsburgh
Foseco - Winlock
Foundry Solutions & Design - Alpharetta
Franklin Iron Works Inc. - Thorsby
Frazer & Jones Co. - Syracuse
Free Flow Technologies Ltd. - Loves Park
Fresno Valves & Castings Inc. - Selma
Friends Foundry Inc. - Woonsocket
Fritz Winter North America LP - Franklin
G & W Electric Co./Manufacturer's Brass and Aluminum Foundry - Blue Island

G
Gartland Foundry Co. - Terre Haute
Gemini Inc. - Cannon Falls
Gemini Inc. - Decorah
Gemini Inc. - Taylor
General Aluminum Mfg. Co. - Ravenna
General Foundry Service Corp. - San Leandro
General Kinematics Corp. - Crystal Lake
General Motors - Bay City

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General Motors - Defiance
General Motors - Flint
General Motors - Indianapolis
General Motors - Lansing
General Motors - Pontiac
General Motors - Romulus
General Motors - Saginaw
General Motors - Spring Hill
General Motors - Toledo
General Motors - Warren
General Motors - Ypsilanti
General Motors de Mexico S A de C V - Toluca
General Motors Fairfax - Kansas City
General Motors of Canada Ltd. - St. Catharines
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Goldens' Foundry & Machine Co. - Columbus
Graham-White Mfg. Co. - Salem
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Grede - Southfield
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Green Packaging Inc. - Hatfield
GreenSand Controls Inc. - Fremont
Griffin Canada Inc. - Winnipeg
Guardian Software Systems Inc. - Oconomowoc
Gudgeon Thermfire Intl. Inc. - London

H
HA International LLC - Oregon
HA International LLC - Toledo
HA International LLC - Westmont
Haley & Aldrich - Conyers
Haley & Aldrich - Greenville
Haley & Aldrich - Miamisburg
Haley & Aldrich, Inc. - Bedford
Harmony Castings LLC - Harmony
Harrison Steel Casting Co. - Attica
Harry H Reich Co. - Trussville
Henry Perkins Co. - Bridgewater
Henry Pratt Co. - Aurora
Henschel Andromat Inc. - Alabaster
Heraeus Electro-Nite Canada Ltd. - Stoney Creek
Heraeus Electro-Nite Co. - Hartland
Heraeus Electro-Nite Co. - Loveland
Heraeus Electro-Nite Co. - Yardley
Heraeus Incorporated - Yardley
Hickman Williams & Co. - Birmingham
Hickman Williams & Co. - Chattanooga
Hickman Williams & Co. - Cicero
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Hickman Williams & Co. - Palos Heights
Hickman Williams & Co. - Plymouth
Hickman Williams Canada Inc. - Cambridge
High Temperature Systems Inc. - Chagrin Falls
Hiler Industries (Kingsbury Cstg. Div.) - La Porte
Hitachi High-Tech Analytical Science - Westford
Hitachi Metals America Ltd. - Novi
Hitachi Metals Automotive Components USA LLC - Wellsboro
Hitech Shapes & Designs - Cincinnati
Hi-Vac Corporation - Marietta
H Kramer & Co. - Chicago
Hodge Foundry Inc. - Greenville
Hodge International - Somerset
Hoosier Pattern Inc. - Decatur
Howell Foundry LLC - Saint Francisville
HS Group HR Inc. - Green Bay
Hsin Lien Machinery Parts Co. Ltd. - Taichung
Humtown Products - Columbiana
Hunter Foundry Machinery Corp. - Schaumburg
Huppert Engineering LP - Auburn Hills

I
I2r Power - Canton
ID Castings LLC - Noblesville
IMERYS - Birmingham
IMERYS - Cincinnati
IMERYS - Niagara Falls
IMERYS - Roswell

IMERYS - Waterloo
Indquip Co. LLC - Jamestown
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Induction Technology Corp. - Apple Valley
Inductotherm Corp. - Pico Rivera
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Industrial Metals Recycling - Elgin
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Iron Age Designs - Burien
I Schumann & Co. - Bedford
Italpresse Gauss - La Grange
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J
Jackson Die Cast LLC - Jackson
Jef-Scot Metal Industries Inc. - Centerville
Jenkins Electric Co. Inc. - Charlotte
Jingang New Materials Co. Ltd. - Houston
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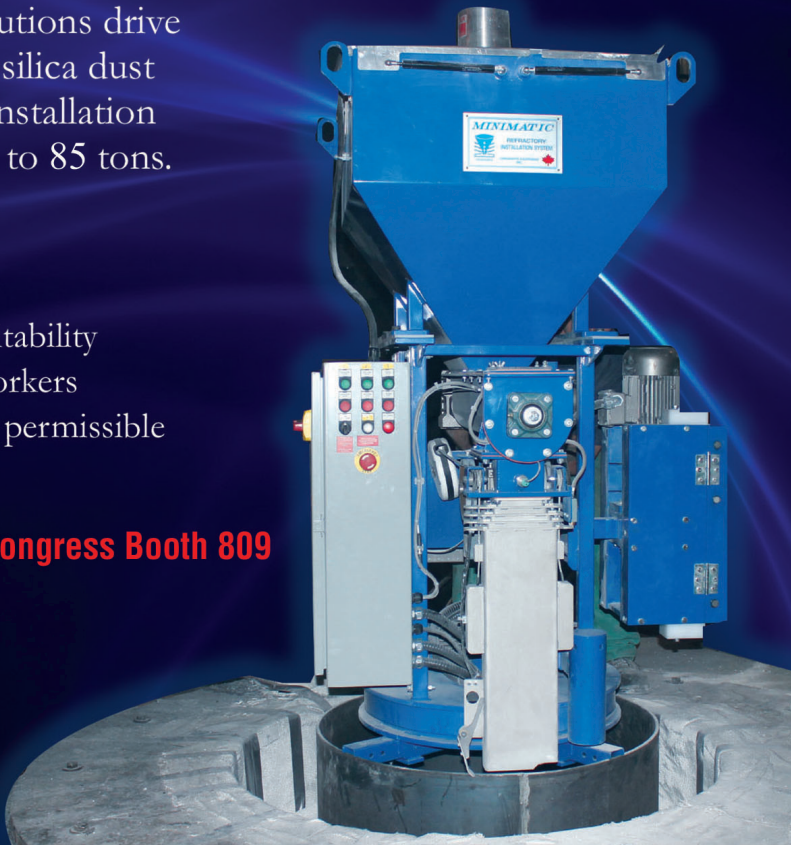
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K

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Kurtz Bros Inc. - Independence
Kurtz North America - Plymouth
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L

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LAEMPE REICH - Trussville
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Lemfco Inc. - Galena
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Liberty Pattern Company - New Liberty
Liberty Technology Co. LLC - Delaware
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Lindberg/MPH - Riverside
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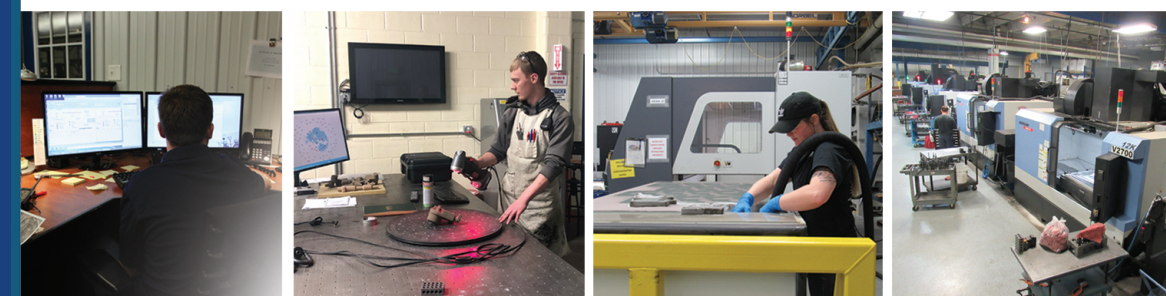
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Martin Engineering - Neponset
Matthews International Corp. - Pittsburgh
Matthews International Corp. - Searcy
Maus North America - Dayton
McConway & Torley LLC - Pittsburgh
McHenry Brass Inc. - Mc Henry
McWane Inc. - Anniston
McWane Inc. - Birmingham
McWane Ductile - Coshocton
McWane Inc. - Crossville
McWane Inc. - Elmira
McWane Inc. - Oakland
McWane Inc. - Oskaloosa
McWane Ductile - Phillipsburg
McWane Ductile - Provo
McWane Inc. - Ste Croix
McWane Inc. - Tyler
Melling Engineered Aluminum Castings - Battle Creek
Meloan Foundries LLC - Syracuse
MeltLab Systems - Winchester
Mercer Forge Corporation - Mercer
Mercury Castings - Brookfield
Mercury Marine - Fond Du Lac
Meritor Inc. - Fletcher
Meritor Inc. - Franklin
Meritor Inc. - Marion
Meritor Inc. - Troy
Metal Technologies Auburn LLC - Auburn
Metal Technologies Components
S De RL De CV - San Luis Potosi
Metal Technologies Inc. - Auburn
MetalTek International - Chattanooga
MetalTek International - Pevely
MetalTek International - Waukesha
MetalTek International - Watertown
MIA Manufacturing Inc. - Del Rio
Michigan Pneumatic Tool Inc. - Romulus
Mid City Foundry Co. - Grafton
Mid City Foundry Co. - Milwaukee
Midland Manufacturing Co. - Fort Worth
Midvale Industries Inc. - Montgomery
Midvale Industries Inc. - Saint Louis
Midvale Industries Inc. - Tulsa
Midwest Manufacturing & Logistics - Minster
Miller and Company - Rosemont
Minerals Technologies - Bethlehem
Modern Equipment Co. LLC - Appleton
Monett Metals Inc. - Monett
Morgan AM&T - Fostoria
Morgan Molten Metal Systems - Wallingford
Morris Bean & Co. - Yellow Springs
Morrow Foundry Inc. - Coffeyville
Mossner Reich - Trussville
MPM Infosoft Pvt. Ltd. - Nagpur
MT Systems Inc. - Canton
Mueller Canada - St. Jerome

Mueller Co. - Albertville
Mueller Co. - Chattanooga
Mueller Co. - Decatur
Mueller Co. - Decatur
Mueller Water Products - Atlanta
Multi-Cast LLC - Wauseon
Multi-Vac a division of M & W Shops - Union Grove

N
Naval Foundry & Propeller Center - Philadelphia
Naval Foundry & Propeller Shop - Philadelphia
Nederman Mikropul - Charlotte
Neenah Foundry Co. - Neenah
Neptune Technology Group Inc. - Tallassee
New London Engineering - New London
Nohr LLC - Beloit
Non-Ferrous Cast Alloys Inc. - Norton Shores
noredesign.com LLC - Mt Pleasant
Norican Group - LaGrange
Northern Foundry LLC - Hibbing
Northern Iron & Machine - Saint Paul
Northfield Manufacturing Inc. - Westland
NorthStar Products - Winona
North Star Products - Milwaukee
Norwood Foundry Ltd. - Nisku
NovaCast Solutions USA Inc. - Naperville
NovaCast Systems AB - Ronneby
NovaCast Systems AB - Goteborg
Novis Works LLC - Canton
NRB Metals LLC - Saint Charles

O
O'Fallon Casting - O'Fallon
O'Hare Foundry Corp. - Saint Louis
Oil City Iron Works Inc. - Corsicana
Olson Aluminum Castings Inc. - Rockford
Osco Industries Inc. - Jackson
Osco Industries Inc. - New Boston
Osco Industries Inc. - Portsmouth
Oshkosh Corporation - Appleton
Oshkosh Corporation - Dodge Center
Oshkosh Corporation - Greenville
Oshkosh Corporation - Hagerstown
Oshkosh Corporation - McConnellsburg
Oshkosh Corporation - Oshkosh
Otto Junker (Junker Inc.) - West Chicago

P
P&W Foundry Inc. - Plano
Pacific Alloy Casting Co. Inc. - South Gate
Palmer Foundry Inc. - Palmer
Pangborn Corp. - Birmingham
Pangborn Corp. - Fairburn
Peerless Metal Powders & Abrasive - Detroit
Perfect Patterns Inc. - Appleton
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Perma-Cast Co. - Pueblo
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George Hardiman
Retired Maintenance Manager
Liberty Casting LLC

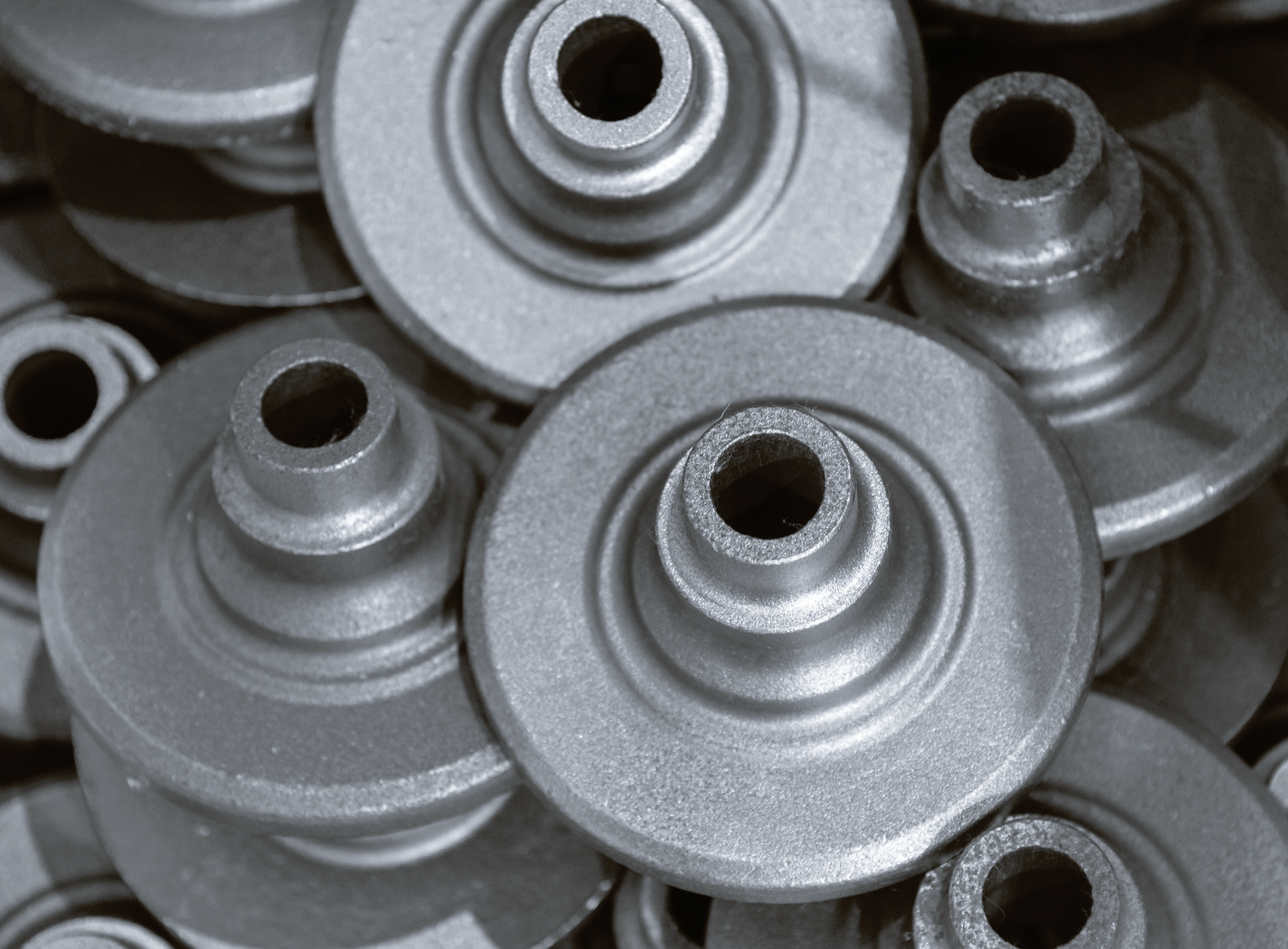


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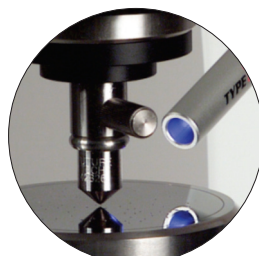
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ProfitGuard LLC - Bingham Farms
Progress Rail, a Caterpillar Company - La Grange
Prototype Casting Inc. - Commerce City
P W Gillibrand Co, Brady, TX

Q

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Quality Castings Co. - Orrville
Quality Electric Steel Castings LP - Houston
Quality Non-Ferrous Foundry - Wyoming

R

Ram S A de C V - San Luis Potosi
Rassini Frenos SA de CV San Martin - Texmelucan
Rassini Frenos SA de CV - Plymouth
Ravenna Casting Center LLC - Ravenna
REFCOTEC Inc. - Orrville
Regal Cast Inc. - Lebanon
Reliability Concepts - Coldwater
Renaissance Manufacturing Group -
Waukesha LLC - Waukesha
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Rheocast Co. - Germantown
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Richmond Industries Inc. - Dayton
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Rio Tinto Iron & Titanium Inc. - Montreal
Rio Tinto Iron & Titanium Inc. - Sorel-Tracy
Rio Tinto Iron & Titanium Inc. - South Jordan
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RJ Lee Group Inc. - Monroeville
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Roloff Manufacturing Corp. - Kaukauna
RoMan Manufacturing Inc. - Grand Rapids

Ross Aluminum Castings LLC - Sidney
RPB Safety LLC - Royal Oak
RRTC Inc. - Belle Mead

S

Sandmold Systems Inc. - Newaygo
Sandusky International Inc. - Sandusky
Schust - Auburn
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Selee Corporation - Hendersonville
Seneca Foundry Inc. - Webster City
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Sherpa Industries LLC - Mount Pleasant
Shipston Aluminum Technologies Inc. - Franklin
Sigma Electric Manufacturing Corp. - Garner
Simpson Technologies Corp. - Aurora
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SinterCast Ltd. - Sunninghill Berkshire
Sintex Minerals & Services Inc. - Rosenberg
Sinto America - Grand Ledge
Skat-Trak Inc. - Calimesa
Sloan Valve Co. - Augusta
Sloan Valve Co. - Franklin Park
Smith & Richardson Mfg Inc. - Geneva
Smith Foundry Co. - Minneapolis
Snam Alloys Pvt Ltd. - Pondicherry
Solar Turbines Inc. - San Diego
Solex Thermal Science Inc. - Calgary
Sotrem (1993) Inc. - Chicoutimi
Southeastern Foundry Products
& Foundry Coatings Inc. - Birmingham
Southland Metals Inc. - Maumelle
Southland Metals Inc. - Mishawaka
Southland Metals Inc. - Pryor
Southland Metals Inc. - Roswell
Specialty Castings LLC - Springfield
Southland Metals Inc. - Tomball
Spectro Analytical Instruments - Mahwah
SP Foundry - South Coffeyville
SP Foundry - Coffeyville
Spring City Electrical Mfg. Co. - Spring City
Spuncast Inc. - Watertown
Stahl Specialty Co. - Kingsville
Stahl Specialty Co. - Warrensburg
Standard Alloys & Manufacturing - Port Arthur
Star Pipe Products - Houston
St Louis Precision Casting Co. - Saint Louis
St Marys Foundry Inc. - Saint Marys
St Paul Foundry - Saint Paul
StrikoWestofen - Holland
Summit Foundry Systems Inc. - Fort Wayne
SunCoke Energy Inc. - Lisle
Superior Aluminum Alloys - New Haven
Superior Aluminum Castings Inc. - Independence
Superior Graphite Co. - Chicago
Superior Graphite Co. - Toluca
Supreme Cores Holdings LLC - Alabaster
Supreme Cores Holdings LLC - Lancaster
Sure-Cast Alum Foundry Co. - Minneapolis
Synchro ERP Ltd - London
SYSCON Sensors - South Bend

T
Taylor Foundry Co. - Wichita Falls
TB Wood’s Inc. - Chambersburg
TDJ Group Inc. - Barrington
Tech 4 LLC - De Pere
Technetronix LLC - Ciudad Juarez
TechniSand Inc. - Roff
TEMC Metal & Chemical Corp. - Taipei City
Tennetek Inc. - Sparta
Textron Defense Systems - Wilmington
Textron Inc. - Muskegon
The Federal Metal Co. - Bedford
The Hill & Griffith Co. - Cincinnati
The Hill & Griffith Co. - Indianapolis
The Raymond Corp. - Greene
The Raymond Corporation - Greene
The Schaefer Group - Beavercreek
The Schaefer Group Inc Louisville
TH Mfg. Co. - Millersburg
THORS eLearning Solutions - Medina
Titan Metallurgy LLC - Oak Park
Tonkawa Foundry Inc. - Tonkawa
Tooling & Equip International - Livonia
Torrance Casting Inc. - La Crosse
Toscelik Granul Sanayi AS - Atasehir
Townley Foundry & Machine Co. Inc. - Bellevue
TPI Arcade Inc. - Arcade
TPI Arcade Inc. - Harmony
TRC Companies Inc. - Ann Arbor
TRC Companies Inc. - Brookfield
TRC Companies Inc. - Grand Ledge
TRC Companies Inc. - Greenville
TRC Companies Inc. - Nashville
TRC Environmental Corp. - Cleveland
TRC Environmental Corp. - Grand Rapids
TRC Environmental Corp. - Madison
Tri-State Cast Technologies Co. Inc. - Boyne City
Tromley Industrial Holdings Inc. - Tualatin
Tyler Pipe Co. - Marshfield

U
Ultraseal America Inc. - Ann Arbor
United Brass Works Inc. - Erie
United Brass Works Inc. - Randleman
Universal Electric Foundry Inc. - Chicago
Urick Ductile Solutions - Erie
Urschel Laboratories Inc. - Chesterton
US Aluminum Castings - Entiat
US Foundry & Mfg. Co. - Atlanta
U S Foundry & Mfg. Co. - Medley
U S Pipe & Foundry Co. - Bessemer
U S Pipe & Foundry Co. - Council Bluffs
U S Pipe & Foundry Co. - Hoover
U S Pipe & Foundry Co. - Lynchburg
U S Pipe & Foundry Co. - Lisle
U S Pipe & Foundry Co. - Union City
US Pole Co. Inc. - Palmdale

V
Valmet Inc. - Waukesha
Van Hydraulics Inc. - Conklin
Verder Scientific Inc. - Newtown

Verichek Technical Services Inc. - Bethel Park
Vermont Castings - Randolph
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Victaulic Co. - Easton
Victaulic Co. of America - Alburtis
Victaulic Co. of America - Leland
Victaulic Co. of Canada - Richmond Hill
Victaulic De Mexico S de RL de CV - Chihuahua
Victaulic Technical Center - Nazareth
Viking Pump Inc. - Cedar Falls
Viking Technologies - Madison Heights
Virginia Industries Inc. - Rocky Hill
Viridis3D an EnvisionTEC Co. - Woburn
VJ Technologies Inc. - Bohemia
Voestalpine Nortrak Inc. - Decatur
Voxeljet AG - Friedberg BY
Voxeljet America Inc. - Canton
Voxeljet China Co. Ltd. - Suzhou
Vulcan Engineering Co. Inc. - Helena

W
Wabash Castings Inc. - Wabash
Wabtec - Wilmerding
Ward Corporation - Fort Wayne
Ward Heat Treating - Fort Wayne
Ward Manufacturing LLC - Blossburg
Washburn Iron Works Inc. - Washburn
Washington Mills Hennepin Inc. - Hennepin
Waterous Company - South Saint Paul
Watry Industries LLC - Sheboygan
Waupaca Foundry Inc. - Marinette
Waupaca Foundry Inc. - Tell City
Waupaca Foundry Inc. - Tioga
Waupaca Foundry Inc. - Etowah
Waupaca Foundry Inc. - Waupaca
WDC Acquisition LLC. - Creston
Wear-Tek - Spokane
Weaver Materiel Service Inc. - Jamestown
Webster Industries Inc. - Tiffin
Weil McLain - Michigan City
Weir Pump and Valve Solutions, Inc. - Saint Louis
Western Foundries Inc. - Longmont
West Salisbury Fdry. & Machine Co. - Salisbury
Wexford Sand Co. - Harrietta
WGB Industries Inc. - Tonawanda
WGS Global Services LLC - Flint
WGS Global Services LLC - Tell City
Wheelabrator - LaGrange
Wheelabrator - Waukesha
Wheelabrator Group - Burlington
Whibco Inc. - Bridgeton
William Goetz and Associates - Grand Blanc
Wirco Inc. - Champaign
Wirco Inc. - Avilla
Wisconsin Aluminum Foundry Co. - Manitowoc
Wisconsin Oven Corporation - East Troy
Woodland/Alloy Casting Inc. - Racine
World Known Precision Industry Co. Ltd. - Taichung City

Y
Yamaha Marine Precision Propellers Inc. - Indianapolis
YXLON - Hudson

AFS Institute

Upcoming Courses

A skilled workforce allows your company to optimize production, minimize errors, and differentiate from the competition.

The premier provider of education for the metalcasting industry is the [AFS Institute](#). Hundreds of foundries, casting purchasers, and suppliers to the metalcasting industry rely on the Institute each year to train and develop their employees. In fact, the Institute has trained more than **90,000** students since **1957**.

- The Institute offers training in these convenient formats:
- **Instructor-Led Training** in the [AFS headquarters](#) in [Schaumburg, Illinois](#).
 - **In-Plant Training** customized for the individual company, delivered on-site at your location.
 - **Regional Training** in other locales.
 - **e-Learning Modules** allowing your workforce to learn anywhere, anytime.

Below is a list of upcoming [AFS Institute Courses](#). To register, fill out the form on the back of this page or visit [www.afsinc.org/Courses](#).

Course:	Location:	Date:	Non-Member Member
Aluminum Crucible Furnace Practices	Schaumburg, IL	7/1	\$1,100 \$900
Introduction to Metalcasting	Wadsworth, OH	7/22 - 7/23	\$1,450 \$1,250
Green Sand Molding 101	Fond du Lac, WI	8/12	\$1,200 \$1,000
Casting Defect Analysis	Schaumburg, IL	8/26 - 8/27	\$1,350 \$1,150
Green Sand Molding 201	Eau Claire, WI	9/23 - 9/24	\$1,550 \$1,350
Improving the Effectiveness of Visual Inspection	Wadsworth, OH	10/7-10/8	\$1,450 \$1,250
Iron Melting 201	Schaumburg, IL	10/14 - 10/15	\$1,350 \$1,150
Iron Metallurgy 201	Schaumburg, IL	10/21 - 10/22	\$1,350 \$1,150
Casting Defect Analysis	Schaumburg, IL	10/28 - 10/29	\$1,350 \$1,150
Aluminum Metallurgy 201	Schaumburg, IL	11/11 - 11/12	\$1,350 \$1,150
Casting Design	Wadsworth, OH	11/18 - 11/19	\$1,550 \$1,350
Green Sand Molding 101	Schaumburg, IL	12/9	\$1,000 \$800
Gating & Riser Design 101	Wadsworth, OH	12/9 - 12/10	\$1,450 \$1,250



AFS Institute

Upcoming Courses

The **AFS Institute** offers practical courses on all metalcasting processes, materials and disciplines. Courses are hosted at AFS headquarters, within plants, and at other venues across North America. Since 1957, the Institute has trained more than 90,000 students in the metalcasting industry.

Please list the courses you would like to sign up for and total the amount at the bottom:

<div>Class</div>	<div>Amount</div>
<div>Class</div>	<div>Amount</div>
<div>Class</div>	<div>Amount</div>
<div>Class</div>	<div>Amount</div>

Optional and tax-deductible: Donate to the AFS Institute and its mission to educate the metalcasting industry.

☐ \$20 ☐ \$40 ☐ Other Amount \$

Total

Student Information

Student's Name

Company

Corporate Member Number (if applicable)

Address

City/State/Prov

Zip

Telephone

Email

Payment Information

☐ Check Enclosed (U.S. Funds Only) Charge To:☐ American Express ☐ Mastercard ☐ Visa

The following information is required to charge your credit card:

<div>Cardholder Name</div>	<div>Email</div>	
<div>Account No.</div>	<div>Exp. Date</div>	<div>Security Code</div>
<div>Signature</div>	<div>Date</div>	

Return completed application with payment to:

American Foundry Society
35169 Eagle Way Chicago, IL 60678-1351
Telephone: 847-824-0181 | 800-537-4237 Fax: 847-824-7848 Web: www.afsinc.org

Cancellation/Substitution policy:

Substitute students will be accepted at any time. However, cancellations of confirmed registrants with full refund cannot be accepted unless received three weeks prior to the first day of the class. After that time, refunds cannot be given. Transferring your registration to a future course will incur a \$50 transfer fee. In the event a course is cancelled for any reason, AFS Institute liability is limited to the return of the registration fee.

To register online for courses, please visit www.afsinc.org/Courses.



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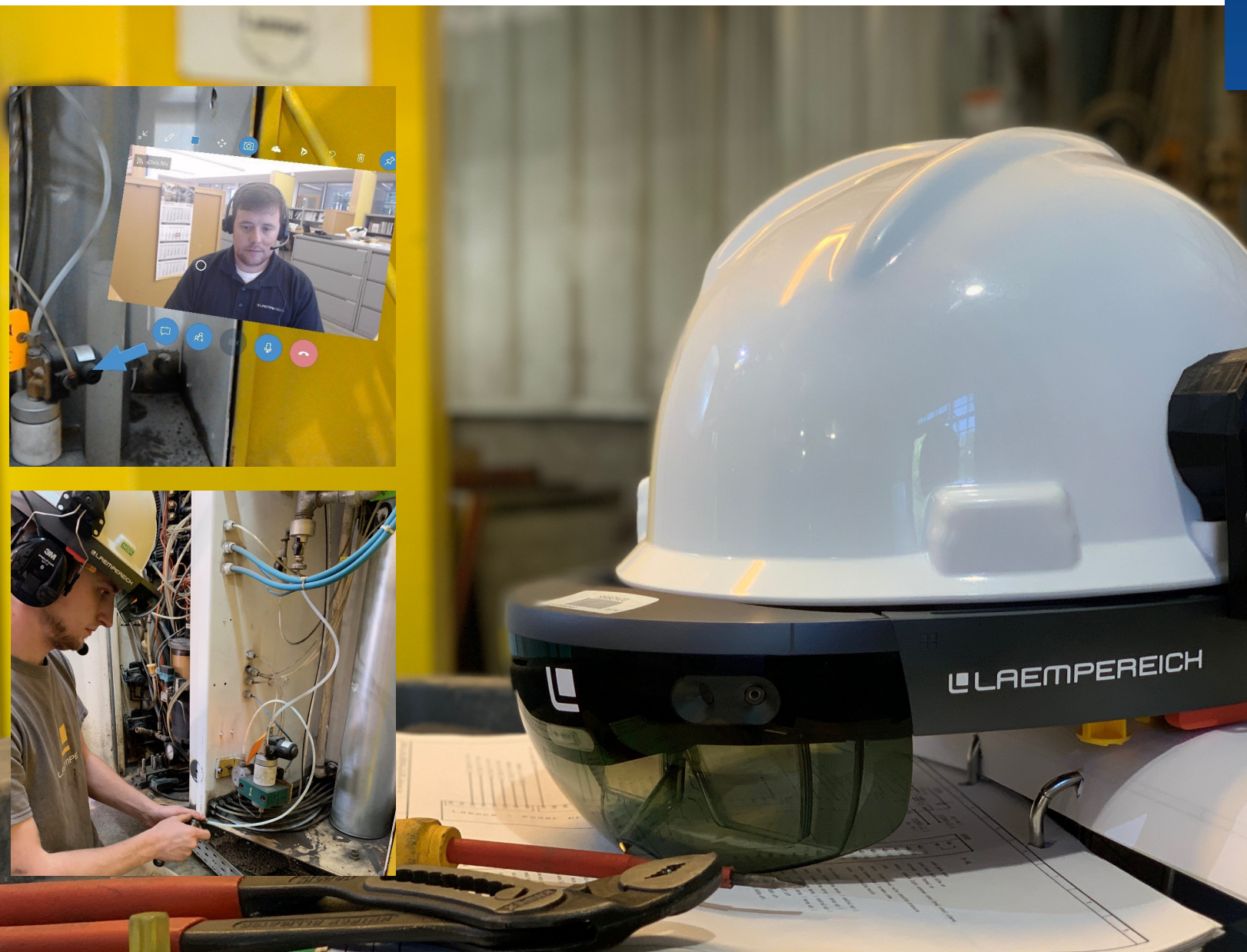


Important: Appropriate Personal Protective Equipment (PPE) must be worn by anyone in proximity to molten metal.



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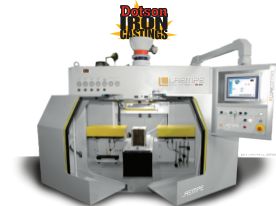
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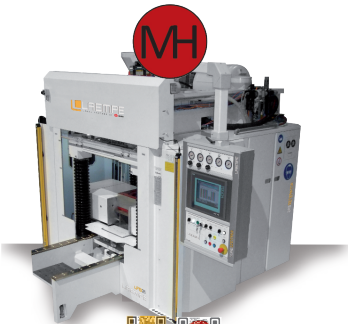


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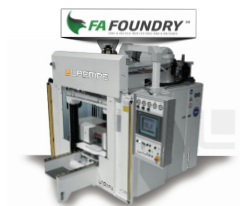
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