Metalcasting Industry Research

Support of research is critical for North America to maintain a strong, vibrant, healthy and continually advancing metalcasting industry. Part of the AFS mission is to promote these activities for the betterment of our membership, our industry and our society.

AFS directly funds research projects from allocation of a portion of the annual dues paid by AFS Corporate Membership. The current AFS Funded Research Projects are described below. The other projects are funded through research partnerships, government funding and industry contributions. AFS participates in these projects by securing industry partners and providing technical management and oversight. Current research funding partnerships include: the Advanced Casting Research Center (ACRC) is part of the Metal Processing Institute (MPI) at Worcester Polytechnic Institute (WPI), the U.S. Department of Defense (DOD), Defense Logistics Agency (DLA) Castings Solutions for Readiness (CSR) Program funded through the American Metalcasting Consortium (AMC), the National Network for Manufacturing Innovation and the three current consortium: (America Makes—National Additive Manufacturing Innovation Institute, Lightweight Innovations For Tomorrow–LIFT which was formerly called Lightweight and Modern Metals Manufacturing Innovation-LM3I and Digital Manufacturing and Design Innovation—DMDI), the National Institute of Standards and Technology (NIST) AMTech award for advanced manufacturing technology planning grant "The Pathway to Improved Metalcasting Manufacturing Technology and Processes—Taking Metal Casting Beyond 2020"and the New Generation Sand Casting Consortium (NewGen), which is a partnership between AFS and the National Industrial Sand Association (NISA) investing in metalcasting research relating to improving and advancing sand casting.

AFS Funded & Monitored Research

Twelve active projects are currently being funded through the allocation of a portion of the AFS Corporate Member Dues in FY2015-2016.

Helium-Enhanced Semi-Permanent Mold Aluminum Casting (12-13#05)

Coordinator: Prof. Paul Sanders, Michigan Tech University; Prof. Kyle Metzloff, UW-Platteville and AFS Aluminum Permanent Mold Committee (2-E)

The effect of helium injection in aluminum permanent mold casting has been investigated by Doutre (2000), Wan and Pehlke (2004), and Metzloff (2009). Filling the air gap that forms between the solidifying metal and permanent mold with helium increases the heat transfer coefficient and casting cooling rate. Higher cooling rates decrease the time to ejection resulting in throughput improvements. Doutre measured the effect of helium on the cooling rate of several aluminum alloys using cylindrical and plate molds and found a 30–50 % reduction in time to ejection temperature. Doutre found that helium-enhanced cooling improved commercial semi-permanent mold intake manifold casting productivity by 29 %, but the details of the helium injection process (injection time, location related to cores, etc.) and the resulting microstructure and mechanical properties were not discussed.

Wan and Pehlke performed both modeling and experiments on helium injection on permanent molds. They found that injection of helium (as compared to air) improved cooling times to 400 °C by 37 % with conductive mold coatings and 48 % with insulating coatings. Metzloff examined the effects of helium-enhanced cooling in a production environment with conductive and insulating mold coatings and the effect of external mold cooling. The helium injection was most beneficial with a standard insulating coating and external cooling, yielding a 33 % reduction in cycle time over the baseline production practice and a 10 % reduction over an optimized cycle without helium injection. The die in this study had a large internal metal core through which helium was injected. The benefit of helium was likely minimized as the casting shrunk onto the metal core, decreasing the air gap in the core area. It was thought that the helium injection would have a greater effect if the air gap was larger, especially in semi-permanent mold castings that have poor thermal conductivity in the sand core regions.

Saleem (2012) studied the effect of helium on the cooling rate and resulting properties of sand castings. This study found a 43–100 % increase in cooling rate with a corresponding decrease in SDAS leading to a 34 % increase in yield strength and a 22 % increase in ultimate strength with no significant loss in ductility or increase in cost. Argyropoulos (2008) found that helium injection into a refractory mold made the gap develop up to 34 % faster compared to air injection, but the heat transfer rate was higher by up to 48 %.

The cost of helium would suggest that gas mixtures should be investigated. A 1992 U.S. Patent by Air Products (5,173,124) provides evidence that a 80 %He–20 %Ar gas mixture has a 12 % higher convective heat transfer coefficient in turbulent flow. It was also noted that a 59 %He-41 %Ar mixture had the same convective heat transfer coefficient in turbulent flow. However, helium injection into the mold-casting shrinkage gap is not thought to provide turbulent flow (Wan and Pehlke). In this case, the more relevant parameter is likely thermal diffusivity. Sevast'yanov (1985) showed a quadratic decrease (decaying faster than a linear rate) in thermal diffusivity as argon was substituted for helium in the range of 20–80 % at 27 °C. Additionally, Purohit (1979) has shown a quadratic decrease in thermal conductivity with argon additions to helium at 727 °C.

The objective of the project is to develop and demonstrate a method for improved productivity and properties of semi-permanent mold aluminum castings using helium-assisted cooling. A semi-permanent mold will be designed to produce a pipe with three section thicknesses using a cylindrical sand core. This simple casting geometry will be used to evaluate the effect of helium injection through a core, and allow for the characterization of a sand core and permanent mold within the same casting. A proposed CAD model has been completed by Carley Foundry. Andrei Starobin at Mold Dynamics will model core outgassing due to binder loss and the pressure head required for helium gas delivery. MAGMA modeling of the mold design will be done as a cost-share in collaboration with MAGMA. MAGMA will be used to optimize the feeding system to produce a sound casting and provide an initial estimate of cooling rates based on literature heat transfer coefficients. The deliverable will be a CAD model and process gas flow (Starobin) and casting parameters (MAGMA).

During mold design, consideration will be given to the requirements necessary for a proposed semi-permanent mold core dimensional study. This research mold is expected to be utilized in several AFS-sponsored projects.

The experience gained during the 2009 Metzloff work for helium injection and temperature collection will be utilized. Co-PI Metzloff will lead the helium injection system and temperature data collection specifications. Thermocouples (1/16 in. diameter to improve response time) will be placed in the mold, core, and casting cavity. The mold thermocouples will be placed as near to the cavity surface as possible and spring loaded to maintain contact with the casting. The helium injection port will be placed in the core print to allow helium flow through the core and into the air gap between the solidifying metal and mold in the remainder of the casting. The mold will be fabricated in the Michigan Tech School of Technology Machine Shop and assembled for casting on a permanent mold machine at a participating member foundry. The temperature data collection and helium injection system will be assembled and tested prior to the casting trials.

A Six-Sigma approach will be used to optimize the process parameters for helium-enhanced semi-permanent mold casting. A full factorial designed experiment will be run to characterize the helium injection process. A center point (run 5) will be used to check for non-linearity in the parameter settings, and an extra run will assess the effect of argon gas mixtures on the cooling rate and properties. Replicates may be run depending on observed experimental variation. Microstructure evaluation to characterize the grain size, SDAS, and porosity and property evaluation of the castings will be conducted. Finally, the projected cost savings from reduced cycle time and reduced part volume (based on strength improvements) will be calculated. The additional costs associated with setup time and gas usage will be accounted for in the total cost analysis. The 2009 study showed a projected cost reduction of ~7 % for permanent mold casting.

Status Update: The project is now complete and the final report is being written. Updates are given at AFS Div. 2 Aluminum 2-E committee meetings and the next meeting is July 7th at AFS. The final results will be published as an IJMC paper and presented at the AFS Casting Congress. Those wishing more information about the project should contact the Steering Committee chair Brian Began at Brian.Began@foseco.com or Prof. Paul Sanders at sanders@mtu.edu.

High Strength Cast Iron Castings Produced by Engineered Cooling (14-15#03) Phase 2

Coordinator: Dr. Simon Lekakh and AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R)

The majority of industrially produced cast iron castings have a microstructure consisting of graphite phase in ferrite/pearlite metal matrix which were developed directly in metal casting processing (as-cast) without needing an additional heat treatment. The "as-cast" cast iron structure was formed during: (i) solidification (prime structure) and (ii) eutectoid reaction (final structure). The current state-of-the-art cast iron industrial processes mainly control the mechanical and thermo-physical properties through the prime solidification structure by:

- carbon equivalent variation for controlling prime austenite/graphite eutectic ratio.
- inoculation treatment for graphite nucleation and decreasing chill tendency.
- magnesium treatment for controlling graphite shape (flake in GI, vermicular in CGI, and spherical in SGI)
- melt refining from dissolved impurities (S, O, N), and
- melt filtration for improving casting cleanliness.

Practically speaking, only one method—an additional alloying by Cu, Mo, Ni and other elements, is used for direct control of the structure of metal matrix formed during eutectoid reaction. The all described above methods could be called "chemical" methods because they control the microstructure through changes in the cast iron composition. However "chemical" methods have some serious limitations: (i) high cost of alloying additions, (ii) limited increase strength in as-cast condition, and (iii) need an additional austempering heat treatment for achievement a higher strength of cast iron castings.

Analysis of the performance of standard cast irons with different graphite shape and targeted properties are included in this project. The mechanical properties data are represented by, so called "Quality index", which is a strength/hardness ratio. For example, standard SGI is significantly stronger than CGI; however SGI has lower thermal conductivity which is a limiting factor for application for cast components of intensively thermo/mechanically loaded heavy-duty engines. The targeted strength of GI will be near the level of current CGI, and targeted strength of SGI in "as-cast" condition will be matched to the strength of heat treated castings.

The objective of this project is to develop a novel metal casting process for production of high strength cast iron castings in "as-cast" condition applying engineered cooling. The goals include:

- increase "quality index" (UTS/HB ratio)
- increase strength without sacrificing toughness
- decrease casting cost by eliminating alloying elements
- decrease energy consumption for heat treatment

Status Update: The Phase 1 project is now complete and a paper based upon that work was published in the Winter 2015 issue. Testing is now being conducted on simulated production shapes in a lab setting on a Phase II effort to continue this work towards commercialization of the technology. The project is being monitored by the AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R). Those wishing more information about the project or how to participate as a sponsor should contact the PI Simon Lekakh at lekakhs@mst.edu.

Development of Ultra-High Strength Light Weight Al–Si Alloys (13-14#01)

Coordinator: Dr. M. Shamsuzzoha and AFS Aluminum Division (2)

This proposal deals with the development of shape castings that produce high strength hypo- and hyper-eutectic aluminum (Al)-silicon (Si) alloys with silicon content in the range of 6–9 % and that possess nano-sized fibrous silicon morphology in the microstructure. In an Al–Si binary system, hypo-eutectic is formed with a silicon composition lower than 12.7 % of silicon. In the microstructure of hypo-eutectic Al–Si alloys, two major components coexist, the primary and the eutectic phase. The primary phase consists of Al containing about 1.67 % Si as solid solution that exists in the form of dendrites, while the eutectic structure consists of an aluminum-rich solid solution of silicon and virtually pure silicon and that is found in between the arms of the primary Al dendrites.

Typical hypo- and hyper-eutectic alloys grown by impurity-modified conventional casting exhibit a microstructure comprising of primary Si that assumes sizes on the order of 10^{-4} m and eutectic silicon with a rather course fibrous morphology of sizes on the order of 10^{-6} m. These properties of the microstructure have not provided ultra-high strength and fracture toughness for such as cast alloys. Recently a new procedure based upon the concept of the solubility of barium (Ba) in the silicon phase has demonstrated that a hypereutectic Al-17wt %-Si alloy can be produced without a primary Si phase being present.

This work will establish the capability of the present process of refinement with respect to the required Ba additions, Si content, and refined microstructure in hypo-eutectic Al–Si alloys. In such pursuits using permanent mold casting techniques, the freezing parameters for an alloy that requires the optimum amount of Ba and that reveals nano-sized microstructure will be determined. Thus determined freezing parameters and Ba content will be subjected to another round of permanent mold castings in which various commercially available light weight Al–Si hypo-eutectic alloys will be used as starting materials. All such cast alloys will be subjected to T6 heat treatment conditions whereupon mechanical properties of the resulting tempered alloys will be determined. It is expected that a comparison of the mechanical properties of these alloys with those known for the commercially available light weight alloys may reveal the scale of improvement in the mechanical properties of the alloys grown by the proposed method. In establishing this capability some concentration will also be given to the related freezing parameters such as under-cooling (ΔT), growth velocity (R), and the inter-lamellar spacing (λ) with the microstructure of the resulting alloys. Such determination is of importance with respect to the application of this technology to foundry castings of Al–Si alloys of improved mechanical properties.

Status Update: The project is underway with continued work on the design of experiment matrix of silicon ranges and Ba alloy additions and heat treatment conditions. The work is being monitored by the AFS Aluminum Division 2 and will be reviewed at the meeting on July 7th at AFS and presentation #15-087 was made at 119th Metalcasting Congress. Those wishing more information about the project or how to participate as a sponsor should contact the Steering Committee Chair Dave Weiss at david.weiss@eckindustries.com or the PI Dr. Shamsuzzoha, at shamsuz@aalan.ua.edu.

New Measurement for Active Clay in Green Sand-Phase 3 (14-15#01)

Coordinator: Dr. Sam Ramrattan, Western Michigan University and AFS Green Sand Molding Committee (4-M)

Measurement of live clay in molding sand is critical to control of foundry green sand. Live clay levels must be controlled to develop and maintain proper strength levels and mechanical properties of the molding sand. Control of the live clay level is also critical in monitoring of moisture and compactability because clay is the primary moisture absorber in molding sand. If clay level could be better understood, the moisture and compactability could be more closely controlled. Inadequate control of compactability is the leading cause of green sand casting defects, and the associated costs of scrap, rework, labor, and energy to individual foundries and the industry as whole warrant investigations into alternative methods of control. The foundry industry needs a faster, more accurate, and low cost alternative to properly measure active clay in green sand. The Methylene Blue Clay techniques employed by the foundry industry for measuring active clay suffer poor reproducibility and are thus incapable of maintaining accuracy. Casting defects are consistently attributed to variations in green sand systems and limitations of the clay control methods for green sand. A better clay measurement technique is necessary to improve green sand systems.

With research support from AFS, Western Michigan University (WMU) has developed a new methodology based on dye absorption for measuring active clays in green sand. The new procedure provides a direct instrument read that requires minimal operator training. However, there is concern regarding test-to-test variability using a particular anionic type dye (orange). Any new cationic dye consumable must be environmentally friendly, of lower cost and with easier clean-up compared to the current procedure (Phase II). The AFS 4-M Green Sand Additives and Testing Committee remains interested in finding a replacement for the Methylene Blue Clay Test. The AFS 4-M Committee has endorsed the Phase II approach but 'questioned' the selection of an anionic type dye (orange) and felt that test-to-test variability of results were not demonstrated to the satisfaction of the Steering Committee.

The purpose of this Phase III research is to identify a cationic dye for the absorption technique developed in Phase II. Another purpose will be to refine the procedure and conduct industrial trials using clay standards. Phase III research will be conducted according to specified tasks that are reviewed by a 4-M Steering Committee.

Status Update: The cationic dye that was identified is now being tested against various sand mixtures and foundry plant trials will be conducted at five foundries and WMU. The work is being monitored by the AFS Green Sand Molding Committee (4-M). Continued training and verification of the test is being done by the working group, including 1-day workshops at WMU. Once this activity is complete the intent would be to create a standardized and validated test approach to be included in the AFS Core and Molding Handbook. Those wishing more information about the project, or participation should contact the Steering Committee chair Mike Slaydon at mslaydon@rochestermetals.com or Dr. Sam Ramrattan at sam.ramrattan@wmich.edu.

Application of DSC Coupled with TGA and MS to Assess Sand Binder Emission (14-15#02)

Coordinator: Dr. Scott Giese, University of Northern Iowa and the AFS 4-F, 4-K and 10-E Committees

Emissions of hazardous air pollutants and organic volatile components have been a major concern for the foundry industry in providing a safe work environment for their employees. Emission studies have evolved from the emission compound identification work performed during the 1990's to the correlation of emission amounts per ton of metal poured conducted in the 2000's, most notably, the extensive emission study performed by the defunct Casting Emission Reduction Program (CERP). Data collected and presented to the foundry by CERP provided critical information for developing binder technologies to address emission reductions in HAP's and VOC's.

The major concern in conducting emission studies is the research expense to pour actual castings and measuring the emissions during the pouring, cooling, and shakeout segments of the metal casting process. For each casting segment, emission products need to be captured for each casting segment and analyzed. Variability in emission components is introduced when different casting alloys are used to simulate various segment heating rates. Additionally, continuous sampling over the casting regime only provides the total emission amount over that particular time reference and fails to illuminate the peak production of certain emission products. From the applied research approach, it is unclear if the components of emission production are a product of complex chemical reactions occurring between the coated sand grains in a soup of VOC's, HAP's, and light gases as the casting cools or are from the rapid exposure of the heated molding sand and core binder to an oxygenated environment during the shakeout of the mold.

Research by the University of Northern Iowa Metal Casting Center on emission modeling collected supporting data using DSC-TGA-MS techniques. Significant findings from the research program identified mold atmosphere, heating rate, and isothermal heating as major factors in emission generation. The DSC-TGA-MS capabilities permitted the use of different atmosphere blends, simulating neutral, reducing, and oxidizing conditions. Interestingly, the emission characteristics for a reducing and neutral environment were identical, but oxidizing conditions significantly altered the decomposition behavior. Higher heating rates showed some early suppression of emission products, particularly at lower temperatures, and some evidence of higher emission generation when heated to elevated temperatures. At the conclusion of the research work, several research questions were recommended warranting further investigation in developing a low cost testing procedure to assess the emission generation and characteristics for green sand and resin bonded cores. These research inquiries were

- What are the kinetic rates of HAP's and VOC's generation?
- How can the DSC-TGA-MS be utilized to replicate actual emission generation?
- Do volatilized HAP's and VOC's affect the emission generation by altering the mold atmosphere?

The proposed research project will greatly contribute to develop a low cost emission protocol to assess HAP and VOC release into the workplace environment. The proposed research approach hopes to support several research areas where emission analysis is critical; particularly for gas evolution in molds and cores to reduce gas related casting defects.

Status Update: Most recently casting experiments to identify the light, fixed gases that are produced during the decomposition of phenolic urethane have been conducted. The information collected will provide the type of atmosphere necessary for the DSC-TGA-MS experiments. Those wishing more information about the project should contact the Steering Committee chair, Mitchell Patterson, at mitch.patterson@ha-international.com or Dr. Scott Giese at scott.giese@uni.edu.

Reclamation of Investment Casting Shell Materials (14-15#04)

Coordinator: Dr. Victor Okhuysen, California State Polytechnic University-Pomona and the AFS 4-L Investment Casting Research Committee

Investment casting shell materials are used once and then disposed. This has economic, environmental, and logistical costs. Investment casting shell materials consist largely of stucco, flour, binder and additives. Of these, the most costly ingredients are the stucco, flour and binder. During processing the binder, usually colloidal silica, undergoes an irreversible reaction to form silica gel. Thus, it is not feasible to reclaim the binder. The stucco and flour are used as aggregates with the binder to produce the shell. These are the materials that this project will focus on.

The typical materials include mullite, fused silica and zircon. The zircon is a minor ingredient by volume, but due to its high cost, it is of great interest. The fused silica and mullite are used in much higher quantities and they also constitute a significant expense. The first step in the reclamation process would consist of the separation of stucco and flour particles ideally to their initial size distributions from the spent shell material. There are multiple mechanical methods that are currently used for the separation of sand and binder in sand casting. In addition, there is significant expertise on particle grinding in the ceramics and mining industry. It is anticipated that some of these methods will be applicable to the existing project. Once this is attained, then the possibility of separating the zircon from the mullite and/or fused silica can be contemplated. For the purposes of this project separation is not being considered, but this would be a likely follow up project in the future.

Phase transformations in the ceramic can occur during the thermal cycle of the investment casting shell. Zircon and pure mullite are not anticipated to have phase transformations. On the other hand, fused silica is known to transform to crystalline silica in the form of cristobalite. The transformation of amorphous phases of silica begins at around 900 C, and as the temperature increases, the amount and rate of transformation increases. The highest rates occur between 1100 and 1200 C, and nearly complete transformation is reached by 1400 C. Lower grades of mullite (47 % alumina) report having some silica, though it is not specified if crystalline or amorphous.

An additional variable in fused silica consists of the alloys produced. In the production of steel pouring temperatures of 1600 C are used. These are clearly beyond the formation temperature into cristobalite. Aluminum pouring temperatures, though, are usually around 700 C, below the transformation temperature to cristobalite. Thus, a goal of this project is to investigate if fused silica can be reused for lower temperature alloys even if it can't be reused in high temperature alloys.

There are regulatory trends to have foundries reduce their solid waste streams and spent ceramics constitute the largest waste stream for investment casters. The reclamation would help foundries meet the regulatory targets. Lastly, if investment casters reclaim their ceramics, this would also simplify their supply chain. They would be able to better control their inventories and depend less on the vagaries of the market and potential supply disruptions. Work performed in Poland showed that the use of mechanically reclaimed shell materials used in superalloy casting can produce shells with equal or better green strength by the use of reclaimed flours and stucco, but for high temperature strengths, only the shells without reclaimed flour matched hot strengths.

Reclamation of the ceramic materials would save in both the purchase of new raw materials and in the disposal of the spent materials. A survey of investment casters was conducted by AFS where 89 % of the respondents indicated interest in reclaiming ceramics. The average consumption of non-zircon ceramics by these facilities was 601,000 lbs per year. An average price per pound was obtained based on available data at $0.57/lb. The average benefit for a foundry would be $342,000/year. There are 22 AFS members for whom the impact would be $7.5 million per year. A survey of the broader U.S. investment casting industry yielded at least 76 investment casters, and the extended benefit would be $26 million/year. This assumes 100 % reclamation of non-zircon flours and stuccoes. Thus, even if partial reclamation was successful it would still be in the millions of dollars. Furthermore, once the ceramics are ground, it would be possible to look at zircon separation and zircon specific reuse would greatly increase the economic impact. Furthermore, this value also excludes shipping and disposal savings.

The project will produce a set of instructions and guidelines as to how to approach the reclamation of ceramic shell materials. Among these instructions there will be: Recommended equipment (based on that used in the successful results in the project), detailed procedures, and detailed notes on any changes on standard procedures currently in place. The target dissemination will include reclamation and use instructions such as:

- How to grind the spent shells including do's and don'ts.
- The equipment used
- The amount of reclaimed material that can be added

- Detailed information on what changes the facility may experience in the production characteristics of the slurry/stucco (i.e. different viscosity, higher/lower slurry life, pH changes, greater/less need for wetting agents, antifoams, etc.)

These materials will be the basis of any papers presented at the Casting Congress or published in journals, the materials to be generated for CMI training and for the poster presentations. Results on milestones will be published at the earliest opportunity mainly through AFS channels.

Status Update: The project and initial testing is now underway creating prototype molds in fused silica stucco and alumino silicates stucco to make the MOR (Modulus of Rupture) testing bars, with an active steering committee determining slurry formulations to be tested. Those wishing more information about the project should contact the Steering Committee chair, Matt Cavins, at mcavins@ofalloncasting.com or Dr. Victor Okhuysen at vfokhuysen@csupomona.edu.

Influence of Mn and S on the Properties of Cast Iron—Phase 2 (14-15#05)

Coordinator: Richard (Rick) B. Gundlach, Element Materials and AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R)

Sulfur is generally considered a tramp element in cast iron, and its level must be controlled. When manganese is not present at sufficient concentrations, sulfur reacts with iron to produce a low-melting phase that can produce hot-shortness in iron castings. Consequently, the industry has always added manganese to control sulfur in cast iron. Various formulae have been promulgated in the industry for balancing Mn and S in cast iron. Many employ a stoichiometric relationship between Mn and S, requiring an excess Mn content to avoid FeS formation. Some simply employ a Mn to S ratio (such as 5–7) to assure that no FeS forms. Others advocate that the sulfur content must simply be at or above 0.04 % S to obtain adequate inoculation response. With the exception of a few investigators, none has considered the solubility of MnS from thermodynamic principles.

Recent research conducted for the AFS 5-R Committee under Research Contract Project 12-13#04 "Influence of Mn & S on the Properties of Cast Iron" has demonstrated that, through balancing Mn and S according to the solubility limit of MnS inclusions at the eutectic temperature, the strength of gray cast iron can be optimized. Based on the literature review and the experimental work, it was possible to define what Mn and S concentrations might produce the best properties with regard to strength. The experimental work focused on Class 35 iron cast in sections up to 3-inches and showed that at optimum Mn and S levels, the strength can be 6 to 10 ksi higher than in poorly balanced chemistries.

The results of the research on Mn and S in gray iron raises many questions and, also, new ideas for future research. Several of those ideas were discussed at the Spring 2014 5-R Committee meeting. The one that was selected for this phase included the following activity to develop a better understanding of the strengthening effects at the optimum Mn:S balancing. While the current study showed that maximum strength occurs at compositions close to the solubility limit of MnS, it is not clear what microstructural features were optimized. The numerous metallographic samples that are available from the previous study are suitable for the proposed research. The samples will be used to determine the microhardness of the pearlitic matrix. These data will be compared with the bulk hardness of the samples and correlated with the tensile strength of the alloys in order to determine whether changes in the pearlitic matrix contributed to the loss in strength in alloys with poorer Mn-S balancing. The same metallographic samples will also be used to perform a broader characterization of the graphite structure, since the several observations from the previous study strongly suggest that the variations in strength are tied to changes in the graphite structure. Features such as cell count, mixed graphite structures (flake distribution types), and the occurrence of spiky graphite morphology will be investigated as a function of Mn and S concentrations and section size.

Status Update: This second phase of the project is underway performing more analysis and testing on the 96 metallographic samples from the original project, as well as some mechanical testing. The work is being monitored by the AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R) plus a group of sponsoring companies. Those wishing more information about the project or how to participate as a sponsor should contact the Steering Committee chair Leonard Winardi at LWinardi@charlottepipe.com or Rick Gundlach at rick.gundlach@element.com.

NDT & Microstructure Correlations to Gray Iron Aging (14-15#06)

Coordinator: Greg Miskinis, Waupaca and AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R)

Gray iron cast components are well known to age or "cure" after casting, resulting in strength and resonant frequency (RF) increases over time. Previous research has shown this aging effect to be logarithmic with most of the effect (70 % or so) coming in the first 15 days after casting. There are multiple theories, however, regarding how best to account for and benefit from this aging process. One benefit may be a reduction in machining tool wear. Improved tool life has been found to occur in aged castings in multiple machining trials over the years.

Literature review provides two theories regarding the mechanism of gray cast iron aging, precipitation of submicroscopic nitrides, and residual stress relief. The case for nitride precipitation rests ultimately on limited tensile data, which, with its large variation, needs a larger study to properly validate. The case for stress relief relies on primarily on the aging effect found in the resonant frequency (RF) of gray cast iron and the effect of stress inducing processing (shot blasting and machining) to the RF and tensile strength.

Ultimately, the testing protocol documented here will need to be repeated with ductile iron. This study will attempt to determine the optimal balance of aging, part and NVH (noise, vibration, harshness) performance, and also secondary operations versus processing limitations and inventory requirements or work in process (WIP) costs. The project objective is the determination of the "ultimate" cause of the aging response, leading to determination of the full aging time for gray iron castings, allowing for more precise non-destructive testing and more successful secondary operations.

Status Update: This project is underway with the resonant frequency and ultrasonic velocity measurements over the agreed aging period having been completed and the material characterization phase started. The work is being monitored by the AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R). Those wishing more information about the project or how to participate as a sponsor should contact the Steering Committee chair Matt Meyer at Matthew.Meyer@kohler.com or Greg Miskinis at Gregory.Miskinis@waupacafoundry.com.

Evaluation of SDAS for Revised Aluminum Microstructure Wall Chart (14-15#07)

Coordinator: Dr. Robin Foley, University of Alabama Birmingham (UAB) and AFS Aluminum Division (2)

Background and Objective: The inventory of AFS Aluminum Division Microstructure Wall charts is depleted and needs to be republished for availability to aluminum foundries. It is also a key resource is the aluminum classes taught by the Institute and many of our universities with metalcasting and metallography classes. The chart features grain size and modification photomicrographs with numerical rating which both casting buyers and casting suppliers utilize. An additional important microstructural feature has emerged over the past several years—secondary dendrite spacing or SDAS—which has a direct correlation with solidification rate and subsequent mechanical properties. Since SDAS has a proven effect on mechanical properties in hypoeutectic aluminum–silicon alloys, and is strongly related to microstructure it is very desirable to incorporate these SDAS correlations in the updated AFS Microstructure Control in Hypoeutectic Aluminum–Silicon Alloys Chart.

The objective of this applied research is to measure SDAS as a function of solidification rate, then establish and publish microstructures on a range of SDAS results which can be incorporated into the renewed and re-published wall chart. The work is being performed at University of Alabama Birmingham (UAB) under the direction of principal investigator Dr. Robin Foley.

Status Update: This project is just starting with initial casting efforts to produce the test samples for metallographic evaluation. Those wishing more information about the project or how to participate should contact the Steering Committee chair David Neff at theneffers@sbcglobal.net or the PI Dr. Robin Foley at rfoley@uab.edu.

Investigation of Cause of Micro-porosity of Various No Pb Copper-Based Alloys (14-15#08)

Coordinator: Dr. Charlie Monroe, University of Alabama Birmingham (UAB) and AFS Copper Division (3)

Copper-based alloys are an important part of the metal casting industry for a variety of reasons which can be attributed to having a great range in mechanical properties and corrosion resistance. Copper-based alloys have been used in plumbing components because of these desirable properties, and traditionally have had lead be a component in the casting. Lead provides improved machinability and provides pressure tightness. As lead has been linked to health concerns, the Safe Drinking Water Act was passed to limit the lead in drinking water. This is what caused the need for new lead-free copper-based alloys. However micro-porosity has been is a common issue with some low-lead copper-based alloys. This can cause unsound pressure tightness, which leads to higher scrap levels that increases the price of the part. Casting simulation tools have been implemented with varied levels of results. Casting simulation, along with research, will be the most practical way to prevent micro-porosity, so it is important to correlate the theoretical solidification science and practical solidification science (experimental results) to the theoretical application (simulation) and practical application (casting) to produce quality castings.

Micro-porosity is a hard defect to analyze because it is not easily seen. This defect is not normally found until the casting is tested for leaks. Proof of micro-porosity is generally proven through optical microscopy. It is also hard to pinpoint what causes micro-porosity and each individual casting whether there is increased air pressure, lack of feeding or other possible causes may have to be considered. These micro-pores can also cause detriments and strength or just overall losses in mechanical property. When a part has micro-porosity and it's put under pressure, the micro-porosity can serve as a nucleation site for cracks. In copper alloys, where they are mainly used for plumbing applications, this pressure tightness is a mandatory factor, so micro-porosity must be eliminated.

This effort under the guidance of the American Foundry Society's Copper Division 3 is being taken to understand the mechanism and possible critical values that should be avoided in creating micro-porosity. The research is split into three parts: causing the micro-porosity in sample, analyzing the sample and simulating the micro-porosity. A Bridgman furnace will be used to study directional solidification. It can give a steady melt front, so that the cooling rate can be mapped. The cooling rate of the furnace can be adjusted to simulate cast thicknesses of 1/8" to 8" thick. The speed of the melt front can be easily varied as well. This furnace also will allow for temperature ranges to be recorded, as well as only needing a small sample volume. This should allow for a procedure to be established to create micro-porosity and be able to increase/decrease its volume.

Status Update: This project is just starting. Those wishing more information about the project or how to participate should contact the Steering Committee chair Kerry Bisset at kbisset@magmasoft.com or the PI Dr. Charles A Monroe at camonroe@uab.edu.

Veining Reduction Project (15-16#01)

Coordinator: Dr. Sam Ramrattan, Western Michigan University and AFS Mold Metal Interface Committee (4-F)

Foundry engineers have long known that there is high test-to-test variability with certain precision sand specimen. A Phase I simulation analysis was used to improve a tool design for producing 50 mm, 8 mm thick polyurethane cold-box (PUCB) disc-shaped specimens. Ramrattan et al. (2014) identified uniformity in sand binder density distribution in PUCB specimens. A new tool was built according to recommendation from the simulation and specimens were produced. Physical, mechanical, and thermo-mechanical testing was conducted on the new specimens and compared to old. The results show that there is lower test-to-test variability with the new disc-shaped specimens. The AFS 4-F Mold-Metal Interface Committee has begun a research project aimed at reducing or eliminating veining using various thermo-mechanical models. Feasibility studies that evaluated three models as veining predictors have been completed at Western Michigan University (WMU) and the results are promising.

The aim of Phase II is to evaluate a variety of PUCB disc shaped cores using casting trial models at cast iron temperature:

i. Model #1—Variable Point Load
ii. Model #2—Tension Stress
iii. Model #3—Variable Specimen Thickness

The purpose is to determine whether the models can be used for predicting the onset of veining and penetration complementing thermal distortion testing (TDT) developed in Phase I and predict the onset of veining and penetration.

Status Update: The Phase II activity is just beginning and initial sample test specimens are being secured. Those wishing more information about the project, or participation should contact the Steering Committee chair Fritz Meyer at friedhelm.meyer@ask-chemicals.com or Dr. Sam Ramrattan at sam.ramrattan@wmich.edu.

Effect of Dross and Gray Iron Skin on Ductile Iron Fatigue Properties (15-16#02)

Coordinator: John Reesman, Caterpillar and AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R)

The mechanical properties of DI, as those of most metallic materials, are measured on and reported (as per ASTM) on standard machined specimens. However, most castings retain most of the as-cast surface. This surface layer, commonly referred to as the casting skin, includes both surface and sub-surface, and is typically incorporated in the term surface quality. Because of the casting skin, the mechanical properties of the part may be significantly different from those found on the standard ASTM specimens machined from the same casting. It is expected that as the thickness of the casting decreases, the relative effect of the skin on the mechanical properties increases. This issue has received only limited attention.

The primary objective of the project is to quantify the impact that endogenous dross (from liquid iron oxidized during mold filling) has on the fatigue properties of ductile iron. The secondary objective is to share, with members of the AFS, the knowledge associated with those findings in terms of the importance of that mold filling speed might have on the fatigue resistance of the cast DI parts and characterization of casting defect causing the reduced fatigue strength.

The innovative aspect of this project resides primarily in the quantification of the impact of a very concrete casting parameter; the mold filling speed. Foundry men know that it is usually not well advised to rapidly fill a mold cavity. However, the impact that such a practice might have on the fatigue resistance of castings is completely unknown. Will rapidly filling a mold reduce the fatigue resistance of a part by 2, 25 or 50 %? Currently, no one can answer this question; there are too many parameters which come into play, such as skin effect (formation of a thin gray iron layer) or even the presence of sand particles, to reliably come up with an answer.

The testing process designed for this project will be useful for foundries which are contemplating similar work for given customers. However, most importantly, the information gathered throughout this project will be an invaluable for AFS members, as they strive to compete on the international markets by providing high quality products.

Status Update: This project has not yet started. The work is being monitored by the AFS Ductile Iron, CG Iron & Gray Iron Research Committee (5-R). Those wishing more information about the project or how to participate as a sponsor should contact the Steering Committee chair Mark Osborne at mosborne@american-usa.com or John Reesman at Reesman_John@cat.com.

Metalcasting Industry Funded & Monitored Research

American Metalcasting Consortium/U.S. Dept. of Defense/ Defense Logistics Agency Funded Projects/ National Institute of Standards/AMTech Program

Castings Solutions for Readiness (CSR) Program

AFS, as part of its efforts in the American Metalcasting Consortium (AMC), has recently secured contracts funded through the U.S. Department of Defense, Defense Logistics Agency, Defense Supply Center Philadelphia and the Defense Logistics Agency, Ft. Belvoir, VA. The group of projects is under an AMC program entitled Castings Solutions for Readiness (CSR). The two new projects are continuations of previous AFS AMC efforts, including one project called Cast High-Integrity Alloy Mechanical Property Standards (CHAMPS) and the other Casting Standards and Specifications.

CHAMPS Project—Additional Alloy Design

The CHAMPS Statistical Properties Project goal is incorporation of material property design data for additional cast alloys, A206-T4 and T7 in the initial phase and then investment cast 17-4-PH and 15-5PH in a second phase that is just beginning, into MMPDS (Metallic Materials Properties Development and Standardization) handbook, which replaced Mil-Handbook 5, so that this material can be specified and used to design and manufacture flight critical components in military and civilian aircraft. This builds on the original just completed E357 effort of establishing a framework to design a series of test specimens that encompass the various section thicknesses used in these applications utilizing process simulation software, validate the approach metallographically, coordinate collection of required samples from a consortium of qualified foundries and submit the data for statistical analysis and approval by MMPDS board for incorporation into the MMPDS standards. The benefit to DLA is that the development of statistical based property data will permit the use of castings across a broader range of applications and will provide the following benefits. The Engineering Support Activities at the DLA will be able to make cast alloy conversion/replacement decisions with assurance using statistical data on tensile, compressive, shear, and bearing properties from the FAA recognized source, MMPDS Handbook. Also reduced lead times with cast components competing on an equal basis with forging and assemblies from sheet, plate, and extruded mill products.

As with the E357 project, the intended outcome will be cast A&B design property allowables for the alloys selected for inclusion in the MMPDS (old Mil Spec Handbook 5) to meet FAA requirements. This will allow aerospace design engineers to specify castings without using design safety factors. Various working groups will be actively looking at melt practices, test casting gating and filling, heat treatment parameters, testing protocol and weld repair standards. The initial casting trials will follow the approach taken for E357 and conducted for 1.5 × 2.5-in. plate cast in both horizontal and vertical gating approaches, and a heat treat study was conducted at various participating foundries. These plates will be tested for tensile properties and undergo microstructural evaluation. The project is now starting with the initial activity investigating modeling the gating and rigging used for a previous E357 project followed by some casting verification trials. Those wishing to participate or wanting more information should contact Steve Robison, AFS, at stever@afsinc.org.

Casting Standards and Specifications

Accessing state-of-the-market technical, specification and training materials for castings is challenging. AFS is working to provide current and qualified information in a network friendly form to users of castings via the Casting Standards and Specifications project. The effort includes both archival and recent technical information in searchable databases. Specifications and standards are summarized, and the user is guided in their application. Tutorials covering the fundamental design concerns are also presented. The development of an online material design property database will greatly enhance the ability for the next generation of component designer to create the lightest weight and most efficient parts quicker and at lower cost. These tools facilitate more effective and efficient procurement to both DoD and industry in the support of weapon systems. Along with data from various AFS research projects, like the recently completed 08-09#01 & 08-09#03 projects for the Development of Fatigue Properties Database, AFS has also incorporated the USAMP Light Metals Materials Database properties and recently strain life fatigue data for CGI Grade 400 and a hi-alloy Class 40 Gray Iron into the AFS Casting Alloy Data Search (CADS) onto the AFS design website: www.metalcastingvirtuallibrary.com/cads/cads.aspx. This completes this phase of the project and AFS is working with various groups, including design software providers, the design departments of OEMs and ASM to create Cast Alloy Material Property Datasheets to be put on the ASM Material Selector and AFS websites. This work has been compiled into an updated DVD that is available from the AFS bookstore. This is an outstanding resource for those needing validated mechanical properties that design engineers need to make the most efficient components. The work planned under this project will add design properties for 4–5 additional cast metal alloys per year, while continuing to upgrade the CADS online database. During the first two years work was completed on Class 25E Gray Iron, Ductile Iron EN-GJS500-07 (lower hardness version of 80-55-06) for 1 and 3 inch section thickness, HiSiMo Ductile Iron, and 1 and 2 inch section Aluminum E357, with specimens coming from the previously completed CHAMPS E357 project. Work is completed for an aluminum Al4Si with samples produced in both sand and permanent mold and additional work is currently underway for 535 and planned for A206. The project would like to secure additional cast materials, including common grades of steel and copper-based alloy.

For more information, contact Thomas Prucha, AFS, at tprucha@afsinc.org or AFS technical and library services, Katie Matticks at katie@afsinc.org.

National Institute of Standards (NIST) AMTech Program

Pathway to Improved Metalcasting Manufacturing Technology & Processes—Taking Metalcasting Beyond 2020

The National Institute of Standards and Technology (NIST) awarded an advanced manufacturing technology planning grant to a metalcasting project submitted by the American Foundry Society (AFS). The Pathway to Improved Metalcasting Manufacturing Technology and Processes –Taking Metalcasting Beyond 2020 project is one of 19 initiatives that were awarded a total of $9 million to develop technology roadmaps aimed at strengthening U.S. manufacturing and innovation performance across industries.

AFS is the lead organization in the project that will be launched by the American Metalcasting Consortium, which is composed of four industry associations that represent 95 % of the nation's 2,000 foundries. The goal is to conduct an industrywide roadmapping effort to identify research and related actions aimed at achieving significant improvements in processing capabilities and productivity. Specific objectives are to:

- Reach industry consensus on metalcasting capability gaps, solution priorities, and investment recommendations.
- Identify potentially transformative technologies requiring collaborative research.
- Establish clear problem definitions and a common framework for parallel work by multiple organizations.
- Chart a transition path to facilitate interoperability of developed solutions with existing systems.
- Build a collaborative infrastructure tailored to the roadmap's targeted outcomes.
- Initiate development of an infrastructure that supports an advanced U.S. metalcasting industry.

Castings are in every sector of the economy including transportation, energy, mining, construction, maritime, fluid power, instrumentation, computers, defense, and household products. A strong U.S. metalcasting industry is needed to maintain global competitiveness. To improve the domestic metalcasting industry, there are significant challenges needed to improve productivity, manufacturing practices, advanced alloy and component performance, and attract employees and students needed for energy efficiency, and environmental compatibility. The vast majority of metalcasters are small businesses that do not have the resources to perform the advanced research and development necessary to remain competitive and maintain sustainable enterprises.

The American Metalcasting Consortium (AMC) roadmapping planning process will identify, select, and develop technological alternatives to ensure a competitive U.S. metalcasting industry. AMC integrates the nation's top academic metalcasting researchers with the four leading metalcasting industry associations (American Foundry Society, Non-Ferrous Founders' Society, North American Die Casting Association, and the Steel Founders' Society of America) and their members to identify new technologies and processes to enhance the global competitiveness of the U.S. metalcasting industry. AMC will develop a roadmap with an integrated, prioritized and readily executable plan of action based on mapping capability gaps to solution paths with the greatest potential to meet goals of the industry. This initial survey was very successful, with 258 responding and then 65 in a follow-up survey-interview process which is being used to help prepare for the AMC Roadmapping Workshop which was held May 12–13, 2015. The results of this workshop will be used to create a draft Roadmap, which will be then sent out for review and input by the various stakeholders of the metalcasting industry before crafting a final Metalcasting Roadmap.

National Network for Manufacturing Innovation

America Makes—National Additive Manufacturing Innovation Institute

America Makes is the National Additive Manufacturing Innovation Institute. As the national accelerator for additive manufacturing (AM) and 3D printing (3DP), America Makes is the nation's leading and collaborative partner in AM and 3DP technology research, discovery, creation, and innovation. Structured as a public–private partnership with member organizations from industry, academia, government, non-government agencies, and workforce and economic development resources, its mission is to innovate and accelerate AM and 3DP to increase our nation's global manufacturing competitiveness. AFS is partnering with Youngstown Business Incubator (YBI) who has been named a recipient of funds from America Makes for the research project "Accelerated Adoption of AM Technology in the American Foundry Industry." Along with YBI, Youngstown State University (YSU), ExOne, Humtown Products, and the University of Northern Iowa (UNI), the project team for "Accelerated Adoption of AM Technology in the American Foundry Industry" will support the transition of binder jet AM to the small business casting industry by allowing increased access to the use of binder jet equipment and the development of design guidelines and process specifications. The AFS and the America Makes Consortium held a very successful Pre-Congress workshop on April 20, 2015 just prior to the 119th Metalcasting Congress. It was attended by 190 participants with workshop speakers presenting the key aspects of the technology, latest research and advancements, how the technology can promote and enhance design freedom and product improvement and highlighted by presentations and a panel discussion by several foundries on how they are using the technology to expand markets, reduce lead time and improve cost. At the end of the workshop, discussion was held to help form the first AFS ad-hoc committee on Additive Manufacturing. This effort will now continue via emails to those who expressed interest and web announcments.

Lightweight Innovations For Tomorrow—LIFT

The Lightweight and Modern Metals Manufacturing Innovation—LM3I—has been renamed LIFT (Lightweight Innovations For Tomorrow) and is headquartered in downtown Detroit. LIFT is led by Ohio-based EWI (Edison Welding Institute), a company that develops and applies manufacturing technology innovation within the manufacturing industry. AFS is part of a 60-member consortium that will pair leading aluminum, titanium, and high strength steel manufacturers with universities and laboratories pioneering new technology development and research. "The long-term goal of the LIFT LM3I Institute will be to expand the market for and create new consumers of products and systems that utilize new, lightweight, high performing metals and alloys by removing technological barriers to their manufacture," the White House said. The Institute will seek to achieve this through leadership in pre-competitive advanced research and partnerships across defense, aerospace, automotive, energy, and consumer products industries. The White House noted that lightweight and modern metals are utilized in a vast array of commercial products, from automobiles, to machinery and equipment, to marine craft and aircraft. "These ultra-light and ultra-strong materials improve the performance, enhance the safety, and boost the energy and fuel efficiency of vehicles and machines," the White House said. The Institute will advance the state of processing and fabrication technologies for lightweight and modern metals by facilitating the transition between basic/early research and full-scale production of associated materials, components and systems. AFS will champion the role of the metalcasting industry as a key metals manufacturing sector in this effort, with two initial projects being started in the casting area., one on thin walled ferrous and the other on thin walled non-ferrous castings.

Digital Manufacturing and Design Innovation—DMDI

The idea behind the Institute is that manufacturing is being transformed by digital design, which replaces the draftsman's table with the capacity to work and create in a virtual environment. AFS feels the establishment of a Digital Manufacturing and Design Innovation (DMDI) Institute will increase the successful transition of digital manufacturing and innovative design technologies through advanced manufacturing, create an adaptive workforce capable of meeting industry needs, further increasing domestic competitiveness, and meet participating defense and civilian agency requirements. This project will benefit the U.S. manufacturing industry by providing resource, focal point and network for resolving technical barriers currently limiting the application and integration of digital manufacturing and innovative design technologies. As it relates to the metalcasting industry, the use of these technologies will assist in the more rapid development and production of lighter weight metal cast components for military, energy, transportation and commercial applications. This can allow for design innovation via part consolidation and near net shape capabilities of metalcasting, the weight reduction potential of such materials as magnesium, aluminum, titanium and next generation ferrous metals, and the improved quality and productivity of advanced casting processes, this unique program can make significant strides toward production of high integrity, complex cast components and advance our manufacturing base. The Institute will also be a resource for training our workforce from manual labor to more highly skilled and technical jobs.

AFS Information Services

Casting Process and Alloy Assistance

The AFS website offers assistance for casting design engineers in selecting the best casting process for a potential component, and also provides casting alloy design and property data on many commonly used alloys. The website provides casting users, design engineers and purchasers with relevant and accurate information on casting capabilities and properties, providing easily accessible and retrievable information from a single site. The alloy data can be quickly exported to a spreadsheet or FEA tools. The comprehensive site includes assistance for selection of alloys, casting process, alloy property data for many common alloys and a metalcaster directory to locate potential casting sources. The Casting Alloy & Process Selector, the Casting Alloy Data Search and the Metalcaster Directory are located on the AFS website, http://www.afsinc.org/. Contact Katie Matticks, technical & library services for assistance or more information kmatticks@afsinc.org.

Technical Resource

Technical department staff and technical committee members provide regular contributions to ***MODERN CASTING*** and ***Metal Casting Design & Purchasing*** magazines. CastTIP and Testing 1-2-3 columns are regular features and document the best practices for various procedures and tests used in the metalcasting industry, and various casting defects, including potential causes and solutions. AFS technical staff associates are available to support AFS members with technical help, casting problems and metalcasting information. Assistance is available through telephone, email requests and CastingConnection discussion posts.

CastingConnection

Want to be connected to the metalcasting industry like never before? Whether you are an AFS member, or thinking of becoming one, the AFS CastingConnection private social professional network is where your experience begins. CastingConnection is an environment to connect, engage and share critical industry information and best practices in real time. Through the Open Forum and sites devoted for our special interest groups, members can gather to network via a comprehensive member directory, participate in focused discussion groups and access and share useful and informative documents and media in all formats.

Library

The AFS online library database serves the needs of the metalcasting industry for current and historic metalcasting information. AFS is continuing to electronically archive the full ***AFS Transactions*** series using non-destructive scanning technologies. The project is nearing completion, with all ***AFS Transactions*** fully electronically archived and web searchable, from the very first edition (published in 1896) to the present.

The updated and advanced AFS library website with almost 40,000 papers and articles about metalcasting are available for purchase. Located at www.afslibrary.com, the website houses the world's largest collection of metalcasting reference material.

The online AFS library is powered by a Google search engine, providing state-of-the-art functionality to help users find articles quickly. Reference services by phone and email assist users in refining their search or locating a specific article. The site provides the option to purchase AFS copyrighted papers and articles by automatic download or email.

For more information on the library website, contact AFS technical and library services, Katie Matticks, kmatticks@afsinc.org.

AFS Technology Transfer

119th Metalcasting Congress

Sponsored by the American Foundry Society (AFS), the 119th AFS Metalcasting Congress was held on April 21–23, 2015 at the Greater Columbus Convention Center, Columbus, Ohio. The Congress provided metalcasters, suppliers, casting buyers and designers with the opportunity to learn about the latest metalcasting innovations and procedures. During almost 50 education breakout sessions attendees received practical, valuable and useful information to help them improve the efficiency and profitability of their metalcasting operations. Featuring exhibitors displaying the latest in metalcasting technology and technical education sessions covering all metalcasting issues, the Metalcasting Congress created a venue to learn and network with foundry and diecasting, supplier and casting customer personnel. Preceding the Congress on Monday, April 20, AFS held the Additive Manufacturing for Metalcasting Workshop. Cohosted and conducted by America Makes Consortium members, this workshop drew almost 200 attendees and covered all the issues relating to this new technology. CastExpo'16 and the 120th Metalcasting Congress will be held in Minneapolis, Minnesota, April 16–19, 2016. CastExpo is the single largest trade show and exposition for metalcasting in the Americas. CastExpo offers metalcasters, suppliers, and casting buyers and designers the opportunity to connect and educate themselves on the latest and greatest metalcasting has to offer. For more information on CastExpo or technical paper submission, contact Metalcasting Congress coordinator Pam Lassila at 847/824-0181 × 240, or plassila@afsinc.org.

Conferences, Workshops and Webinars

AFS organized two technical conferences this fall, highlighting best practices and the latest technologies in aluminum casting and ferrous melting. AFS Design and Production of High Quality Aluminum Castings conference, October 5–7, 201, provided practical information and the latest research on melt treatment, molten metal cleanliness, heat treating, casting process optimization, worker safety and energy conservation. The AFS International Ferrous Melting Conference, October 7–9, 2015, covered all topics relating to ferrous alloy melting, including refractory, induction melting, induction holding, cupola melting, slag, charge materials, metallurgy and chemistry control, casting defects from melting practices, and energy conservation. Both conferences were held at the Sheraton Music City Hotel, Nashville, Tenn. For more information on AFS conferences and workshops, contact Laura Kasch, AFS technical assistant, 847/824-0181 × 246, or technicalassistant@afsinc.org.

Technology Transfer Thursdays

The American Foundry Society conducts a webinar program highlighting the latest research in the metalcasting industry. Technology Transfer Thursdays presents the research and findings from AFS Funded Research projects and how these new developments can benefit the metalcasting industry.

Recent webinars featured the results of a recently completed AFS research projects on the quenched cupola and veining reduction—a thermo-mechanical approach by Dr. Sam Ramrattan, WMU, which had over 115 participants on the webinar. The most recent one conducted March 4, 2015, "Magnesium Melt Cleanliness" was presented by Prof. C. (Ravi) Ravindran, Ryerson University. After a summer hiatus, the webinars will begin again soon. Technology Transfer webinars are offered to the metalcasting industry at no cost. For more information contact Laura Kasch, AFS technical assistant, 800/537-4237 × 246, technicalassistant@afsinc.org.

Metalcasting Industry Calendar of Events

2016

Feb 3–5	**AFS Labor Relations & Human Resource Conference,** Hyatt Regency Pier Sixty-Six, Ft. Lauderdale, FL
Feb 10–12	**AFS 78th Annual Wisconsin Regional Foundry Conference & Exposition,** The Potawatomi Hotel & Casino, Milwaukee, Wisconsin
Feb 15–16	**AFS Metalcasting Supply Chain Summit,** Hilton Chicago O'Hare Airport, Chicago, IL
Feb 16–17	**AFS Supplier Summit,** Hilton Chicago O'Hare Airport, Chicago, IL
Feb 24–15	**AFS Advanced Foundry Air Seminar,** The Crowne Plaza Atlanta Airport Hotel, Atlanta, GA
Feb 14–18	TMS 2016 145th ANNUAL MEETING & EXHIBITION, Nashville, TN
Mar 2–4	**AFS Southeast Regional Conference,** Wild Dunes Resort, Isle of Palms, SC
Mar 22–24	SME FABTECH Canada, Toronto Congress Centre, Toronto, ONT
Apr 16–19	**CastExpo'16, Minneapolis Convention Center,** Minneapolis, MN
May 16–19	SME RAPID 2016, Orange County Convention Center, Orlando, Florida
May 18–19	**AFS Government Affairs Conference,** Hyatt Regency Washington on Capital Hill, Washington, DC
May 21–25	WFO 72nd World Foundry Congress, Port Messe Nagoya, Nagoya, Japan
Jun 1–3	Ductile Iron Society (DIS) Annual Meeting, Hilton Garden Inn, Perrysburg, OH
Jun 14–15	ACRC (Advanced Casting Research Consortium) Spring Meeting, WPI, Worchester, MA
Jun 15–16	AMC (American Metalcasting Consortium) Annual Tech Review, Hilton Garden Inn, Des Plaines, IL
Jun 22–23	HTDC 2016 (High Tech Die Casting), Venice, Italy
Aug 14–15	**AFS Advanced Foundry Waste Seminar,** Hotel TBD, Milwaukee, WI
Aug 16–18	**AFS 28th Environmental, Health & Safety Conference,** Hotel TBD, Milwaukee, WI
Aug 25–26	**AFS Chapter Officers Conference,** Location to be determined
Sep 11–13	**AFS Foundry Executive Conference,** The St. Regis Deer Valley, Park City, UT

Sep 26–28	North American Die Casting Association (NADCA), Die Casting Congress and Tabletop, Greater Columbus Convention Center, Columbus, OH
Oct TBD	**AFS Conference on Additive Manufacturing and 3D Printing**
Oct 14–16	Non-Ferrous Founders' Society (NFFS) 2016 Industry Executive Conference & Annual Meeting, Loews Ventana Canyon Resort, Tucson, AZ
Oct 15–18	Investment Casting Institute (ICI) 63rd Annual Technical Conference and Expo, Hyatt Regency Columbus, Columbus, OH
Oct 26–28	Ductile Iron Society (DIS), 2016 World Conference on ADI, Westin Hotel, Atlanta, GA
Nov 16–18	SME FABTECH, Las Vegas Convention Center, Las Vegas, NV
Nov 17–18	FEF College Industry Conference, Westin Hotel, Chicago, IL
Dec 7–10	Steel Founders' Society of America (SFSA) National T&O Conference, The Drake, Chicago, IL

2017

Apr 25–27 **AFS 121st Metalcasting Congress,** Wisconsin Center, Milwaukee, WI

For further information on conferences and meetings, please contact the appropriate organization directly at the phone number or web address shown below. Information is updated frequently on the AFS website: www.afsinc.org.

American Foundry Society	847/824-0181
Aluminum Association Inc.	703/358-2960
American Metalcasting Consortium	843/760-3219
American Society of Mechanical Engineers (ASME)	212/705-7100
ASM International	440/338-5151
Casting Industry Suppliers Association	623/547-0920
Ductile Iron Society	440/665-3686
FEF	847/490-9200
Industrial Minerals Association-North America	202/457-0200
Investment Casting Institute	291/573-9770
Iron Casting Research Institute	614/275-4201
Institute of Indian Foundrymen	www.indianfoundry.org, ifc.aff2012@gmail.com
The Minerals, Metals & Materials Society (TMS)	724/776-9000
National Industrial Sand Association	202/457-0200
Non-Ferrous Founders' Society	847/299-0950
North American Die Casting Association	847/279-0001
SME	ww.sme.org and www.rapid3devent.com
Steel Founders' Society of America	815/455-8240
World Foundry Congress	www.wfc2016.jp
World Foundry Organization	World Foundry Organization info@thewfo.com