Metalcasting Industry Research

AFS is involved in several research partnerships funded through government funding and industry contributions and other means. Support of research is critical for North America to maintain a strong, vibrant, healthy and continually advancing metalcasting industry. AFS participates in these projects by securing industry partners and providing technical management and oversight.

Current research funding partnerships include:

- Advanced Casting Research Center (ACRC), which is part of the Metal Processing Institute (MPI) at Worcester Polytechnic Institute (WPI).
- US Department of Defense (DOD), Defense Logistics Agency (DLA) Castings Solutions for Readiness (CSR) Program and Innovative Casting Technology (ICT) Program, both funded through the American Metalcasting Consortium (AMC).

AFS Funded & Monitored Research

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.

Lost Foam Process Stainless Steel ASTM A351 CF8 M

Coordinator: Marshall Miller, Flowserve Inc, Flowserve Corporation, Irving, TX

This project goal is to produce low-carbon (.08% C maximum) stainless steel in the lost foam process. This steel casting market is primarily ruled by the sand and investment casting processes. Sand, while reasonably fast for delivery, especially in 3D-printed core and tool applications, is relatively imprecise compared to lost foam and investment requiring extensive machining of the casting and requires more weight for draft, stock and molding dimensional issues. Investment, while precise, has size and cost limitations. While there have been examples of success producing ASTM A351 CF8 M grade of stainless steel (.08% C maximum), a sponsored study to develop the necessary parameters for producing stainless steels in the lost foam process has not been performed so that the process can be refined and deployed. Defining the base chemistry metal parameters to accommodate carbon pickup, pattern bead type (i.e., STMMA, EPS, PMMA) and density are not tested and defined aside from tolerable pattern density levels. Coating type and permeability are not yet established nor molding media parameters although they are basically understood. This project will produce ASTM A351 CF8 M stainless steel with .08% maximum carbon level in the lost foam process by understanding and implementing practices of bead selection, bead expansion, expanded bead density, permeability and fusion, coatings and their permeability, carbon consuming additives, metal pouring rates and base composition and molding media refractoriness and permeability.

The work is being monitored by AFS lost foam division. Those interested in more information about the project or how to participate should contact AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Development of Improved Repair Welding Alloy and Process for Al-Cu Sand Castings

Principal Investigator(s): David Weiss, Eck Industries, Manitowoc WI; Thomas Wood, Michigan Technological University, Houghton MI

Current practices to weld 206 alloy castings, particularly for repair of wall defects or defect depths of greater than 0.25" result in unsatisfactory welds. Both 206 and 2319 weld rods are typically used for repair welding of 206 castings. A recent project to determine the effect of weld repair on the static and dynamic properties of A206 sand castings did not successfully produce welds of the desired quality. The work determined that the major problem is the chemistry of the weld wire used to make the welds. The two alloys currently used by AFS foundries (A206 and 2319) either produce inconsistent weld quality (A206) or low ultimate tensile strength (2319).

To mitigate the effects of weld wire chemistry and other variables on weld repair quality, this project will utilize a set of statistically designed experiments to optimize a weld alloy chemistry and the welding parameters necessary for

the successful weld repair of A206 sand castings. The key objectives are:

- Develop new weld wire alloy
- Develop improved repair welding practices.
- Establish effect of welding parameters on weld quality.
- Determine the effects of homogenizing post-weld heat treats
- Determine effect of weld repair on tensile properties of A206 sand castings

The work is being monitored by AFS Aluminum Division. Those interested in more information about the project or how to participate should contact AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Effects of Metallurgical Factors on Micro-Porosity in Ductile Iron Castings

Principal Investigator(s): Dr. Simon Lekakh, Research Professor, Department of Materials Science and Engineering, Missouri University of Science and Technology, Rolla MO

Cast iron with spherical graphite (SGI) has a unique combination of high strength with good melt fluidity allowing the metalcasting industry to produce complicated geometry castings. There are many successful examples when integrated SGI castings have been substituted for steel stampings or forgings. SGI has less solidification shrinkage than steel; however, it is significantly higher than in gray iron. Currently, foundries use effective techniques to prevent formation of macro-shrinkage defects in hot spots; however, increasing complexity of ductile iron castings makes it difficult to produce sound castings without more widely distributed micro-porosity. Intensive risering helps with the elimination of large shrinkage pores but does not always guarantee the absence of micro-porosity. Elimination of micro-porosity will improve casting integrity and increase such important whole casting properties as fatigue life and low-temperature toughness.

The objective of this project is to study metallurgical factors that affected micro-porosity formation in SGI castings using novel experimental and simulation methods. The research will experimentally determine the mutual effects of SGI liquid metal processing on micro-porosity, link solidification kinetics to micro-porosity, suggest methods for control micro-porosity in SGI castings and improve SGI casting soundness.

The work is being monitored by AFS Cast Iron Division. Those interested in more information about the project or how to participate should contact AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Effect of Filling Conditions on Steel Casting Quality

Principal Investigator(s): Dr. Laura Bartlett, Dr. Mingzhi Xu, Missouri University of Science and Technology, Rolla MO

Recent understanding on the effect of filling conditions on casting surface and performance of aluminum castings has resulted in design of new gating systems that eliminate damaged metal, greatly increasing casting quality and yield. It has been proposed by recent researchers that nearly all surface and internal defects in steel castings result from air entrainment during turbulent filling conditions causing unnecessary weld repair, low mechanical properties and customer rejections. Novel gating systems have been boasted by some to greatly reduce oxide and gas defects and completely eliminate the need for post-welding of steel castings. However, there has never been a quantitative study to determine the effectiveness of these gating systems for steel castings, and the impact of filling conditions on actual steel quality is currently unknown.

The purpose of the research is to quantitatively evaluate the effect of different filling conditions on steel casting quality and mechanical properties. A series of test castings will be produced utilizing different rigging systems commonly used in steel foundries. Filling of gating systems such as direct pour, horizontally gated and bottom gated systems will be designed using filling and solidification software. The results of casting trials will be compared to the use of best practices design involving bottom fill utilizing vortex gating. The objective will be to quantitatively compare casting metal quality and filling simulation results for a variety of filling conditions utilizing a combination of optical metallography, automated nonmetallic inclusion analysis and evaluation of mechanical properties.

This project is being monitored by the AFS Steel Division. Those wishing more information about the project or how to participate should contact AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Prediction and Control of Distortion in Permanent Molds

Coordinators: Dr. David Schwam, Case Western Reserve University and AFS Permanent Mold Committee

Permanent molds are subjected to high thermal stresses and are prone to distortion. Each casting cycle introduces heat into local areas of the mold, increasing the temperature and creating severe thermal gradients. Most of the mold material stays in the elastic deformation region and returns to the original dimensions upon cooling. However, in some

parts of the mold the compressive surface stresses may exceed yield, resulting in permanent, plastic deformation. Other metallurgical events are also in play as the mold distortion occurs over many casting cycles where time at temperature is an issue.

This is primarily a computational effort supported by experimental data. In this study, finite element modeling will be used to identify the sources of mold distortion and also to explore methods to minimize mold distortion. Computer software will be used to assess both thermal stress and the change in microstructure that will occur due to time and temperature for the hot face of the mold cavity.

A permanent mold will be obtained from participating companies along with the CAD used to fabricate it. The geometry of the used mold will be captured with a laser scanner (CWRU). Computer simulations of stress and distortion will be conducted by Dante Solutions to identify sources of mold distortion, and predictions for the specific mold will be compared to the laser scanned model.

This project is being monitored by the AFS Permanent Mold Practices Committee. Those wishing more information about the project or how to participate should contact AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Air Sampling Method for OSHA Silica Compliance

Coordinators: Robert Scholz, TRC Environmental, and AFS EHS Committee

OSHA's new worker exposure standard for respirable, crystalline silica requires that foundries limit exposure during work shifts to about one-half of the concentration level of the previous permissible exposure limit (PEL). Meeting this strict standard will necessitate that foundries refine their ability to identify and address root causes of exposure. Unfortunately, the method of averaging silica exposure over the work shift does not provide a basis for pinpointing those activities that have the greatest impact on overall average exposure levels. Real-time monitoring of silica concentrations could provide the needed diagnostic capability. However, this method is only in the developmental stage at this time. Instruments are commercially available to measure the concentration of silica-bearing respirable particulate matter (RPM). If real-time RPM measurements can be correlated to its silica content in a foundry situation, the needed capability for diagnosing the root causes of exposure could be made available to foundries. The goal of the project emanating from this proposal is to develop a procedure for providing the needed correlation in a wide variety of foundry process operations.

The work is being monitored by AFS Environmental Health and Safety Committee. For more information, contact the PI Robert Scholz at rscholz@trcsolutions.com or AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Quantify Casting Quality Through Filling Conditions

Coordinators: Dan Hoefert, Eck Industries, and AFS Aluminum and Light Metals Committee

Today, predicting the actual filling damage that oxides may cause to a casting remains largely based on theory, experience and speculation. In the past decade, great strides have been made in simulation capabilities. Heat transfer data and computational fluid flow have been combined to do a wonderful job of predicting porosity and mechanical properties. Filling concerns such as excessive filling velocity, eddies and other turbulent conditions can also be noted with simulation software. However, simulation software does not take the chemical reaction of oxide formation into account. Filling results only offer an indirect indication of the potential oxide damage, with no effect to the predicted porosity or mechanical results. As such, serious pitfalls can exist when it comes to interpreting simulation results.

Without correlating filling concerns related to oxide damage, misleading simulation results can be predicted. If a gating design includes well-placed feeders and chills, but includes turbulent filling conditions, simulation can falsely predict excellent soundness and mechanical properties, despite the filling damage noted indirectly by viewing the filling results. As foundries look for competitive ways to tool and fill castings, this confusion can tempt a foundry to choose a more turbulent-fill gating design if the simulation results predict quality advantages over a more tranquil-fill gating design. This project is intended to help answer these difficult questions with meaningful data that can be used to quantify these concerns.

The project is being monitored by AFS Aluminum & Light Metals Division. Those wishing more information about the project can contact the PI Dan Hoefert at Dan.Hoefert@eckindustries.com or AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org).

Evaluation of Alternative Aggregates for Use in Green Sand Systems

Coordinator: Jerry Thiel, University of Northern Iowa

The lower cost of silica sand and its relatively high refractoriness makes it a viable and economical choice for green sand systems, with millions of tons of silica sand used every year. However, a new rule by Occupational Safety and Health Administration (OSHA) considerably toughens the use of silica sand in a foundry. The regulation will require foundries to implement extensive engineering controls, which will be cost prohibitive for small-to-medium-sized metalcasting facilities. One possible solution for foundries will be to utilize a non-silica aggregate in their green sand systems. This will minimize or eliminate the respirable crystalline silica, in addition to the large capital cost associated with engineering controls mandated in the new regulations. Little research has been conducted in the use of alternate non-silica aggregates in a green sand system, and these materials need to be characterized and tested for ensuring good results when bonded with a bentonite clay.

It is the intent of the project to determine what limitations non-silica aggregates have in the replacement of silica sand and then to educate the industry in these areas. The work is being monitored by AFS Technical Department. Anyone interested in more information about the project should contact the PI Jerry Thiel at thiel@uni.edu or AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org). The research will be completed later in 2018.

Alternative Granular Media for Green Sand Casting

Coordinators: Dr. Sam Ramrattan, Western Michigan University

The new Occupational Safety and Health Administration (OSHA) regulations limiting exposure to respirable crystalline silica has renewed interest in alternatives to silica sand which can withstand the heat of metalcasting and the rigors of repetitive reuse. Foundries have used alternative materials for decades. Chromite, zircon, olivine and carbon sands have each been successfully used to solve operating problems and thus have developed their specific niches in the foundry materials inventory. However, there are several other materials that are candidates for replacing silica sand, such as fused alumina, sintered bauxite and ceramic sands. Compositions and shapes could be readily tailored for a metalcasting process with overall recycling (reclamation) affording sustainable materials management.

This study examines materials that are readily available as alternatives to silica sand from a functionality perspective evaluate their effectiveness for green sand casting.

Status Update: The work is being monitored by AFS Technical Department. Anyone interested in more information can contact the PI Dr. Sam Ramrattan at sam.ramrattan@wmich.edu or AFS Technical Research Assistant Ryan Davis, (rdavis@afsinc.org). The research is completed, and final reports are being written and will be ready for publication soon.

Metalcasting Industry Funded & Monitored Research

American Metalcasting Consortium/Defense Logistics Agency Funded Projects

Innovative Casting Technology (ICT) Program

AFS, as part of the AMC, has secured a contract funded through the US Department of Defense, Defense Logistics Agency, Defense Supply Center Philadelphia and the Defense Logistics Agency (DLA), Ft. Belvoir, VA. The group of projects is under an AMC program entitled Innovative Casting Technology. Two new projects are starting in 2018.

Casting Alloy Data Search (CADS)

AFS through AMC/DLA has developed a very effective web-based tool called Casting Alloy Data Search (CADS) for the design engineers and ICME professionals, which has been used for over five years by the foundry industry and accessible through their Web site. CADS needs to further expand to accommodate more ICME relevant data generation for optimization and more accurate predictions, such as thermo-physical and thermo-mechanical properties required for process simulation, beyond casting alloys, for example molding materials. The goal of this research project is to enhance the current CADS and create an additional module of CADS for the nonmetallics, such as molding and core materials being used in the sand casting process, and populate by generating and validating data useful to the ICME professionals.

CADS is developed in partnership with Product Development & Analysis (PDA).

Integration of ICME Tools in Casting Design and Process Optimization for Intelligent Manufacturing

The project will develop an effective and integrated ICME framework as an approach to make more efficient casting designs and improved manufacturing approaches. Current physics-based simulation tools are limited to simulate for a few, finite known process variabilities, but do not account for many more process variables, including dimensional, compositional and section thickness variability inherent to the metalcasting process. A comprehensive approach of physics-based simulation with probabilistic meta-modeling using historic data is unique and will allow for rapid and more accurate predictions.

AFS Information Services

Casting Process and Alloy Assistance

The American Foundry Society Web site provides tools to assist casting design engineers in selecting the best casting process for a potential component and also provides casting alloy property data on many commonly used alloys. The goal is to give casting users, design engineers and purchasers relevant and accurate information on casting capabilities and properties, providing easily accessible and retrievable information from a single site. The alloy property data can be quickly exported to a spreadsheet or FEA tools. The casting alloy & process selector, *Casting Alloy Data Search (CADS)*, is located on the AFS Web site, www.afsinc.org under the tabs: *Designers & Buyers* tab or can be accessed directly at: http://www.metalcastingvirtuallibrary.com/cads/cads.aspx. For more information, contact Steve Robison, AFS Chief Technical Services Officer, at 847-824-0181 ext. 227, or srobison@afsinc.org.

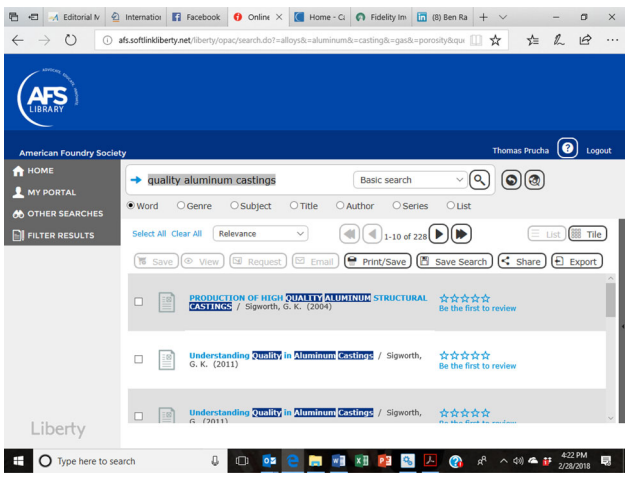
Casting Source Directory

The *Casting Source Directory* is also available to the public on the AFS Web site. The site provides a directory of North American metalcasters in a single source. Potential casting buyers can search by metal, alloy, casting process, casting size (weight) and US state to locate a casting provider that meets their needs. The *Casting Source Directory* is located on the AFS Web site under the *Designers & Buyers* tab or can be accessed directly at https://www.afsinc.org/metalcaster-directory. For more information, contact Steve Robison, AFS Chief Technical Services Officer, at 847-824-0181 ext. 227, or srobison@afsinc.org.

CastingConnection

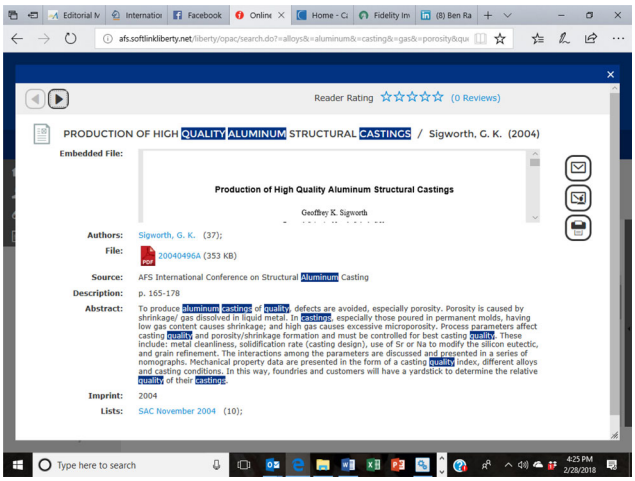
CastingConnection is a private, professional social network to connect, engage and share critical industry information and best practices in real time. Through the Open Forum and sites devoted to our special interest groups, members gather to network via a comprehensive member directory participate in focused discussion groups. AFS members access and share useful, informative documents and media in all formats. Visit https://castingconnection.afsinc.org.

Library



The new AFS online library serves the needs of the metalcasting industry for current and historic information on metallurgy, casting processes and material property data. The digital library is open to all AFS members. With a simple-to-use search, members have access to relevant technical and research articles and reports from all AFS published sources. Author and summary information is available for viewing, and full articles can be downloaded. AFS is electronically archiving all technical and management papers from *AFS Transactions.* When completed, all technical and management papers published in *AFS Transactions*, from the very first edition (published in 1896) to the present, will be available. The library is located on the AFS Web site (www.afsinc.org) under the "Innovation & Management" tab. The library also includes summary information for technical articles published in the International Journal of Metalcasting. For more information, contact the AFS Technical Research Assistant Ryan Davis at 847-824-0181 ext. 219 or rdavis@afsinc.org.

e-Learning



AFS has launched a new program that offers industry-specific training, information and education for metalcasters in a web-based format for a single access fee. The e-Learning program gives subscribing organizations full access to online modules for formal staff training on a wide variety of metalcasting topics. Individual e-Learning modules also are available a la carte. More information and a video demonstration are available at www.afsinc.org/e-learning.

AFS Technology Transfer

AFS CastExpo and 123nd AFS Metalcasting Congress

Representatives of the entire metalcasting industry supply chain will be at CastExpo 2019 on April 27–30, 2019, in Atlanta GA, USA. CastExpo 2019 is the largest North American gathering of the metalcasting supply chain, including full-scale exhibits, cutting-edge technology demos and new equipment and materials. Innovative education sessions will include keynote presentations, technical and management presentations and a new education track targeted for casting designers and purchasers. The education sessions will provide casting personnel opportunities for personal and professional development through three days of practical advice, the latest technology advancements, new process and material developments and foundry case studies. Education sessions will cover all common cast metals and processes, as well as information

relevant to business, management and special interest groups. The AFS Hub will feature areas for connecting with AFS staff and other attendees, the AFS Bookstore, The AFS Institute and Member Services and the Casting of the Year Display. For more information on Congress, contact Metalcasting Congress coordinator Pam Lassila at 847-824-0181 x240, or plassila@afsinc.org.

Conferences and Workshops

AFS is hosting a series of webinars to help foundries move toward compliance with the upcoming new regulations on respirable silica exposure. The webinars will cover many issues relating to compliance with the new standard, including alternate non-silica molding media, silica testing, medical testing and other issues. AFS has also scheduled monthly "members-only" webinars covering a wide range of technical issues to bring the latest technological developments to member. For more information, contact the AFS Technical Assistant, 847/824-0181 x246, technicalassistant@afsinc.org, or visit the AFS website at www.afsinc.org.

AFS is offered an extended program of educational opportunities covering all aspects of metalcasting including aluminum casting, iron casting, EHS issues, additive manufacturing, government issues and marketing. These educational events are scheduled to provide relevant and practical information to improve productivity and profitability for metalcasting facilities. The list below shows the complete schedule for upcoming AFS technical and management education events. For more information, contact the AFS Technical Assistant, 847/824-0181 x246, technicalassistant@afsinc.org, or Chief Technical Services Officer, Steve Robison at 800-537-4237 x227, stever@afsinc.org

- Oct 7–8, 2018; **AFS Advanced Air Seminar**, Warrensville Heights, OH
- Oct 9–11, 2018; **AFS 30th EHS Conference**, Warrensville Heights, OH
- Oct 10, 2018; **Advanced Cupola Concepts Seminar,** Coschocton, OH
- Nov 5–7, 2018; **AFS 2018 Aluminum Casting Conference**, Knoxville, TN
- Dec 11–12, 2018; **AFS Marketing Conference**, Rosemont, IL

The recent AFS Additive conference on Manufacturing for Metalcasting provided the more than 120 attendees with practical information and case studies demonstrating how metalcasters are using 3D printing technology to secure new customers, improve existing components and enhance their profitability. More than two days of presentation and demonstrations from foundries and suppliers covered the three primary areas that have seen significant benefits from 3D printing: printed sand molds and cores, printed hard tooling and printed expendable patterns for use in investment casting.

During the AFS Cast Iron Inoculation Conference, leading experts in the cast iron foundry industry covered all aspects of iron inoculation and how it relates to iron quality and performance. Topics included: nucleation potential, inoculation methods and materials, quality assurance and efficient operation and maintenance of inoculation feeders.

At the AFS Practical Cupola Operations Workshop (May 1–2, 2018) presenters discussed best practices on all issue related to couple operation, including basic principles, charge materials, refractory systems, cupola operation, preparing for startup and tapping out. The workshop also included a plant tour of three operating cupolas.

New Institute Chief to Focus on Delivery of Education Services

August 22, 2018

The AFS Institute recently completed a $1 million investment in metalcasting classroom-course and e-Learning curriculum. Now AFS has hired a new Institute leader, Clarence Trowbridge, to optimize the delivery of education and training to the metalcasting community. Trowbridge joined AFS as vice president of education and workforce development on August 20. The AFS Institute, formerly known as CMI, is the educational arm of AFS.

"The skills shortage is affecting metalcasters from coast to coast, making it harder to hire talent," said Doug Kurkul, CEO of AFS. "That puts a premium on retaining existing employees and training them for success. Clarence Trowbridge is especially well-positioned to help foundries achieve their workforce-related goals at this time."

Trowbridge brings 30 years of workforce development experience for companies including Inland Steel Company and BP. From 1996 to 2006, he built a successful education program for ESW Inc. In 2016, he published a book, *Maintenance Workforce Solutions: An Organizational Development Approach.*

Trowbridge, who also has experience working in a foundry, is a former sergeant in the US Army, where he was an electronics repair technician. As a reservist, he was an instructor for the Army Non-Commissioned Officer Academy in Indiana. He has an MBA in organizational development and a bachelor's degree in communications.

"I'm honored to be part of the continuing AFS traditions of advocacy, education and innovation," Trowbridge said, "Speaking of innovation, we'll be expanding the Institute's services to a suite of customized training programs based on companies' specific workforce needs. I look forward to meeting face to face with many foundry leaders in the months and years to come."

The AFS Institute offers classroom instruction, e-Learning and in-plant training to metalcasters across all materials and processes. A calendar of classroom courses scheduled through spring 2019 can be found at www.afsinc.org/training-excellence-metalcasting as can a list of 108 e-Learning modules available through the Institute. In-plant training can be scheduled by calling Bo Wallace at 800-537-4237, ext. 249.

The American Foundry Society is a dynamic technical and advocacy organization that serves and represents the $33 billion metalcasting industry. AFS is the only association serving the entire industry, including all metals and processes, with a three-part focus on advocacy, education and innovation. AFS also publishes Modern Casting *and* Metal Casting Design & Purchasing *magazines and presents Metalcasting Congress and CastExpo, the largest metalcasting trade events in North America. Founded in 1896, the organization is based in Schaumburg, Illinois, with an advocacy office in Washington, D.C. More information is available at afsinc.org.*


2018 ADVANCED FOUNDRY ENVIRONMENTAL AIR SEMINAR
Oct. 7-8, 2018
Cleveland Marriott East
Warrensville Heights, OH
Areas of information covered during the seminar are:
• Emission estimation
• Demonstrating compliance
• Permitting
• Regulatory requirements
• Practical control technologies
ADVOCATE. EDUCATE. INNOVATE.
AFS
AND THE INSTITUTE
30TH ANNIVERSARY OF THE EHS CONFERENCE
ENVIRONMENTAL, HEALTH, AND SAFETY CONFERENCE
Oct. 9-11, 2018
Cleveland Marriott East
Warrensville Heights, OH

2019 AFS/FEF Student Technology Contest

Call for Submissions – $3,000 Scholarship Available!

Submit Your Undergraduate Research Project Now

Organized by the American Foundry Society (AFS) and the Foundry Educational Foundation (FEF), the **AFS/FEF Student Technology Contest** is an opportunity for students to showcase their undergraduate research projects at CastExpo '19 (April 27-30, 2019) in Atlanta, Georgia. All eligible submissions will be judged by AFS technical staff and a panel of metalcasting industry experts. The winning submission will receive a $3,000 FEF scholarship. Top submissions will also be published in the AFS *International Journal of Metalcasting*.

Qualifications

The **AFS/FEF Student Technology Scholarship Contest** is open to North American citizens that are undergraduate students currently enrolled in metalcasting-related programs at FEF-certified and affiliated schools. Students must be registered with FEF and enrolled in the current academic year. The project must represent current or recent undergraduate-level work performed by the student(s) in metalcasting technology or molten metal processing. Each student may enter only one submission.

All presenting students must register and attend CastExpo '19, April 27–30, 2019, in Atlanta, Georgia. Congress registration is complimentary with a valid student ID. Students must be available for digital poster presentations and Q & A on Monday, April 29, 2019, from 11:30 to 12:30 p.m.

Presentation Details

Monday, April 29, 2019, 11:30–12:30 p.m., The Hub, at CastExpo '19. Each student will have approximately 10 min to present their submission (in AFS digital poster format) and field Q & A from the judges.

Participation Guidelines

Online applications including name(s) of presenting authors, project title and abstract are due by February 28, 2019. Applications can be completed at: https://bit.ly/2QcNrkm.

Students must use the provided digital poster template at: http://bit.ly/2mcvdkA.

A digital poster proof is due no later than March 5, 2019.

Judging Criteria	Points
Technical Content—completeness of work, interpretation of work, and results, analysis, discussion, references/bibliography	40
Sufficiency of data to validate conclusions.	
Relevance—relevance and applicability of the research to the metalcasting industry	25
Innovation—originality of ideas, concepts or approach	25
Presentation—overall style is effective. Information is concise and logically organized	10
Total	**100**

QUESTIONS? Contact: Kim Perna, Technical Assistant, American Foundry Society at: kperna@afsinc.org.