



KENT D. PEASLEE JUNIOR FACULTY AWARD

Year-End Report.....2020-2021

A year-end report is due on 31 May. Your final report (after year 3) will be posted to the AIST website for others to view and may be included, in whole or in part, in the AIST *Iron & Steel Technology* magazine. Prior to submitting your report:

- The mentors must have the opportunity to review your report and each provide a letter supporting the annual progress of your original proposal.
- A headshot and current address for the professor and each student involved must be provided.

Project Title Enhancing Georgia Southern Student Engagement with Iron and Steel Industry through Extracurricular Activities and Research

Team Leader

Title Mingzhi Xu
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Team Members (include name, class and major)

1. Shelton Fowler, master student, Mechanical Engineering
2. Samuel Holt, master student, Mechanical Engineering
3. James Liggett, master student, Manufacturing Engineering
4. Danial Garcia, senior, Mechanical Engineering
5. Dawson Richardson, senior, Mechanical Engineering
6. Aubrey Harold, junior, Manufacturing Engineering
7. Ajana Smith, freshman, Mechanical Engineering
8. Jacob Sapp, senior, Mechanical Engineering

Project Summary:

In spite of the impact of COVID-19, year 2020-2021 has been fruitful at Georgia Southern. The expansion of the Mechanical Engineering and Manufacturing Engineering departments, thanks to the state-funded new Engineering Research Building, has freed up more space for the metallurgy teaching and research laboratories. The ferrous foundry renovation started in June 2020 and finished in Jan 2021, with the help of this grant, enabling Georgia Southern to melt and cast both ferrous and non-ferrous alloys up to 100 lbs/heat. New equipment in the areas of heat treating, hot working, melting, metallography was built or purchased to expand the research and teaching capabilities. A new course Steel Heat Treatment and Microstructure was developed and taught in both Fall 2020 and Spring 2021 by Dr. Jingjing Qing, who was the recipient of the AIST Steel Curriculum Development Award. New course contents, including hot working, iron and steel casting, were added to the existing curriculum. The American Foundry Society student chapter also hosted an internal casting competition, more than ten students participated and submitted five entries. A team of three students competed in the Steel Foundry Society of America's (SFSFA) Cast in Steel competition, and won the "most intricate casting" award. More than eighty students participated in the AIST Steelmaking 101 training in Fall 2020 and Spring 2021. Drs. Mingzhi Xu and Jingjing Qing met with AIST Southeast Chapter officers, and are scheduled to have students present in the upcoming AISI Southeast annual conference in September 2021. In Jan 2021 and April 2021, two industry events were held on campus, hybrid and in-person individually. From these two events, a total of thirteen industry professionals were on campus to interact with the students. In addition, eight students (listed above) were involved in three iron and steel research projects. A total of \$9,000 scholarship was awarded to five students that are involved with iron and steel activities on campus.

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Questions should be directed to Lori Wharrey at lwharrey@aist.org or +1.724.814.3044.



Project Goals

To enhance the iron and steel environment, and improve student engagement at Georgia Southern University.

Project Details

Facility Update

One of the most efficient ways to raise the interest in iron and steel among the students is the real hands-on experience of melting and pouring molten metal. At the time of receiving this award, Georgia Southern only had the capability of melting and casting aluminum alloys. During the award period, Georgia Southern upgraded their non-ferrous furnace melting capability to cover copper alloys, and tripled the capacity of aluminum melting (from 20 lbs to 60 lbs per heat) through a major industry donation. Georgia Southern also received a donation of a 50-kw induction furnace melt unit. Leveraging with the Peaslee grant, Drs. Xu and Qing were able to allocate \$300,000 to renovate and expand the existing foundry space, including installation of a brand new transformer for the induction furnace, the pouring floor, and the ventilation system. The renovation began in June 2020, and was fully completed in Jan 2021. The renovated foundry laboratory space is approximately 2,500 sq. ft., including 2,000 sq. ft for molding and melting, 500 sq. ft for chemistry and metallography sample preparation and analysis, as shown in Figure 1. The foundry laboratory has been extensively used since the renovation was completed, for both the course and extracurricular activities. More details will be covered in the later sections.

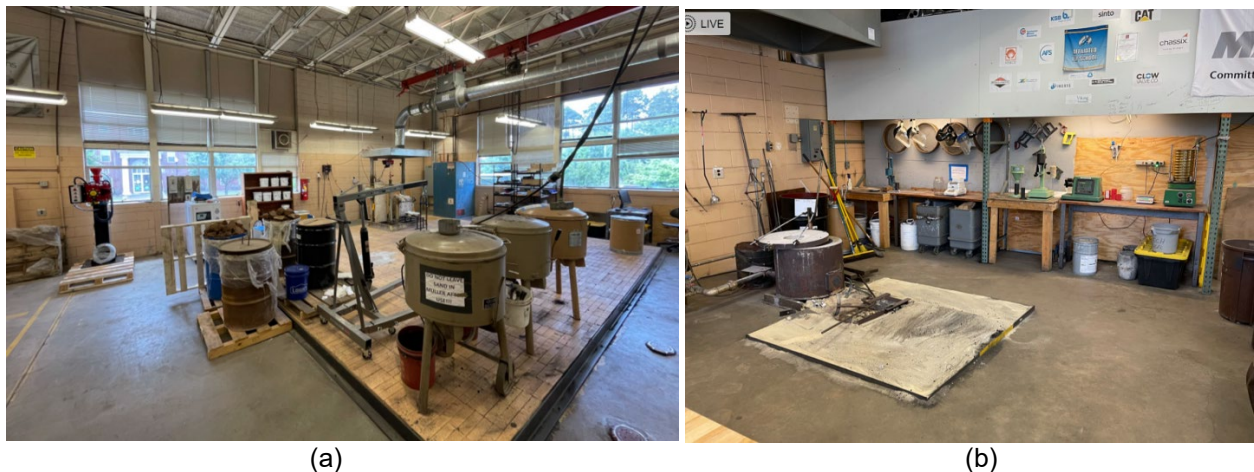


Figure 1. Renovated foundry space including (a) molding and ferrous melting, (b) sand testing and non-ferrous melting

In addition, more equipment was purchased and/or built during the award period to support the iron and steel related activities. These include one agitated water quench tank, two green sand testing apparatus, one 30KW induction melt and cooling unit, one 16-ton hydraulic forging press, one Zeiss DIC optical microscope, one Tinker-Omega continuous sand mixer, and miscellaneous metallographic preparation equipment. The Peaslee award was used to fund fully or partially some of these purchases. More details are included in the later section.

Curriculum Development

Dr. Xu worked really closely with Dr. Qing (actually his wife) to develop the new course Steel Heat Treatment and Microstructure. Dr. Xu sat in the course during the fall 2020 when the course was offered for the first time. More details can be found in Dr. Qing's year-end report.

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Dr. Xu has greatly expanded the curriculum of Materials Processing course and Metalcasting course. Steelmaking processes were covered in both courses for at least two lectures. Bonuses were provided to encourage the students to attend the AIST steelmaking 101 short course. In Fall 2020 and Spring 2021, a total of 80+ students participated the AIST training course. Moreover, hands-on ferrous melting and pouring were added to both courses. Particularly, in the metalcasting course, the students were challenged to design a set of cast iron cookware (skillet, Dutch oven) as their final projects. The project required the students to work in small groups, utilizing all modern tools, including SolidWorks, MAGMA flow and solidification simulation, additive manufacturing, CNC machining, to design their own patterns. The students had to consider not to exceeding the critical flow velocity, and minimizing shrinkage porosity in the final product. The projects were completed successfully, even though students were only provided with five 2-hour lab sessions to complete the entire designing, manufacturing, and finishing processes. The finished cast iron cookware was seasoned by the students and is shown in Figure 2.



Figure 2. The finished cast iron cookware (a) and an example of the pattern made by the students (b)

Student activities

The American Foundry Society student chapter remained strong in the year 2020-2021. Various activities and workshops were able to be hosted virtually and in small groups. In Fall 2020, the chapter hosted their own internal casting competition for the first time. Five different teams consisting more than ten students submitted their entries. The judging and awarding ceremony took place in Jan 2021 with five industry professionals from the AFS Piedmont Chapter who participated on campus. The five judges were able to interview the students from the five teams and evaluate their castings in person. Finally, the first place was awarded to the brass trophy, made by the team of James Liggett.

A team of three students, lead by Shelton Fowler, competed in the Steel Founder Society of America (SFSa) Cast in Steel international casting competition. The theme for the year 2020-2021 was a Thor's hammer that was under 6 lbs. The team utilized the Tetrakaidecahedron structure to create a lightweight but strong product. To take the advantage of different metals, the teams decided to investment cast the lattice with ductile iron, which has great flowability and little shrinkage porosity. The final impact bearing part of the hammer was sand cast with AISI 4140 steel. The casting process was extensively simulated to ensure a good filling, and that the steel would partially melt the ductile iron and form a tight metallurgical interface with it. Heat treatment processes



Figure 3 Brass trophies that won the first place during the internal casting competition

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were designed with the help of academic mentor, Dr. Von Richards, to remove the unwanted carbide along the steel/cast iron interface. Thermodynamic software JMatPro was used to design the austenitization and Q&T process in order to achieve the best properties in the steel and ductile iron. The finished casting is shown in Figure 4. The hammer won the “most intricate casting” during the competition. A more detailed technical report for manufacturing the hammer can be found at <https://www.sfsa.org/doc/cis2021/GASouthern.pdf>



Figure 4. Finished Thor's Hammer made by the students for SFSA Cast in Steel competition

Under the CDC guidance, a members-only foundry night was hosted in March 2021 on campus. Thirteen members were in attendance, most of whom was able to see our new ferrous furnace in action for the first time. We poured 8 skilletes and a few investment castings. A group picture is shown in Figure 5.



Figure 5. Group photo from the members-only foundry night

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Another industry-student interaction event, FEF advisory board meeting, was hosted on campus on April 28, 2021. Eight industry professionals were able to attend the event in person. During the event, the professionals had interacted with more than twenty students through interviews, presentation, group lunch, and lab tours. The advisory board also presented three AFS Piedmont chapter scholarships to the students.



Figure 6. Three AFS Piedmont chapter scholarships were awarded to students

Moreover, Georgia Southern maintained the Foundry Educational Foundation affiliate status for the second year in 2020-2021, and is scheduled for the certification process in summer 2021. In November 2020 and March 2021, ten students participated in the Foundry Educational Foundation (FEF) College Industry Conference, and competed for the 24 scholarships with 100+ national FEF students. Two Georgia Southern students, James Liggett and Michael Windham, were awarded for the honorable scholarships.

Research Activities

Three master students are leading three ongoing research projects. Five undergraduate research assistants are hired to facilitate various tasks.

Shelton Fowler is leading in a research project collaborated with AFS cast iron committee to in-situ measure the casting wall movement during metal solidification along multiple axis. The apparatus contains three sets of fused rod and laser transducer to experimentally capture the casting dimensional change during solidification. The apparatus has been fully designed and currently being finalized. The measurement will begin in Fall 2021. Parameters to be studied include mold rigidity, metal composition, pouring temperature, inoculation condition for cast iron, and gating/riser configurations. A more fundamental study proposal has been submitted to National Science Foundation.

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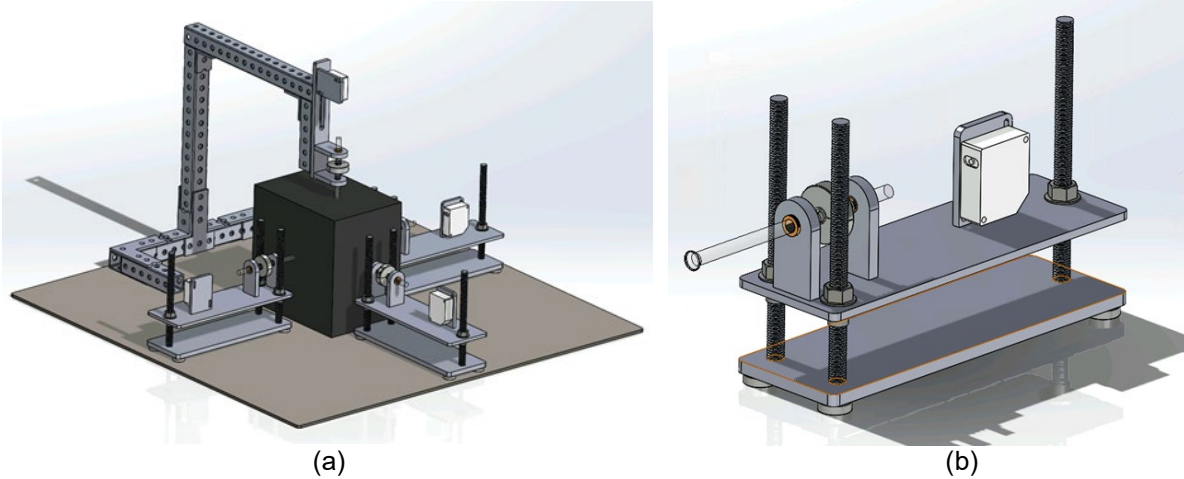


Figure 7. Testing apparatus (a) for multi-axial casting wall movement measurement, and the assembly of the fused rod and laser transducer (b)

Samuel Holt is exploring the possibility of recycling fused silica in steel investment casting industry. In general, the fused silica devitrifies and transforms to cristobalite during the pour, and thus cannot be reused. Sam is attempting to retard the transformation by reducing the available thermodynamic energy and kinetic paths for the transformation through various firing conditions. A large amount of shell hot strength and XRD results have been obtained and an article is currently under preparation.

James Liggett and his team help with the preliminary experimentation on understanding the graphite/austenite development during gray iron solidification by using interrupted solidification developed by Dr. Qing. An article is currently under preparation, and the preliminary data supported the idea of austenite grain refinement in gray and ductile iron. Two proposals on this topic have been submitted to AFS and Ductile Iron Society.

Dissemination of Results:

One presentation is scheduled for the AIST Southeast Annual Conference in Sep 2021.

Two journal articles are being prepared

One article being prepared for AISTech 2022

Project Cost:

During 2020-2021

Student support: \$2,000

Travel: \$300

Materials and supplies: \$5,000

Major equipment: \$12,000 to partially fund a \$27,000 continuous sand mixer

\$12,000 for an induction furnace/cooling melt system

\$2,000 to partially fund a \$30,000 microscope

Student Participation:

Eight students (listed in the first page) are directly involved with the research projects and leading other related activities.

Around twenty AFS student chapter students participated in various events and industry interactions.

Over eighty students attended AIST steelmaking 101 training course.

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Steel Plant Interaction:

Below is a list of professional that are serving as advisory committee members. Plant tours were restricted during the pandemic, but should resume back to normal in the coming year.

Table I. List of advisory committee members

Name	Company	Email
Mike Smith	Aludyne - Chassix	Mike.Smith@chassix.com
Matthew Mullen	Briggs & Stratton	mullen.matthew@basco.com
Jim Harwood	Carolina Metal Castings	jim@carolinametalcastings.com
Chris Barnes	Caterpillar	Barnes_Chris@cat.com
Taylor, Shawn M.	Charlotte Pipe & Foundry	staylor@charlottepipe.com
John Grahek	denisonindustries	jgrahek@denisonindustries.com
Paul Huffman	Dominion Metallurgical	phuffman@dom-met.com
Nick Bacik	FEF	Nick@fefinc.org
Mark Cotton	FOSECO	mark.cotton@vesuvius.com
Harry Tian	Georgia Iron Works	Harry.tian@ksb.com
Paul Taylor	Georgia Iron Works	paul.taylor@ksb.com
John Boyd	Goldens Foundry	jboyd@gfmco.com
George Boyd	Goldens Foundry	gboydsr@gfmco.com
Barry Morgan	Hill and Griffith	bmorgan@hillandgriffith.com
David Tucker	IMERYS	dave.tucker@imerys.com
Chris Lang	IMERYS	chris.lang@imerys.com
Matt Jacobs	MAGMA	m.jacobs@magmasoft.com
Marc Harris	Mueller and Water products	mharris@muellerwp.com
Nick Bucci	Nucor Steel Hertford County	nick.bucci@nucor.com
Emily Shedlarski	Simpson Group	eshedlarski@simpsongroup.com
Ted Kostilnik	Specialty Foundry Products	tkostilnik@comcast.net
Marty Putnik	Viking Technologies	marty.putnik@viking-technologies.com

Project Duration:

Aug 2020 – May 2021

How many students from this university have accepted employment in the steel industry upon graduation?

During 2020-2021, one student has been hired permanently as a sales engineer at Core&Main, a steel and cast iron product supplier.

Five students are having internships at iron and steel foundries, including JC Steele, Waupaca Foundry, Carolina Metal Casting, and Nematik.

Future of Grant:

☒ I have just completed year-_1_ of the three-year grant.

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- ☒ I hereby confirm that the plan contained in my original proposal will continue during the next academic year and request funding (US\$35,000) to continue the KDP JFA plan as submitted in my original proposal.
- ☐ The plans contained in the original proposal are now complete. I have \$_____ remaining and request permission to continue promoting the steel industry to engineering students at my university using these funds. I agree to provide an annual report to AIST until the funds are depleted.
- ☐ The plans contained in the original proposal are now complete. I would like to discuss how the final results could be posted to the website, shared with other universities, shared with AIST members, added to the AIST Library, or presented at a conference.

Mirza Zafar

5/31/2021

Signature of Professor and Date

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