2025 – 2026 Kent D. Peaslee Junior Faculty Award
Year-end Report

Enhancing Montana Tech Engineers Involvement in Iron and Steelmaking

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Proposed period of performance and estimated budget:
3 Years and $ 150,000 (total)

Year 1: August 2025 to July 2026, $ 50,000 (Completed)
Year 2: August 2026 to July 2027, $ 50,000
Year 3: August 2027 to July 2027, $ 50,000

Project summary

This report summarizes the first year of Dr. Basak Anameric and the associated teams' contributions to the "Enhancing Montana Tech Engineers' Involvement in Iron and Steelmaking" project. This project was funded by the AIST Foundation's Kent D. Peaslee Junior Faculty Award. The project aimed at helping to establish and nourish students' interest and provide a pipeline for capable, knowledgeable, and enthusiastic engineers to serve in the iron and steel industry, expand the research and development activities, and nurture community engagement.

During the first year of the award, significant progress was made on the activities designed to support the awareness, conversion, study, and retention aspects of the student recruiting and success pipeline. The major accomplishments included the successful launch of the Montana Tech Iron and Steelmaking Days (I&S Days), advancement of the new Iron and Steelmaking Laboratory (I&S Lab), expansion of industry-supported senior design projects, support for undergraduate research, and the development of new collaborative research partnerships.

The inaugural Montana Tech I&S Days brought together 36 students and 8 representatives from industry and academia for technical lectures, roundtable discussions, laboratory demonstrations, networking opportunities, and a virtual steel mill tour. The event also featured the ribbon-cutting ceremony for the new I&S Lab.

The award also supported the continued development of the I&S Lab through the acquisition of laboratory supplies and safety equipment, commissioning of key research infrastructure, and training of students in laboratory operations.

The number of senior design projects focused on iron and steelmaking increased from one of seven projects in 2024–2025 to two of six projects in 2025–2026, with five of eight projects planned for 2026–2027. The award was used to support student stipends and the purchase of consumables for these projects. These projects have already demonstrated tangible outcomes, including internships, graduate research opportunities, conference presentations, and employment within the iron and steel industry.

Industry engagement activities included participation of the industry representatives in the I&S Days, guest lectures, and site visits to Nucor Louisiana, Nu-Iron Trinidad and Tobago, and Nucor Berkeley to explore future graduate research collaborations.

Community engagement efforts included laying the groundwork for future K–12 outreach activities. Partnerships were established with local schools and the Science Mine, a local museum, to develop educational programming, including classroom presentations, an iron and steelmaking educational pinball machine, and immersive career exploration activities utilizing virtual reality technology.

Building on the accomplishments of year 1 of the award, future efforts will focus on expanding K–12 outreach and increasing student participation in iron and steel-related research.

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1. Introduction

Montana Technological University (Montana Tech), originally chartered as the Montana State School of Mines, is Montana's only special-focus institution, emphasizing STEM (science, technology, engineering, math), nursing, and occupational safety (see Figure 1). It is ranked number one in Montana for best value and provides the highest return on educational investment in the state. Its graduates generally face low debt and high, above-average starting salaries. Montana Tech comprises two campuses: the North and Highlands Campuses. The university has a unique 14:1 student-to-faculty ratio, an on-campus underground mine and museum, and over 90% career placement.

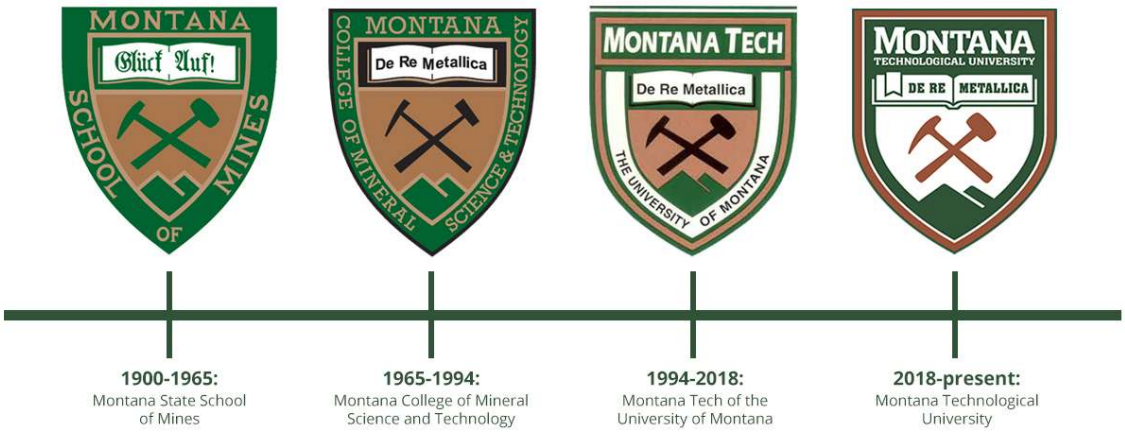

Figure 1. The evolution of Montana Technological University (Montana Tech) through the years.

The total enrollment in the 2025-2026 academic year was 2,516 students (2,310 undergraduate and 206 graduate students). An average of 50% of undergraduate students enrolled at Montana Tech study engineering disciplines, such as Metallurgical and Materials, Mining, Petroleum, Mechanical, Civil, Environmental, and Electrical engineering. These programs produce strong candidates for careers in the iron and steel industry. The students receive technical, hands-on training that aligns with core industry needs.

Hence, a mutually beneficial partnership between the iron and steel industry, Montana Tech, and its students was initiated with the AIST Foundation Kent D. Peaslee Junior Faculty (KDP) Award in August 2025, to establish and nourish students' interest and provide a pipeline for capable, knowledgeable, and enthusiastic engineers to serve in the iron and steel industry, expand the research activities, and nurture the community engagement.

Activities supported by this project were designed to respond to awareness, consideration, conversion, study, retention, and advocacy aspects of the student recruiting and success pipeline shown in Figure 2.

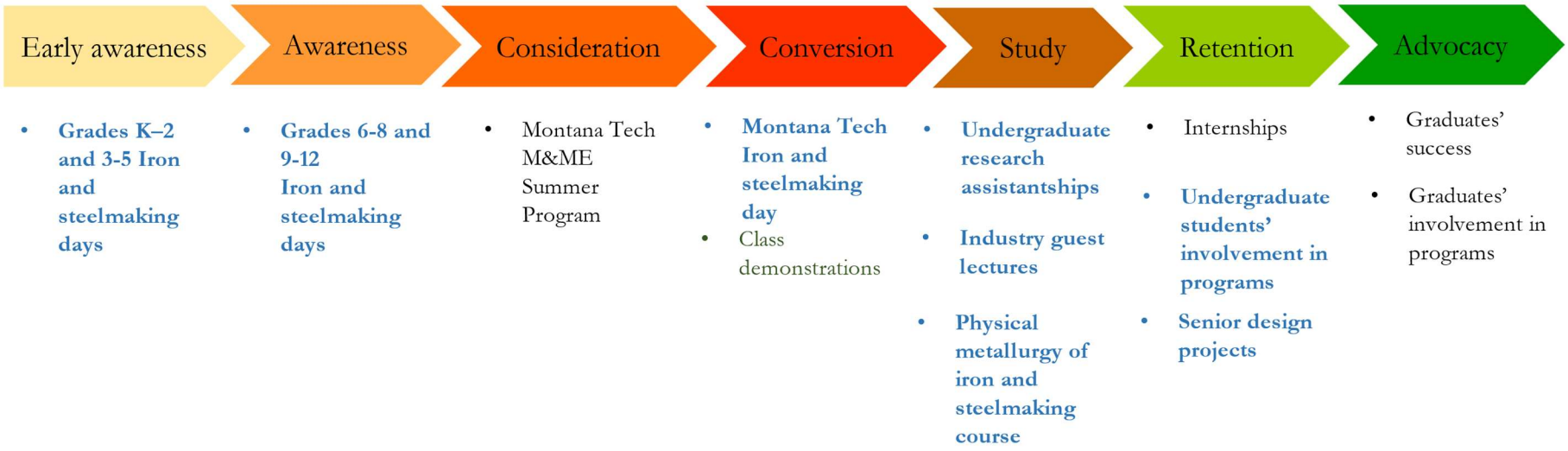

Figure 2. A schematic of the student recruiting and success pipeline, including awareness, consideration, conversion, study, retention, and advocacy aspects. The activities supported by this project are highlighted in bold blue text.

Metallurgical and Materials Engineering Department

The Metallurgical and Materials Engineering (M&ME) Department has a long-standing history, having celebrated its centennial in 2022. The program offers an ABET-accredited B.Sc. degree and serves as a campus leader in research and in M.S. and Ph.D. education. Its curriculum integrates extractive metallurgy, mineral processing, and physical metallurgy with materials science, providing students with a comprehensive and well-rounded foundation.

The program emphasizes hands-on, industry-relevant learning, including:

- Extensive laboratory experience with a strong focus on metal-related industries
- Foundational coursework in thermodynamics, kinetics, and physical metallurgy
- Training in waste treatment and advanced materials processing

Student enrollment in the program has steadily increased since 2023, as shown in Figure 3. This is driven in part by enhanced recruitment efforts, including a summer camp for high school students, as well as strengthened initiatives to expand the department's visibility and leadership in iron and steel education and research.

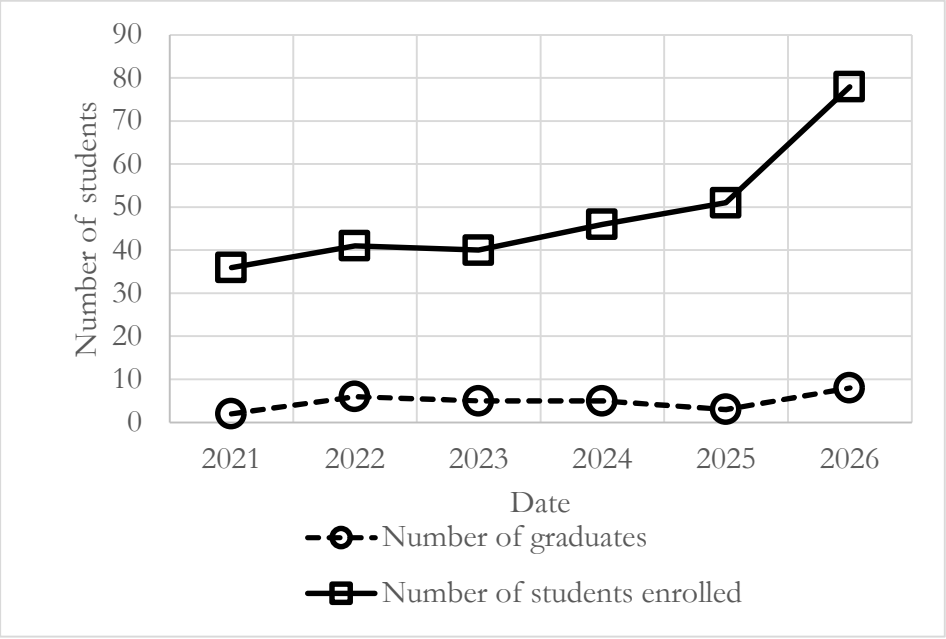

Figure 3. Number of students enrolled in the M&ME department.

Graduates of the program have been highly successful in securing employment or pursuing further education, as shown in Figure 4. Approximately 90% of those who continue their studies remain in the Metallurgical and Materials Engineering (M&ME) program for graduate education.

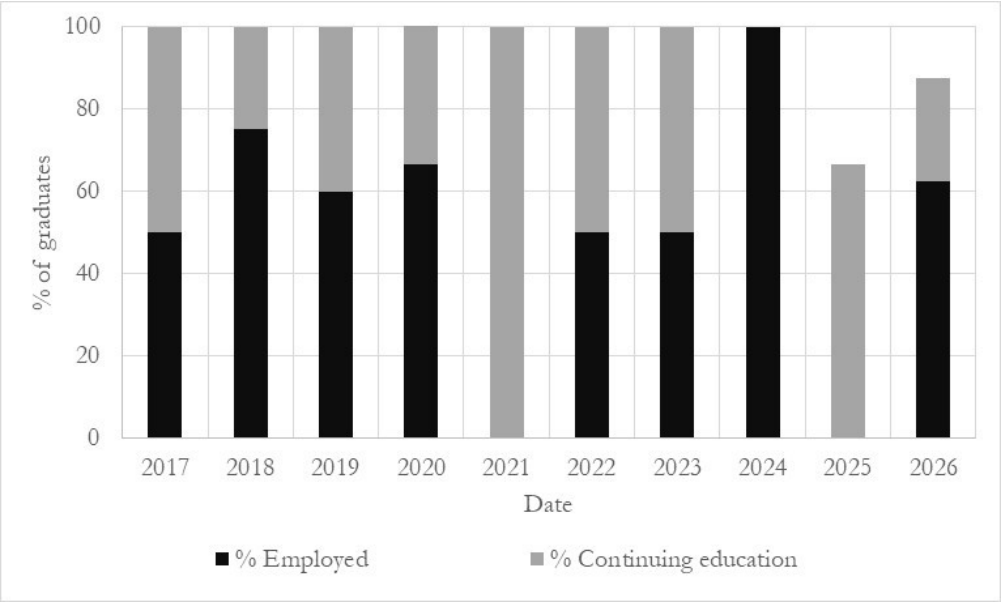

Figure 4. The percentage of M&ME B.Sc. graduates employed in the industry and continuing education

The M&ME recruiting and retention initiatives include:

- Summer program directed at high school students
- High school presentations
- Tech Days
- EMET 230 - Materials and the human experience class
- Casting and blacksmithing club activities
- Guest lectures
- Class demonstrations
- Internships
- Site visits
- Undergraduate research project involvement
- Graduate research project involvement
- Laboratory class projects
- Senior design projects
- Industry information sessions
- Face-to-face meetings
- Scholarships
- Montana Tech Iron and Steelmaking Days

Montana Tech and the M&ME have been actively working to strengthen their collaboration with the iron and steel industry. The number of graduates hired by the industry and the number of students conducting internships are shown in Figures 5 and 6. Current Montana Tech collaborators in the iron and steel industry include:

- Nucor
- Opta
- Steel Dynamics
- Cleveland Cliffs Inc.

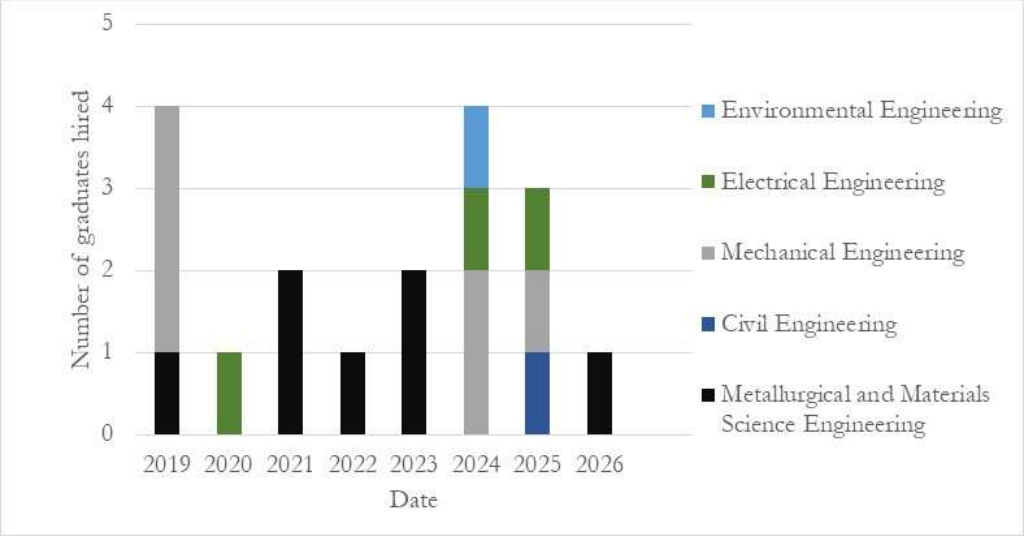

Figure 5. The number of graduates hired by the iron and steel industry

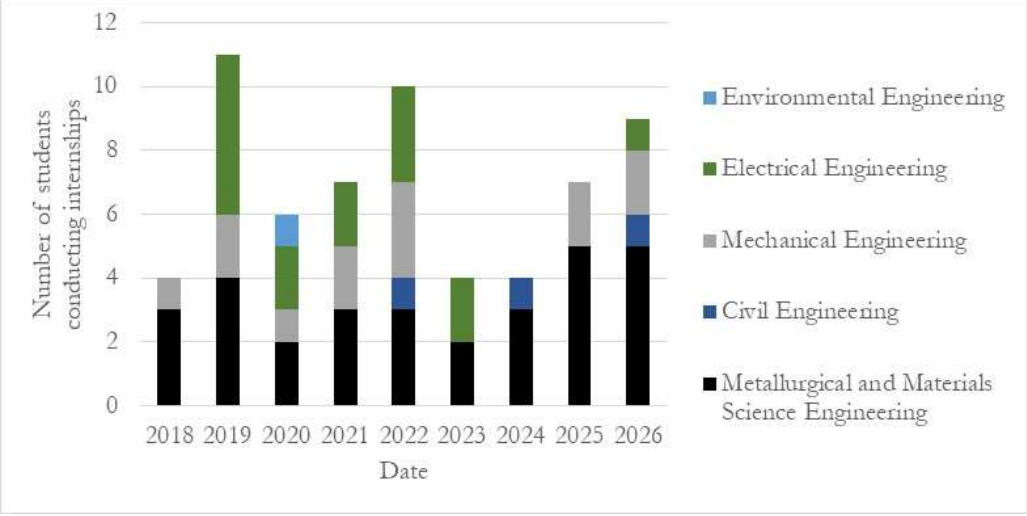

Figure 6. The number of students conducting internships in the iron and steel industry

Moreover, in 2023, Dr. Basak Anameric, the principal investigator (PI) for this project, joined Montana Tech. Her position was made possible through an endowment established by Nucor to strengthen iron and steelmaking expertise. Dr. Anameric brings 16 years of industry experience, having held roles in research and development, innovation, production support, and quality control. Since joining the university, she has secured significant funding to support the development of an iron and steelmaking research group and laboratory infrastructure. She has also been actively involved in teaching relevant courses and advising senior design projects. She has a strong commitment to student success and a passion for advancing iron and steel education.

2. Project goals

The project goals included:

a) Talent and workforce development
   i. Establish and nourish students' interest in the iron and steel industry
   ii. Provide essential education and training needed to produce workforce-ready graduates
b) Community engagement
   i. Provide activities to educate and excite the community to provide an alliance to support young engineers
   ii. Provide opportunities for direct contact
c) Research and development
   i. Build connections with the iron and steel companies or suppliers to the industry
   ii. Conduct applied research addressing problems faced by the industry
   iii. Provide project-based educational opportunities

The activities carried out to attain these goals included:

a) Montana Tech Iron and Steelmaking Days (I&S Days)
b) Advancement and support of the Iron and Steelmaking Laboratory (I&S Lab)
c) Senior design projects support
d) Industry site visits
e) Guest lectures
f) Undergraduate and graduate research activities

3. Project details

A. Montana Tech Iron and Steelmaking Days (I&S Days)

The objectives for the I&S days were to

- Introduce students to the fundamentals and opportunities within the iron and steel industry
- Provide additional education and industry perspectives on iron and steelmaking
- Celebrate the establishment of the new Iron and Steelmaking Laboratory (I&S Lab)
- Showcase the laboratory and the students who contribute to its activities.

Students from Montana Tech's North and Highlands campuses, local high school science teachers, and their students were invited to attend the event. The I&S Days were held on the 17th and 18th of February, 2026, at the North Campus Student Union Building (see Figure 7).

Figure 7. 2026 Montana Tech I&S Days logo

The days included:

- Lectures focused on industry decarburization efforts
- Lectures for the EMET 420 Physical Chemistry of Iron and Steelmaking course
- A round table discussion to delve into "What is the industry looking for in engineers and professionals?"
- A round table discussion to delve into "Role of civil and environmental engineers in the iron and steel industry."
- A presentation on the AIST Scholarships and opportunities, and students' internship experiences
- A virtual steel mill tour
- A social networking hour
- A ribbon cutting for the I & S Laboratory
- Laboratory demonstrations
- Company and industry information sessions

The Days were a success. It was attended by 8 industry and academia representatives and 36 students (see Figure 8). The highest attendance was during the round table discussion.

Learnings from the days to help with scheduling future days included:

- Brings the days, especially the virtual steelmaking torus, to high schools
- Making additional arrangements with the other faculty members to clear students' schedules
- Continued sharing of the recorded lectures
- Continued scheduling of the days before the spring Montana Tech career fair

Drew Kofahl
Nucor – Technical Services Supervisor at Nucor Steel Memphis, Inc.

Bill King
Cleveland- Cliffs Inc. – Principal Process Research Engineer

Jose Lujan
Opta Group
Vice President, Strategy, R&D

Daniela Perez
Nucor – Technical College Recruiter

Victoria Morton
Nucor – Environmental Engineer

Scott Christensen
Nucor – Building Group, Design Supervisor

Dr. Jon Kellar, Professor, Douglas Fuerstenau Professor, and Nucor Professor, Department of Materials and Metallurgical Engineering, South Dakota School of Mines & Technology

Dr. Mario Buchely, Roberta and G. Robert Couch, Assistant Professor, Materials Science and Engineering, University of Missouri, Science and Technology

Figure 8. Industry and academia participants for the 2026 Montana Tech I&S Days.

i. Industry Decarburization Lectures

Presentations on industry decarburization efforts were delivered by Jose Lujan, Vice President of Strategy and R&D at Opta Group, who discussed the decarburization of the iron and steel industry, and Drew Kofahl, District Technical Services Manager at Nucor, who presented on alloy design strategies that support decarburization and electrification initiatives (see Figures 9 and 10).

Figure 9. Pictures from 2026 Montana Tech I&S Days, Jose Lujan's lectures

ii. EMET 420 Guest Lectures

Guest lectures for the EMET 420 Physical Chemistry of Iron and Steelmaking course were also presented by industry representatives. Jose Lujan delivered a lecture on iron and steel treatment with a focus on sulfur removal, while Drew Kofahl presented on alloy design principles and applications.

Figure 10. Pictures from 2026 Montana Tech I&S Days, Drew Kofahl's lectures

iii. Roundtable Discussion: What Is the Industry Looking for in Engineers and Professionals?

This roundtable discussion was moderated by Jerry Downey, Ph.D., P.E., Professor, Department Head, and Goldcorp Professor in the Department of Metallurgical and Materials Engineering at Montana Tech.

Panelists included:

- Jon Kellar, Ph.D., Professor, Douglas Fuerstenau Professor, and Nucor Professor, Department of Materials and Metallurgical Engineering, South Dakota Mines
- Mario Buchely, Ph.D., Roberta and G. Robert Couch Assistant Professor, Department of Materials Science and Engineering, Missouri University of Science and Technology
- Jose Lujan, Vice President of Strategy and R&D, Opta Group
- Drew Kofahl, District Technical Services Manager, Nucor
- Victoria Morton, Environmental Engineer, Nucor
- Bill King, Principal Process Research Engineer, Cleveland-Cliffs Inc.

The discussion (pictures from the discussion are shown in Figure 11) centered on questions generated through a student survey completed by approximately 40 students. Topics included:

- Skills and mindsets that have become increasingly important in recent years
- Alignment and disconnects between academia and industry
- The impact of artificial intelligence, automation, and data analytics on workforce needs
- Common misconceptions students have about industry expectations
- Gaps between academic preparation and real-world engineering practice
- The relative importance of technical skills, interpersonal skills, and hands-on experience
- The value of internships, co-ops, senior design projects, and industry-sponsored projects
- Workplace behaviors and attitudes that contribute to professional success
- Opportunities for continuous learning and workforce development
- Characteristics that distinguish strong candidates during the hiring process
- Assessment of adaptability, problem-solving, and collaboration skills
- The importance of communicating technical information to non-technical audiences
- Common mistakes applicants make during interviews and hiring processes
- Definitions and indicators of professional success
- The advantages of early specialization versus broad technical exposure

iv. Roundtable Discussion: The Role of Civil and Environmental Engineers in the Iron and Steel Industry

This discussion was moderated by Scott Christensen, Design Supervisor at Nucor Building Group.

Panelists included:

- Drew Kofahl, District Technical Services Manager, Nucor
- Victoria Morton, Environmental Engineer, Nucor
- Jose Lujan, Vice President of Strategy and R&D, Opta Group

The discussion explored the contributions of civil and environmental engineers to the iron and steel industry, including sustainability initiatives, environmental compliance, infrastructure development, and emerging opportunities within the sector.

Figure 11. Pictures from the 2026 Montana Tech I&S Days round table discussion, What Is the Industry Looking for in Engineers and Professionals?

v. AIST Scholarships and Student Opportunities

Presentations on AIST scholarships, student opportunities, and internship experiences were delivered by Courtney Young, Student Program Administrator at AIST, along with Montana Tech students Abigail Clark (M.S. student), Addison Cross (B.S. student), and Grace Ekness (B.S. student), all from the Department of Metallurgical and Materials Engineering. Pictures of the students during their presentations are shown in Figure 12.

vi. Virtual Steel Mill Tour

A virtual steel mill tour was presented by Daniela Perez, Technical College Recruiter at Nucor. The session provided participants with an overview of modern steelmaking operations, production processes, and career opportunities within the industry.

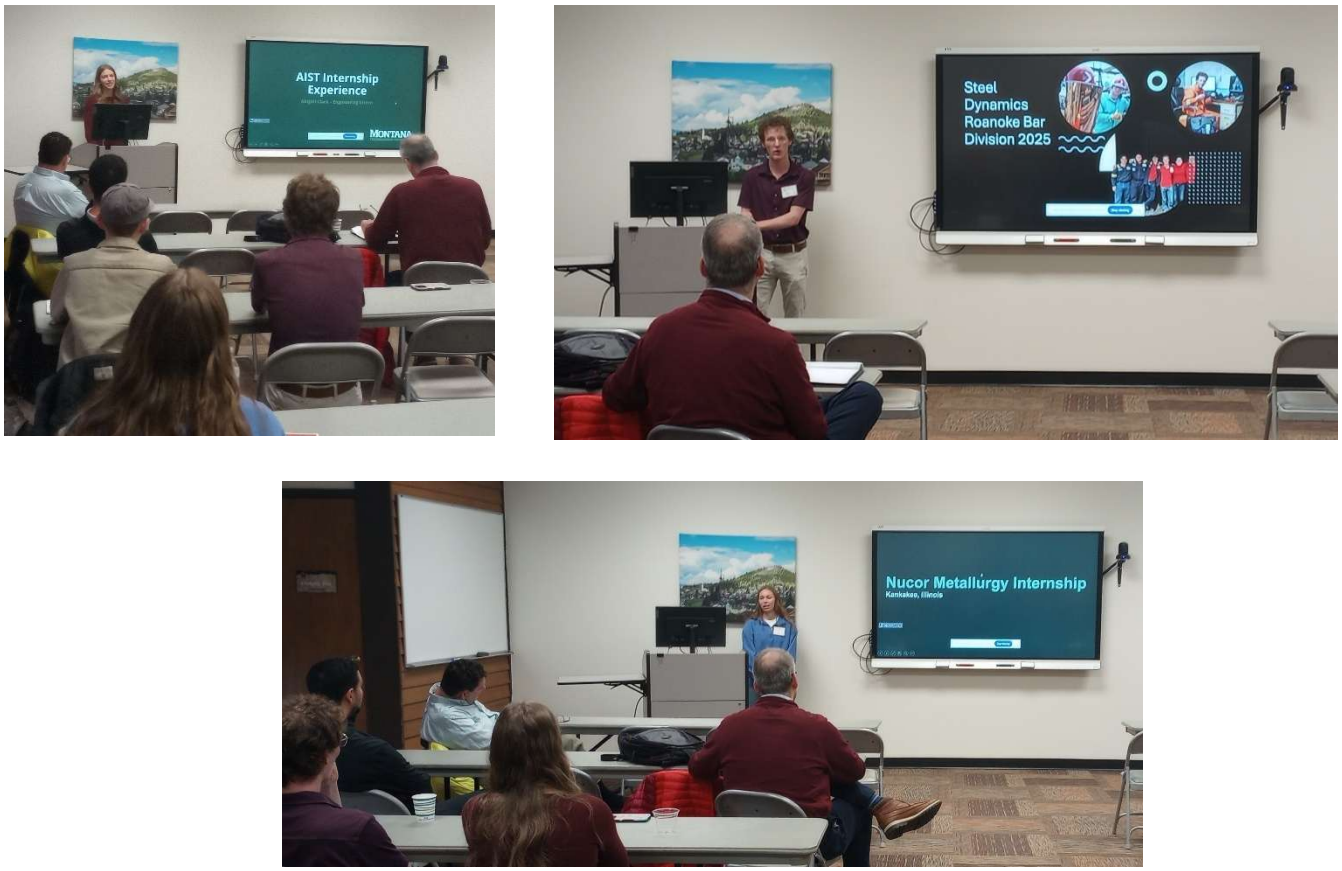

Figure 12. Pictures from the 2026 Montana Tech I&S Days, Abby Clark, Addison Cross, and Grace Ekness's internship experience presentations

vii. I&S Laboratory ribbon-cutting ceremony

A ribbon-cutting ceremony for the new Iron and Steelmaking Laboratory (I&S Lab), as shown in Figures 13 and 14, was held during the I&S Days. The laboratory serves as a hub for innovation, experiential learning, applied research, workforce development, and strong industry-academic collaboration. The ceremony was attended by Montana Tech Chancellor Jonny MacLean, Department Head Dr. Jerry Downey, industry representatives, and many students.

Chancellor Jonny MacLean highlighted the significance of the new facility:

"Montana Tech's new Iron and Steel Making Laboratory represents a significant investment in the future of American industry. It will help prepare the next generation of STEM leaders to find solutions in critical materials and manufacturing as we address our country's infrastructure needs. I'm grateful for the faculty, students, and industry partners who made this new lab possible."

Figure 13. Pictures of the I&S Laboratory.

Figure 14. Pictures from the ribbon-cutting ceremony for the I&S Lab.

Department Head Dr. Jerry Downey underscored the impact of the new laboratory on student experiences.

"The new Iron and Steelmaking Laboratory will be a game-changer for our students," Downey said. "Steelmaking is the core of metallurgical engineering, and having this modern facility right here on campus will enable our students to actually work these processes rather than just imagine them. Thanks to the tremendous support we receive from the steel industry, and especially Nucor, and Dr. Basak Anameric was able to build this lab. Students will see it early in their coursework and again when they reach their advanced level classes. It will give them a degree of preparation that lectures only can't provide. At the end of the day, what really matters is providing students the practical

grounding to hit the ground running upon graduation, which is something Montana Tech is famous for doing."

The laboratory supports both undergraduate and graduate education by providing state-of-the-art facilities for hands-on instruction, research, and professional training. It also serves as a platform for collaborative projects between Montana Tech and industry partners.

The establishment of the laboratory was made possible through the generous support of industry partners. Funding provided by Nucor enabled the acquisition of key equipment, including a laboratory hood system, briquetter, reduction-under-load test system, tumble drum, high-temperature/high-capacity thermogravimetric analysis furnace, and induction furnace. Cleveland-Cliffs Inc. contributed personal protective equipment to support safe laboratory operations and student training.

viii. Laboratory demonstrations

The demonstrations during the days included (pictures from the demonstrations are shown in Figures 15 to 21)

- Briquetter and improving the properties of the DRI briquettes by Abby Clark
- Reduction under load test set-up and production of cold-bonded briquettes for DRI production by Steven Foster
- Induction furnace by Daniel Ziesing
- Hydrogen evolution from molasses bond DRI briquettes by Gabriel Marquis
- Metallography by Addison Cross, Abby Clark, and Grace Ekness
- Optical microscopy by Stephen Hanson
- Casting by Addison Cross and Daniel Ziesing
- Blacksmithing by Carson LeLacheur and Justus Peterson

a) Impressions from students

Multiple students presented during the days and demonstrations offered viewpoints on how industry support and the new laboratory would impact them. Steven Foster, a metallurgical and materials engineering junior from Helena, gave a presentation, "Cold-bonded Iron Oxide Briquettes for Direct Reduced Iron Production."

"Montana Tech is rooted in metals," Foster said. "It's only fitting we now have a laboratory dedicated to the world's most important metallic material. Dr. Anameric deserves a lot of credit for making all this happen."




Figure 15. Pictures from 2026 Montana Tech I&S Days, briquetter and improving properties of DRI briquettes demonstrations by Abigail Clark

Gabriel Marquis, a senior from Colstrip, presented on hydrogen gas generation from molasses-bound iron briquettes, his senior design project.

“The newly developed Iron and Steel lab will be instrumental in giving Montana Tech's students valuable hands-on experience with the steel industry,” Marquis said. “The research done in this lab will help modernize and revolutionize steel production, improving steel quality, sustainability, and reducing the environmental impacts of the industry. It is a very exciting development for the department."

Grace Ekness, a junior from Shepherd, shared her experiences as a recipient of the $7,500 Association for Iron & Steel Technology scholarship and as a Nucor intern.

“This scholarship has impacted my time as a student by ensuring I have the opportunity for hands-on experience in the iron and steel industry,” Ekness said. “Hands-on experience directly relates to what is taught in the metallurgical and materials engineering program, which increases my desire to learn. This scholarship has also allowed me to focus my efforts on my education rather than employing my efforts elsewhere.”




Figure 16. Pictures from 2026 Montana Tech I&S Days, reduction under load test set-up and production of cold-bonded briquettes for DRI production demonstrations by Steven Foster

Student attendees at the roundtable discussion, "What Is the Industry Looking for in Engineers and Professionals?", reported that the conversation and thoughtfully selected discussion topics made them feel heard, valued, and welcomed into the industry. They also expressed appreciation for the industry representatives who took the time to engage with them, share their expectations, and provide guidance on how to succeed in their future careers.

Student attendees at the lectures reported gaining new insights into the industry's commitment to carbon neutrality and sustainability initiatives. They also indicated that the presentations helped them envision their own role in contributing to these efforts and becoming part of the solution to environmental challenges.




Figure 17. Pictures from 2026 Montana Tech I&S Days, induction furnace demonstrations by Daniel Ziesing

ix. Iron and steelmaking routes poster

To help convey the depth and versatility of the iron and steel industry, a poster shown in Figure 22 was designed. This poster was displayed at gathering areas for the lectures, round table discussions, and demonstrations. The same poster will be used to support high school science class presentations scheduled for the years 2 and 3 of the award.

Figure 18. Pictures from 2026 Montana Tech I&S Days, hydrogen evolution from molasses bond DRI briquettes demonstrations by Gabriel Marquis

x. Plans for the 2027 Montana Tech I&S Days

The 2027 Montana Tech Iron and Steelmaking (I&S) Days are scheduled to be held on the 16th and 17th of February 2027. Planning efforts are already underway to build upon the success of the 2026 event and further strengthen engagement between students, academia, and industry.

For the 2027 event, I will continue collaborating with Aaron Frale, Director of Career Services, and his team, including Quinn Kendall, Career Services Employer Events Coordinator, and Cynthia Wier, Career Services Internship Coordinator. Together, we will continue to expand outreach efforts and extend invitations earlier, starting in September 2026, to iron and steel producers, industry suppliers, and supporting partners to participate either in person or virtually.

Through continued promotion of the event, including presentations at the AISTech University–Industry Roundtable Relations meeting and the distribution of early invitations to prospective participants, we anticipate increased industry engagement and student participation. As a result, we project attendance of approximately 10 representatives from industry and academia and 50 student participants at the 2027 I&S Days.

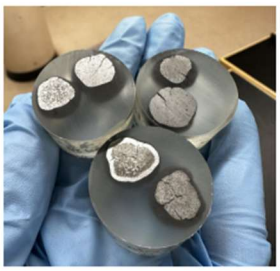

Figure 19. Pictures from 2026 Montana Tech I&S Days, metallography demonstrations by Addison Cross, Abigail Clark, and Grace Ekness

For the 2027 I&S Days, we will invite industry representatives to discuss the future of scrap-based steelmaking. Topics will include scrap availability and quality, balancing direct reduced iron (DRI) and scrap in electric arc furnace (EAF) operations, projected global growth in EAF steelmaking, and strategies for strengthening raw materials supply chain resilience.

A featured roundtable discussion will focus on the question: "Why are problem-solving and project management skills essential for today's engineers?" This session will provide students with valuable insights into the skills most sought after by industry employers. For this round table discussion, we will again share a survey with the students, gather the questions they have, and prepare prompts accordingly.

The event will also include laboratory demonstrations that showcase our students' work and provide attendees with hands-on learning experiences. In addition, a social hour will offer opportunities for students to connect directly with industry representatives and faculty members.

During the planning of the 2026 Iron & Steel Days, discussions with high school science teachers, administrators, and principals revealed that transporting students to the Montana Tech campus can be challenging and resource-intensive. In response, for the 2027 program, we plan to bring Iron & Steel Days directly to participating schools, including offering the virtual steel mill tour on-site to increase accessibility and student engagement.

Figure 20. Pictures from 2026 Montana Tech I&S Days, casting demonstrations by Addison Cross and Daniel Ziesing

Also, for the 2027 I&S Days, we will create life-size posters featuring iron and steel industry professionals in authentic plant settings, such as the basic oxygen furnace (BOF) shop floor and electric arc furnace (EAF) operations. Each display will include a face cutout, allowing students to step into the role of an iron or steelmaker and take professional-style photographs for their LinkedIn profiles and other career networking platforms. This interactive activity will provide a fun and engaging way for students to envision themselves in the industry while promoting professional identity and career awareness.




Figure 21. Pictures from 2026 Montana Tech I&S Days, blacksmithing demonstrations by Carson LeLacheur and Justus Peterson

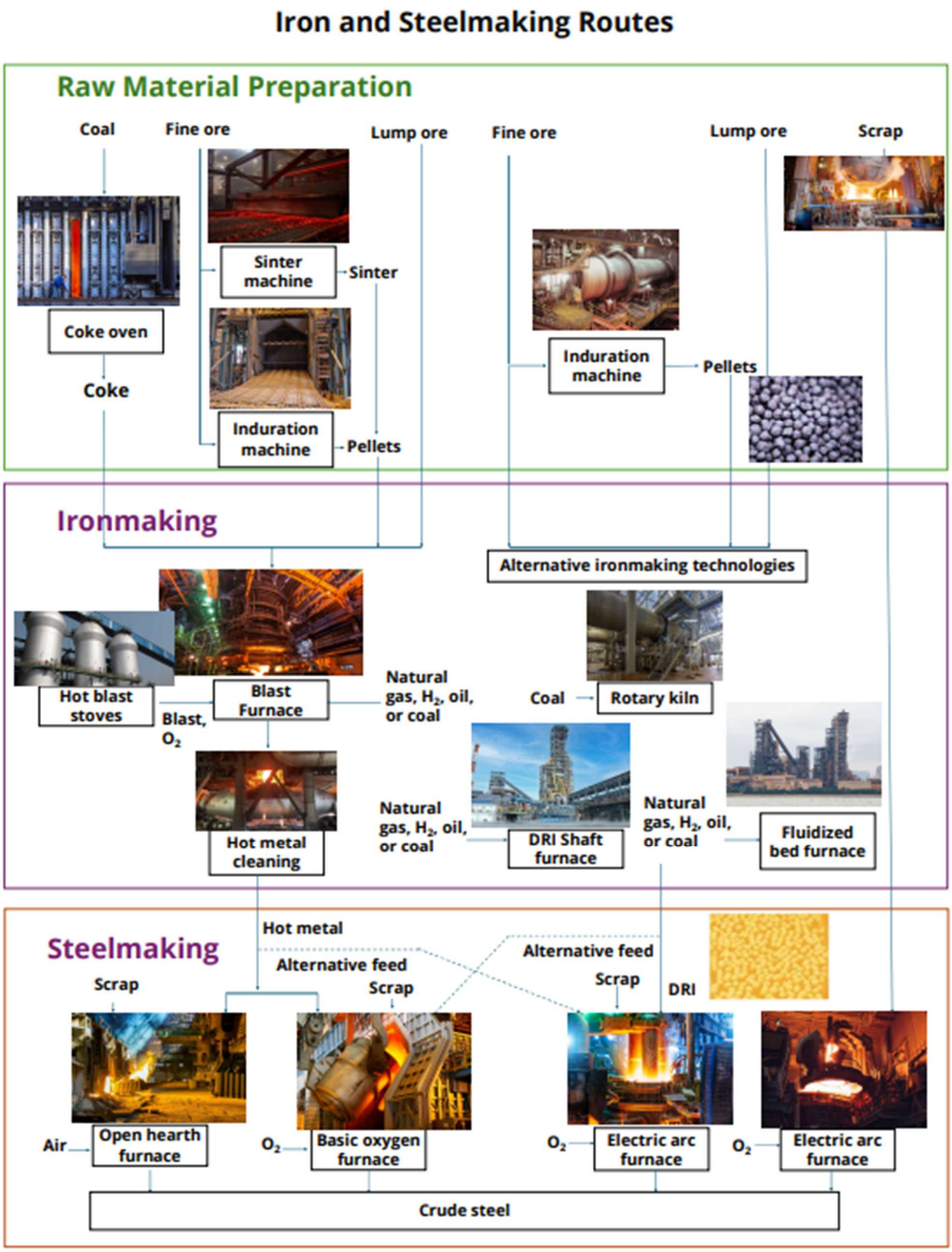

Figure 22. Iron and steelmaking routes poster prepared and displayed as a part of the 2026 I&S Days

B. K-12 Iron and Steelmaking Days (K-12 I&S Days)

During the first year of the award, several planning and outreach activities were successfully completed:

- Collaborated with Daniela Perez, Technical College Recruiter at Nucor, to incorporate Nucor's partnership with Discovery and virtual steel mill tours into Montana Tech I&S days. Invited all the local high school science teachers and students to attend.
- Met with local elementary, middle, and high school principals to discuss strategies for tailoring event activities to the needs and interests of their students and to identify effective approaches for student participation.
- Worked with administrators at the Science Mine to develop an educational iron and steelmaking display.
- Faculty in the M&ME promoted Montana Tech I&S days during outreach visits to local high schools.

During the second and third years of the award, the following activities are planned:

- Design and construct an educational iron and steelmaking pinball machine as part of a senior design project. Upon completion, the pinball machine will be donated to the Science Mine, where it will serve as a permanent interactive exhibit for museum visitors.
- Produce a video documenting the casting of Montana Tech memorabilia through a senior design project. The video will be presented to students in grades 6–8 during science classes by the senior design team members, providing an engaging introduction to iron and steelmaking processes.
- Conduct career exploration day presentations for students in grades 3–5 using virtual reality (VR) headsets. Participants will experience immersive footage recorded inside iron and steel manufacturing facilities, offering early exposure to careers in the metals industry.

C. Advancement and support of the Iron & Steelmaking Laboratory (I&S Lab)

The I&S lab was designed to support education, research, and workforce development across a broad range of iron and steelmaking topics while complementing the capabilities of the existing M&ME laboratories. The facility provides students and researchers with hands-on opportunities to investigate raw material preparation, including agglomeration and briquetting, reduction processes, ironmaking, steelmaking, and materials characterization.

The laboratory is equipped with the following major equipment (as shown in Figure 23):

- Balling disk
- Briquetter
- Tumble drum
- Reduction-under-load testing system
- High-temperature, high-capacity thermogravimetric analysis (TGA) furnace
- Induction furnace

Together, these resources provide a versatile platform for experiential learning, applied research, and industry-focused projects in iron and steelmaking.

Award funds were used to

- Purchase essential safety equipment and laboratory consumables required for instructional and research activities.
  Safety equipment acquired included hard hats, face shields, and aluminized heat-resistant gloves.
  Consumables purchased included crucibles, ramming refractory, plastic refractory for the induction furnace, and flasks.
- Hire a contractor to complete the installation of the high-temperature, high-capacity thermogravimetric analysis furnace and train the students who would be working on it.
- Complete the commissioning of the gas mixing system for the reduction under load test set up and high-temperature, high-capacity thermogravimetric analysis furnace.
- Purchase a scale, a balance, and a mixer
- Purchase a metal change

Figure 23. I&S Lab equipment, including a low intensity magnetic separator, briquetter, reduction under load test set up, reduction under load furnace reactors, high temperature high-capacity thermogravimetric analysis furnace, and a 7.5 kg induction furnace

MONTANA TECHNOLOGICAL UNIVERSITY

D. Senior design projects

Students complete their senior year (one credit in the Fall semester EMET – 489 W M&ME Senior Design I, and two credits in the Spring semester, EMET – 499 W Capstone M&ME Senior Design II) with a senior design project. These projects are a critical component of engineering education because they provide students with the opportunity to integrate and apply the knowledge and skills required throughout their academic program to solve complex, real-world engineering problems and master project management. Through these projects, students gain valuable experience in project planning, teamwork, communication, problem-solving, and decision-making while working within practical constraints, budget, scope, and schedule. Senior design projects also strengthen connections between academia and industry. Hence, they serve as an important bridge between classroom learning and engineering practice, helping prepare graduates for successful careers and lifelong professional development.

At the end of the spring semester, students get an opportunity to present their findings at Tech-Expo and the M&ME Industry Advisory Meeting (IA meeting). Pictures of the students who worked in iron and steelmaking-related senior design projects presenting at the Tech-Expo and M&ME IA meeting are shown in Figure 24.

Working with my mentor, Dr. Paul Sanders, I developed courses on problem framing, project pitching, literature search, proposal preparation, project planning and management, execution strategies, stage gating and decision making, reporting, and project closure to strengthen the EMET 489 and 499 courses. The schematic of the course structure is shown in Figure 25.

Working with my mentors Drew Kofahl and Thomas Cash, and with the award funds, I established and supported two senior design projects: "Hydrogen evolution from molasses-bound DRI briquettes" and "Casting of Montana Tech memorabilia". For both of these projects, Drew Kofahl and Thomas Cash served as industry advisors for the students. They periodically met with the students and guided them on the industry expectations and the impact of their projects. The Tech-Expo posters for these projects are shown in Figures 26 and 27.

Figure 24. Pictures of Daniel Ziesing and Gabriel Marquis presenting on their senior design projects during the 2026 Tech-Expo and 2026 M&ME Industry advisory meeting.

Figure 25. A schematic of the senior design courses Fall semester EMET – 489 W M&ME Senior Design I, and two credits in the Spring semester, EMET – 499 W Capstone M&ME Senior Design II structure.

For the 2026–2027 academic year, Jose Lujan and his team have agreed to advise two senior design projects: "Evaluating the Effectiveness of Calcium Treatment via Inclusion Morphology Control" and "Assessment of Tundish Powder Effectiveness in Inclusion Removal." Drew Kofahl has agreed to continue advising the "Casting of Montana Tech Memorabilia" project, and Thomas Cash has agreed to continue advising the "Hydrogen Evolution from Molasses-Bound DRI Briquettes" project. In addition to these projects, students will work on a project to design and construct a pinball machine, which provides a brief overview of the iron and steel industry.

Award funds will be used to support these projects by providing student stipends and purchasing the consumable materials required for experimental work and project completion.

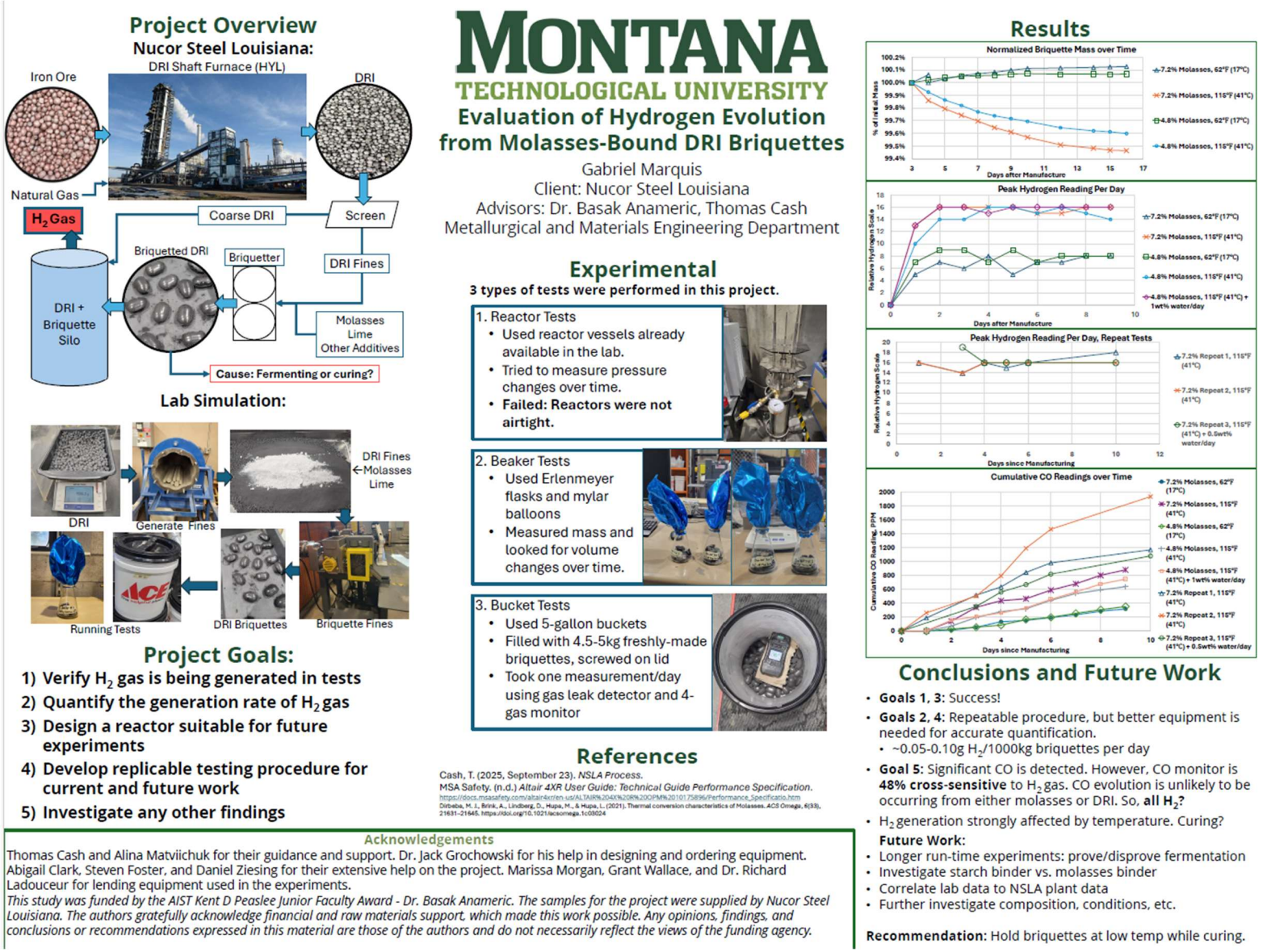

Figure 26. 2025- 2026 TechExpo poster for the Evaluation of Hydrogen from Molasses-Bound CRI Briquettes senior design project

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Casting of Montana Tech Memorabilia

Daniel Ziesing
Advisors: Dr. Basak Anameric (Academic) and Drew Kofahl (Industrial)

Background

This project aimed to commission an induction furnace in the new iron and steel making laboratory, **design and cast a Montana Technological University memorabilia item** for promotional outreach and **provide detailed work instructions for the training and operation** of the induction furnace.
The goal of the project is to aid in increasing iron and steel research within the metallurgical department and outreach to the community. This project included participating in the Montana Tech Steelmaking Days demonstrations, commissioning an induction furnace, commissioning a resistance furnace, green sand molding, AutoCAD modeling, and casting a final product.

Furnace Commissioning	
1. Pillar Induction Furnace • Chiller, Ventilation, Power Supply • Refractory and Crucible Installation **2. Alternate Resistance Furnace** • Nabertherm Furnace Commissioning	Deliverables: • Work Instructions • Operational Furnace • Training
Product Design	
1. AutoCAD • 3D designing and printing • Troubleshooting **2. Material Choice**	Deliverables: • Final Pattern • Diverse material stockpile
Mold Design	
1. Green Sand Testing **2. Sand Processing** **3. Pattern Preparation**	Deliverables: • Work Instructions
Mold Design	
1. Casting • Melt, Pour, and Shakeout **2. Post Processing** **3. Defect Analysis and Troubleshooting**	Deliverables: • Final Cast Product

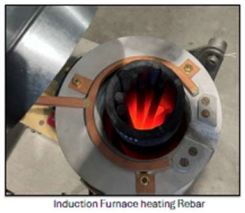
Acknowledgements: This project was funded by AIST Kent D Peaslee Junior Faculty Award – Dr. Basak Anameric (Raw material and financial support)

Addison Cross, Dr. Nathan Huft, Steven Foster, Abigail Clark, Gabriel Marquis, Jack Grochowski, Clint Bannister, Cleveland Cliffs

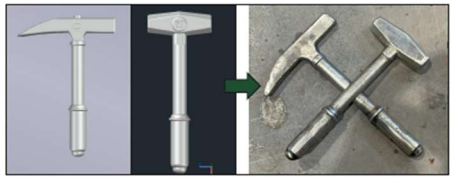
Commissioning

Goal: Ensure operational ability of Montana Tech's Pillar Induction System

- Chiller – Fill with water, check for leaks
- Ventilation – Measure capture velocity with Pitot tube
- Power Supply – Heat charge of rebar
- Furnace – Install refractory and crucible
- Develop work instructions based on literature review and safety standards


Induction Furnace heating Rebar

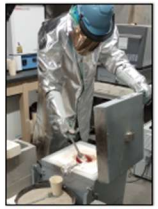

Resistance Furnace Casting Copper


1st Design Iteration to final Cast Bronze Product

Casting

Goal: Produce a final cast product of acceptable quality

- Metal choice based on material availability and castability
- Melt and pour metal charge into prepared sand mold
- Cool and shakeout
- Analysis to ensure fully filled and defect free casting


De-drossing aluminum melt


Casting Aluminum in Petrobond

Safety

- Followed ASHRAE commissioning guidelines
- ASTM E2349-19 Foundry Safety Procedures for casting
- Pillar manuals used to identify equipment hazards
- PPE: Silvers provided by Cleveland Cliffs
- Steven Foster trained in casting procedure


Headframe iteration #2


Iron and Steel Day Induction Furnace Demonstration

Green Sand Testing

Goal: Acquire and produce functional foundry sand and develop processing procedure

- Acquire green sand and flasks
- Compressive strength testing with different sand compositions
- Determination of best sand composition
- Design of sand processing
- Pivot to Petrobond for surface finish


Casting with gating system


Aluminum green sand casting (left) compared to Petrobond (Right)

Results and Conclusions

Scope Deliverables

- Montana Tech memorabilia casted despite major commissioning and material sourcing roadblocks
- Lab ventilation has 400% of required capture velocity

Green Sand

- 3% Moisture target for green sand
- Green sand constrains pattern definition

Casting Procedure

- Nabertherm furnace is suitable for aluminum and bronzes due to operation parameters
- Completed work instructions for casting, green sand, and induction auxiliary maintenance

Future Works

- Headframe casting
- Marketing and sales of product
- Reduction smelting with induction furnace
- Complete induction furnace commissioning

Figure 27. 2025 - 2026 TechExpo poster for the Casting Montana Tech memorabilia senior design Tech-Expo senior design project

The number of iron and steel-related senior design projects has increased. During the 2024–2025 academic year, one of seven senior design projects was focused on iron and steelmaking. In 2025–2026, that number increased to two of six projects. For the 2026–2027 academic year, five of eight senior design projects will be directly related to iron and steelmaking.

This upward trend demonstrates growing student interest and increasing industry engagement in our program. I anticipate that during Years 2 and 3 of the award, both the number of iron and steel-related senior design opportunities and the level of support available to students will continue to expand. In addition, I plan to identify and secure complementary funding sources to leverage this investment, sustain program momentum, and ensure long-term growth and impact beyond the award period. In addition, I will continue to invite students from other engineering disciplines to work with the M&ME students on these projects.

The senior design project "Investigation of the Sticking and Clustering Phases in DRI Briquettes," completed during the 2024–2025 academic year, demonstrates the long-term value of industry-supported senior design projects. The Tech Expo poster for this project is shown in Figure 28. The student involved in this project secured an internship with the company that supplied the project's raw materials. This student subsequently continued the work through an M.Sc. research project titled "Improving the Properties of DRI Briquettes". The Tech Expo poster for this project is shown in Figure 29. With the experience she gained from her senior design project and internship, she will be able to complete her studies in one year and start working in the steel mill by September 2026. Support from the award also enabled the student to present her work at the AISTech 2026 Technical Sessions and Poster Competition, providing valuable professional development and networking opportunities. A picture of her standing in front of her poster is shown in Figure 30.

Similarly, the student who completed the "Casting of Montana Tech Memorabilia" senior design project developed, completed during the 2025-2026 academic year, fell in love with the iron and steel industry and ultimately secured employment.

These examples illustrate how industry-supported senior design projects can create a pipeline of opportunities that extends well beyond the undergraduate experience. I am grateful for the opportunity to contribute to this pipeline and to utilize the KDP award to expand its reach and impact.

Motivation

A rising demand for high quality steel and relatively low availability of scrap has motivated projects exploring and optimizing direct reduced iron (DRI) production as a lower-carbon intensity alternative to traditional blast furnace methods. Approximately 75% of the worlds DRI production is done through shaft furnace processes, primarily the MIDREX and HYL ENERGIRON technologies. A major operational challenge in DRI production via shaft furnaces is the sticking and clustering of pellets and briquettes. This unintended agglomeration of iron ore pellets during the reduction process can hinder the countercurrent gas flow of the furnace, limiting production efficiency. To improve DRI production in shaft furnaces, it is crucial to understand the factors influencing sticking and clustering and develop effective briquetting strategies using binders and recycled DRI fines.

Objectives

(i) Identification of the phases which are instrumental in causing sticking and clustering in briquettes and pellets.
(ii) (Future work) Master's project to investigate binder type and addition rate that will prevent the sticking and clustering of briquettes.

Scope

Experimental

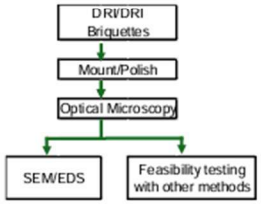


Figure 1: Flow chart of methodology.

Figure 2: Mounted and sectioned DRI samples. Two to three DRI pieces were mounted in each sample.

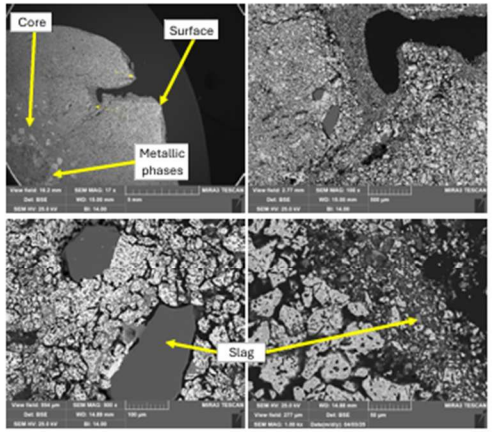


Figure 3: Scanning electron microscopy (SEM) images of a DRI briquette at wide field, 100x, 500x, and 1000x displaying heterogenous structures of slag, oxide, and metallized phases at the core and surface of the particle.

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IDENTIFICATION OF THE STICKING AND CLUSTERING PHASES DURING THE DIRECT REDUCTION OF BRIQUETTES

Abigail Clark – Metallurgical and Materials Eng.
Advisors: Basak Anameric, Ph.D & Grant Wallace, Ph.D

Executive Summary

This project focused on the evaluation of the sticking and clustering characteristics of briquettes, produced from iron oxide pellet fines. Throughout the project, plant trial products were evaluated with intention to study sticking and clustering test products in future studies.

Results

Six DRI samples and three DRI briquette samples were analyzed with SEM/EDS. The slag fusion temperatures of the core and surface for both ternary systems were compared to the eutectic temperature of 1100°C, shown in Figure 4. Residual FeO values are shown in Figure 5.

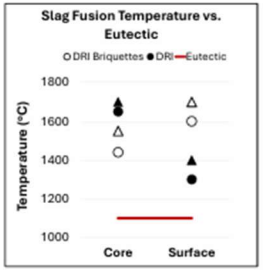

Figure 4: Fusion temperatures compared to eutectic temperature of 1100°C. Al_2O_3-CaO-SiO_2 (circles) and CaO-FeO_x-SiO_2 (triangles)

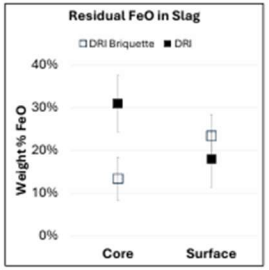

Figure 5: Plotted residual FeO values in slag, showing standard error. Residual FeO is influenced by heating and reduction pattern.

Future Work (Master's Project)

- XRD analysis
- Vickers microhardness, LECO C/S analysis
- Briquetting (binder type and rate), ISO 11256 and HYL Sticking tests.
- Incorporation of Master's project with industry practices.

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Eisenhüttenleute, V. D., & Allibert, M. (2012). *Slag Atlas*. Verl. Stahleisen.
Wang, R., Purohit, S., Raymond, K., & Honeyands, T. (2024). Sticking in shaft furnace and fluidized bed ironmaking processes: A comprehensive review focusing on the effect of coating materials. *Metallurgical and Materials Transactions B*, *55*(5), 2977–3006. https://doi.org/10.1007/s11663-024-03180-x
Yi, L., Huang, Z., Li, T., & Jiang, T. (2016). Sticking of iron ore pellets in direct reduction with hydrogen and carbon monoxide: Behavior and prevention. *Journal of Central South University*, *23*(2), 504–513. https://doi.org/10.1007/s11771-016-3369-6

Acknowledgements

Basak Anameric, Grant Wallace, Nathanael Rawlins, Grace Ekness, Cristina Stefanescu, Gary Wyss, Ethan Mishler, Spencer Toomey

Results

Percentage of oxides for core and surface slag from both DRI briquettes and DRI were used to locate slag fusion temperatures in Figure 6.

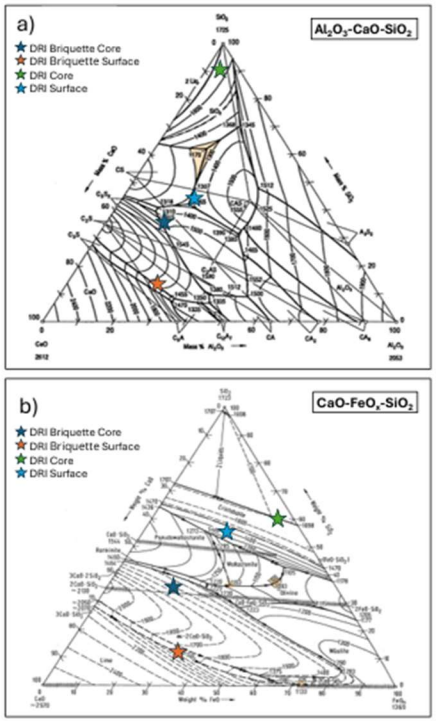

Figure 6: Ternary diagrams for the Al_2O_3-CaO-SiO_2 (a) and CaO-FeO_x-SiO_2 (b) systems, showing critical eutectic points highlighted in orange and compositional data (stars). The surface slag compositions were closer to the eutectic points than the core slag values.

Discussion

- The average fusion temperature of slag present at the core area was higher than the slag present at the surface area for both DRI and DRI briquettes.
- Hence, slag present near the surface will be more likely to stick.
- DRI briquettes had a slightly higher average fusion temperature. This is likely due to the higher CaO percentage (B_2=~8) than DRI (B_2=~1.8)

Conclusions

- Established work instructions for mounting, sectioning, and polishing DRI and DRI briquette samples.
- Slag fusion temperatures for all slag categories were >1100°C eutectic temperature for both ternary systems.
- Slag is not a phase that is instrumental in causing sticking and clustering in DRI and DRI briquettes.
- All six DRI samples and three DRI briquette samples analyzed displayed similar results.

Figure 28. 2024 - 2025 TechExpo poster for the Identification of the Sticking and Clustering Phases During the Direct Reduction of Briquettes, senior design project

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Experimental

Figure: Project scope. Pictures on the left include tumble drum, briquetter, compression strength tester, and sponsor shaft furnace. Pictures on the right include polished DRI samples, DRI and BRI briquette samples, DRI briquettes produced in the laboratory, an induction furnace, and an electric arc furnace.

Conclusions

- Commercial DRI and DRI briquettes were characterized for their size distribution, compressive strength, and fine generation properties.
- Briquettes with similar properties to commercial DRI briquettes were produced in the laboratory
- Operating conditions were varied to produce briquettes with improved properties.
- Recommended operating conditions include 3.2% molasses, 2.4% lime, and curing above room temperature (around 46°C from experiments).
- It was identified that curing and strength development of the briquettes followed first-order kinetics; the majority of the strength development took approximately 6 days.
- Compressive strength of the briquettes was not indicative of their fine generation characteristics.

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IMPROVING THE PROPERTIES OF DIRECT REDUCED IRON BRIQUETTES

Abigail Clark, Steven Foster, and Basak Anameric
Department of Metallurgical and Materials Engineering

Abstract

Direct reduced iron (DRI) fines can be recycled into briquettes and used in downstream steelmaking processes. Briquettes are produced by agglomerating and compacting DRI fines with binders such as molasses and lime, cement, and bentonite. Although many different binders have been developed and studied for iron oxide agglomeration and induration, far fewer studies have been conducted to evaluate the effectiveness and efficiency of binders for the briquetting of DRI fines. Hence, this study focused on the improvement of the properties of DRI briquettes produced using molasses and lime binder.

Throughout the study, samples from an industrial operation were evaluated, and then briquettes that are representative of these observations were produced in laboratory conditions. Impact of binder addition rates, DRI size distribution, curing conditions, and the addition of supplemental binders was studied. Briquettes were evaluated for their compressive strength, tumble, and abrasion indicies and melting characteristics.

It was identified that the fines generation characteristics of the briquettes provided more in-depth information about the DRI briquettes and their suitability when compared with the compressive strength values. Overall physical and mechanical properties of the briquettes could be improved by adjusting the binder and binder addition rates. The curing and strength development of the briquettes require approximately 6 days.

Future Work

- Phase 3: Study Optimization, Fine generation (ISO 3271) and Melting tests
- Phase 4: Plant Trials, Further binder and binder-extender investigation

Acknowledgements

Basak Anameric, Steven Foster, Gabriel Marquis, Daniel Ziesing, Sudhakar Vadiraja, Nathan Huft, Alina Matviichuk

Results

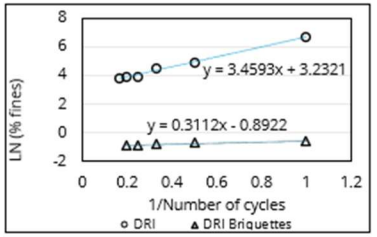

Figure: The natural log of percent fines generation vs. 1 over 200 rotations per test cycle is presented.

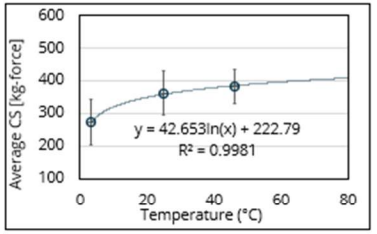

Figure: Effect of curing time on CS of 2.4% molasses, 0.8% lime briquettes cured at room temperature. % increase in CS relative to green strength.

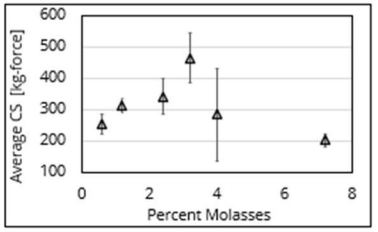

Figure: Effect of molasses percent on average CS for briquettes cured at room temperature for six days (0.8% lime, 16203kPa compaction pressure)

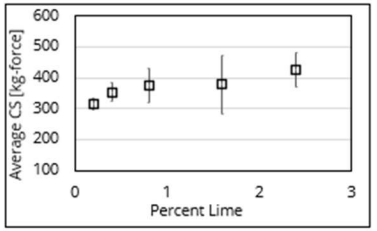

Figure: Effect of lime percent on average CS for briquettes cured at room temperature for six days (2.4% molasses, 16203kPa compaction pressure)

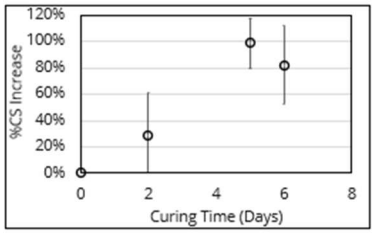

Figure: Effect of curing time on CS of 2.4% molasses, 0.8% lime briquettes cured at room temperature. % increase in CS relative to green strength.

Figure 29. 2025 - 2026 TechExpo poster for Improving the Properties of Direct Reduced Iron Briquettes, Tech-Expo MSc project

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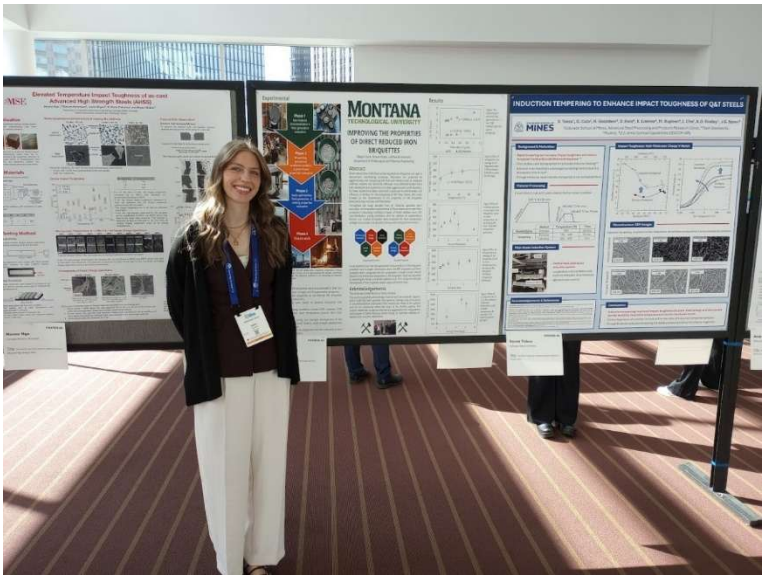

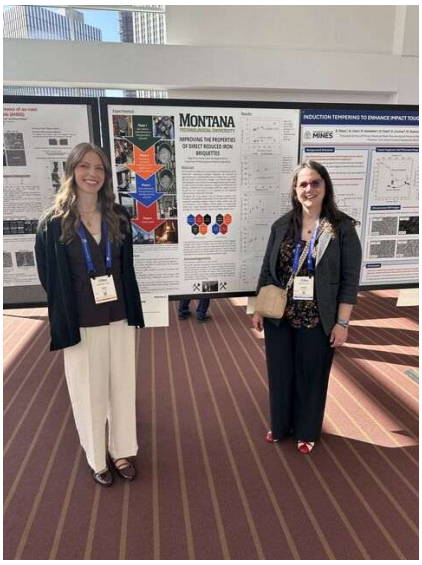

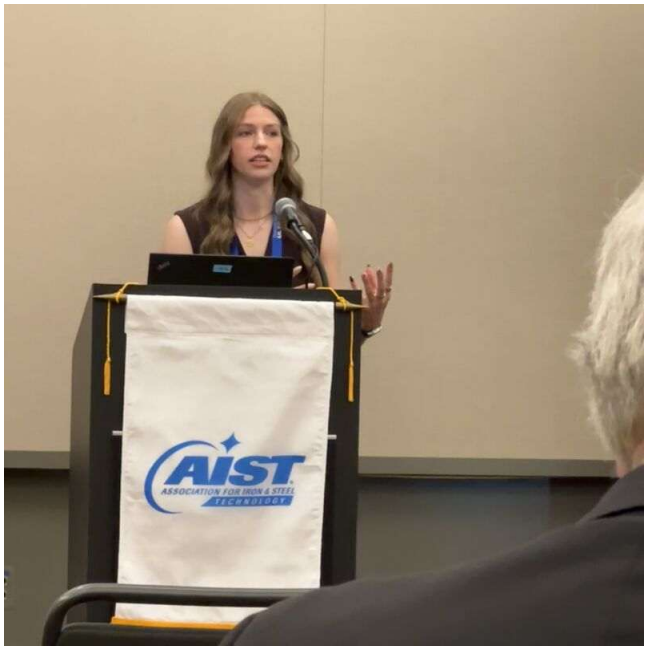

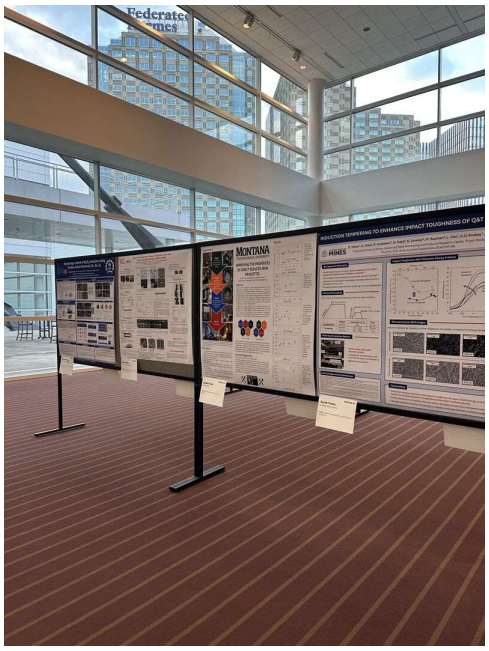

Figure 30. Pictures of MSc. Student Abby Clark presenting and standing by her poster "Improving the properties of direct reduced iron briquettes" at the 2026 AISTech Conference and Exposition in Pittsburgh, PA.

E. Research and teaching

i. Undergraduate research

Award funds were used to expand undergraduate research opportunities by providing student stipends, supporting travel for an undergraduate student to present research findings at the AISTech 2026, and purchasing consumable materials necessary for research activities in the I&S Lab.

The results and insights generated through these projects will serve as a foundation for future research initiatives and will be used to develop competitive proposals for both undergraduate and graduate research opportunities.

a) Cold- bonded briquettes for DRI production

The project was funded by the 2025 Montana Tech Summer Undergraduate Research Funds (SURF). The SURF poster for the project is shown in Figure 31. The KDP award was used to provide travel funds for the student to be able to travel to and present at the AISTech 2026 (see Figure 32).

Abstract

Cold-bonded iron ore briquettes are a type of iron ore agglomerate held together by binders, such as cement or molasses, that are produced without high-temperature hardening and induration. Cold bonding and cold-bonded briquettes offer a more environmentally friendly alternative to traditional iron oxide pellets. Advantages include energy savings and the ability to use a wide variety of binders and fines, including waste oxides and iron oxide fines that are difficult to process. This study focuses on the evaluation of cold-bonded briquettes produced with magnetite (Fe_3O_4) concentrate, flux, and binder. Bentonite, molasses, and cement were selected as binders.

Experimental

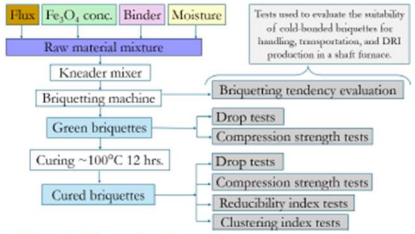

Figure: Schematic of the experimental procedure.

Table: An approximate chemical composition of the raw materials used using iron titration and XRF methods. Magnetite concentrate and dolomite-lime was sourced from northern Michigan operation, bentonite (sodium montmorillonite) was sourced from western Wyoming operation, cement was Type 1-Portland cement, and molasses was unsulfured blackstrap containing 3% ash.

Raw materials	$\%Fe_3O_4$	$\%Fe_2O_3$	$\%SiO_2$	$\%Al_2O_3$	%CaO	%MgO
Magnetite conc.	95.6		4.1	0.1	0.2	
Bentonite		3.2	58.1	11.8	1.0	1.4
Cement		3.2	14.2	3.3	59.0	0.6
Dolomite-lime		0.4	1.2	0.3	24.8	20.8
Molasses ash			8.7		49.5	32.1

Table: Binder and flux weight percentages in briquettes.

B4*: $(\%CaO+\%MgO)/(\%SiO_2+\%Al_2O_3)$.

Mix ID	Binder	wt%	Flux	wt%	B4*
B1	Bentonite	0.6	Dolo-lime	7.5	0.8
B2	Bentonite	1.5	Dolo-lime	7.5	0.7
B3	Bentonite	3.0	Dolo-lime	7.5	0.6
C1	Cement	1.0	Dolo-lime	6.5	0.9
C2	Cement	3.0	Dolo-lime	6.5	1.1
C3	Cement	7.0	Dolo-lime	6.5	1.5
C4	Cement	7.0	None	0.0	0.8
M1	Molasses	3.0	Dolo-lime	7.5	0.9
M2	Molasses	7.0	Dolo-lime	7.5	1.0
M3	Molasses	11.0	Dolo-lime	7.5	1.1
M4	Molasses	14.0	Dolo-lime	7.5	1.1

Conclusions

- Briquettes produced using 7% molasses had adequate drop and compression properties (green and cured).
- However, they did not have acceptable reducibility and sticking and clustering characteristics.
- Future studies are recommended to identify binders and/or binder combinations containing molasses that can lead to production of briquettes with favorable physical and metallurgical properties.

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Cold-bonded Iron Oxide Briquettes for Direct Reduced Iron Production

Steven Foster, Dr. Basak Anameric
Metallurgical and Materials Engineering Department

Introduction

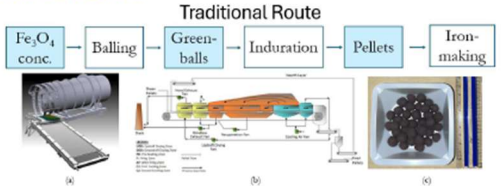

Figure: (a) Balling drum (Wang D., et al., 2015), (b) Schematic diagram of the straight grate induration furnace (Moraes S., et al., 2017), (c) Indurated pellets used as standard.

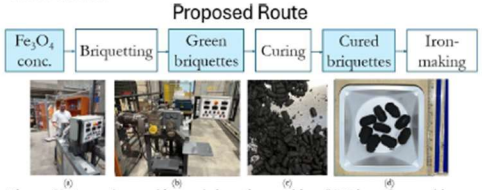

Figure: (a) Researcher working on briquetting machine, (b) Briquetting machine with hydraulic rolls exposed, (c) Green briquettes made with 7% molasses binder, (d) Cured briquettes made with 7% molasses binder.

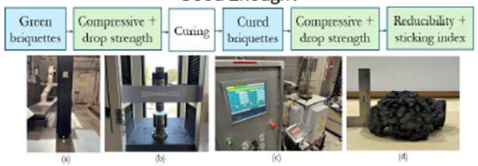

Figure: (a) 30 cm drop test apparatus, (b) Compression strength tester (ISO 4700, 2015), (c) Sticking and clustering machine, (d) Clustering index test products (ISO 11256, 2015) using briquettes made with 7% molasses binder.

Acknowledgements

This summer SURF project was supported by Montana Tech's Undergraduate Research Program, and special thanks to Dr. Basak Anameric and Daniel Goettlich for their guidance and help.

Results

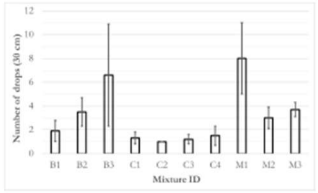

Figure: Drop test results of green briquettes from a height of 30 cm. Low dosage (3%) molasses demonstrated the highest average number of drops, though with significant variability.

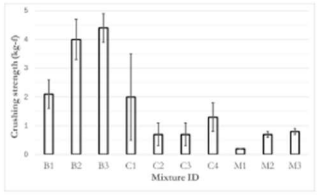

Figure: Compression test results of green briquettes. Bentonite served as the strongest binder at this stage.

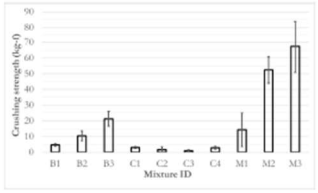

Figure: Compression test results of cured briquettes. Higher dosage (7% and 11%) molasses briquettes overwhelmingly outperformed the other binders.

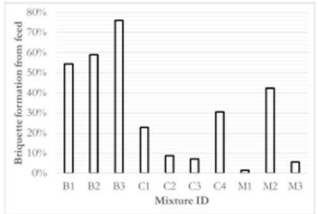

Figure: Percentage of raw material mix (feed) that formed briquettes after briquetting process. Bentonite was the most effective binder, while low (3%) and high (11%) dosage molasses proved unsuccessful.

Figure (left): Reduced standard pellets from sticking and clustering index test (ISO 11256). The pellets retained their form throughout the reduction process.

Figure (right): Reduced 7% molasses briquettes (ISO 11256). The briquettes crumbled, leading to formation of fines which inhibited gas flow and reducibility.

References

- ISO 11256, 2015, Iron ore pellets for shaft direct-reduction feedstocks – Determination of the clustering index.
- Halt, J. A., & Kawatra, S. K. (2017). Review of organic binders for iron ore agglomeration. online source: http://chem.mtu.edu/chem_eng/sklka wstr/2013/2013_May_OrganicBinderReview.pdf, accessed on 24th November.
- Moraes S., Baptista J., and Ribeiro T., Iron Ore Pelletizing Process: An Overview, 2017.
- Povromo, J. J., & Swanson, A. W. (1999). Iron-bearing raw materials for Direct Reduction. *Direct Reduced Iron: Technology and Economics of Production and Use. Iron and Steel Society/AIME, 410 Commonwealth Dr, P. O. Box 411, Warrendale, PA 15086-7512, USA, 1999.*, 59-79.
- Wang D., Servin M., Berglund T., and Mickelsson K., Parametrization and validation of a nonsmooth discrete element method for simulating flows of iron ore green pellets, Powder Technology, 2015.

Figure 31. 2025 SURF poster for the Cold-Bonded Iron oxide briquettes for Direct Reduced Iron Production

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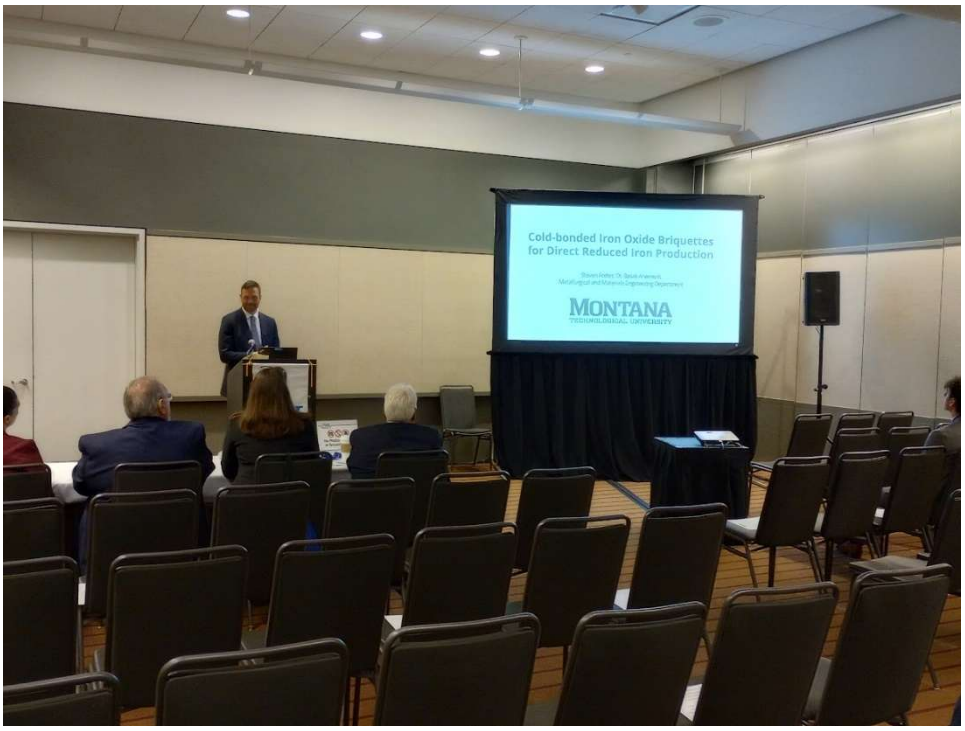


Figure 32. BSc student Steven Foster presenting on " Cold -bonded briquettes for DRI production" at the 2026 AISTech Conference and Exposition in Pittsburgh, PA.

The success of this project led to its continuation in 2026. Building on the initial findings, ongoing research is focused on evaluating the cold-bonding behavior, reduction characteristics, and clustering properties of hematite-based briquettes. This follow-on work aims to improve briquette performance and expand understanding of the factors influencing their behavior during reduction processes.

b) Enhancing Hydrogen-Reduced Direct Reduced Iron for Decarburization

The PI collaborated with Monserrat Sofía López-Cornejo, Professor in the Department of Materials Engineering at Instituto Tecnológico de Morelia, to develop and submit a proposal for consideration under the AIST Sustainable Technologies for Steel Manufacturing Grant program. This collaboration was made possible through professional networking opportunities facilitated by the KDP Award.

The proposed study focuses on investigating the kinetics of carburization in hydrogen-reduced direct reduced iron (H_2-DRI) using methane (CH_4), as well as evaluating its melting and steelmaking behavior in an electric arc furnace (EAF).

Beyond its immediate research objectives, this collaboration establishes a foundation for future joint research initiatives between the two institutions. Potential areas of continued investigation include the carburization behavior of H_2-DRI using carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_4) gas mixtures; the utilization of bio-syngas as a carburizing medium; and the evaluation of slag foaming behavior under varying DRI-to-scrap charge ratios during EAF steelmaking.

ii. Graduate research

Award funds were used to arrange site visits to Nucor Louisiana, Nu-Iron Trinidad and Tobago, and Nucor Berkeley to explore collaboration opportunities for graduate research. These site visits will be held during the last week of June and the first week of July.

An additional site visit to the Cleveland Cliffs Inc. Toledo plant is being scheduled.

These engagements will help to continue networking and identify potential research projects to align with industry needs.

iii. Curriculum alignment and guest lectures

The following courses are mandatory for attaining a BSc degree in metallurgical and materials engineering:

- EMET 340, Chemical kinetics and mass transport
- EMET 402, High temperature processes and pyrometallurgy
- EMET 420 and 520, Physical chemistry of iron and steelmaking

For the instruction of these courses, I bring my industry experience and talk about problem-solving and critical thinking strategies. I also invite industry representatives to provide guest lectures and talk about their experiences.

The enrolment for the EMET 420 and 520 has been increasing. For the 2024-2025 academic year, the class enrollment included 5 undergraduate and 1 graduate student. For the 2025-2026 academic year, the class enrollment increased to 18 undergraduate students.

During the site visits, I will conduct throughout the summer, I will discuss with the industry partners their input to enhance these classes and further align them with the industry needs. I will also invite them to join us for guest lectures to present and to learn from.

To maximize the impact of the guest lectures, invitations are shared with all students in the M&ME as well as students from other engineering disciplines. These presentations have consistently attracted strong student interest and attendance. For example, a guest lecture delivered by my mentor, Thomas Battle, titled "Alternatives to the Blast Furnace for the Production of Metallic Iron," attracted approximately twice the number of students normally enrolled in the course, demonstrating the significant value students place on direct learning from industry professionals.

4. Dissemination of the results

A. Talent and workforce development

i. Montana Tech I&S Days

- Held on February 17–18, 2026.
- The event brought together 36 students and 8 representatives from industry and academia to explore contemporary topics in iron and steelmaking, workforce development, sustainability, and career opportunities.
- The event served as an important platform for showcasing the I&S Lab, students, and increasing awareness of opportunities within the iron and steel industry.
- Recorded presentations will continue to be used as educational resources and shared with students and educators.
- Lessons learned from the inaugural event are being incorporated into the planning of future I&S Days to further expand participation and impact.

ii. Research presentations and professional conferences

- Research findings generated through undergraduate and graduate student projects were disseminated through poster presentations at Montana Tech's Tech Expo, presentations to the M&ME IA board, and participation in national conferences. These presentations provided opportunities to communicate project results to industry professionals, researchers, and educators while fostering professional development and networking opportunities for participating students
- Undergraduate student Steven Foster presented his work on "Cold-Bonded Iron Oxide Briquettes for Direct Reduced Iron Production" at AISTech 2026.
- M.Sc. student Abigail Clark presented her research, "Improving the Properties of Direct Reduced Iron Briquettes," during the AISTech 2026 Technical Sessions and Poster Competition.

iii. Curriculum integration

- Site visit learnings, including industry insights, will be integrated directly into undergraduate and graduate coursework, including EMET 340 Chemical Kinetics and Mass Transport, EMET 402 High Temperature Processes and Pyrometallurgy, and EMET 420/520 Physical Chemistry of Iron and Steelmaking.

- Industry guest lectures and case studies have enhanced classroom instruction by exposing students to current industrial practices, challenges, and technological developments. The increasing enrollment in EMET 420/520, from six students in 2024–2025 to eighteen students in 2025–2026, demonstrates growing student interest in iron and steelmaking and reflects the impact of these dissemination and engagement efforts.

B. Community engagement

i. K-12 I&S Days

- Collaboration between the local elementary, middle, and high school administrators and science teachers was initiated through outreach meetings and invitations to participate in Montana Tech I&S Days.
- K-12 presentations, and a teaching tool – a pinball machine will be prepared during the years 2 and 3 of the award.

C. Research and development

i. Industry and academia collaboration

- Was represented throughout the project by activities carried out as a part of the Montana Tech I&S Days, senior design, undergraduate and graduate research projects, advising and mentoring, and guest lectures.
- Collaborators included Nucor, Cleveland-Cliffs, Opta Group, South Dakota Mines, and the University of Missouri of Science and Technology.
- Networking opportunities supported through the project also led to the development of new research collaborations, including a joint proposal with Instituto Tecnológico de Morelia focused on hydrogen-reduced direct reduced iron (H_2-DRI) and sustainable steelmaking technologies.
- Senior design projects carried out included:
  - Casting of the Montana Tech memorabilia
  - Evolution of hydrogen from molasses-bound DRI briquettes
- Summer undergraduate research projects carried out included:
  - Cold-bounded briquettes for DRI production
- Graduate research projects carried out included:
  - Improving the properties of molasses-bound DR briquettes

D. Future activities

- During Years 2 and 3 of the award, efforts will continue through expanded Montana Tech I&S Days programming, direct engagement with K–12 schools, conference presentations, research publications, industry collaborations, and outreach activities.

- Planned initiatives include

  - Classroom presentations featuring virtual steel mill tours,
  - Development of an educational iron and steelmaking pinball machine for permanent display at the Science Mine,
  - Creation of educational videos highlighting casting and steelmaking processes.
  - Increased undergraduate and graduate research efforts and utilization of the I&S Lab
  - M&ME summer program demonstrations

- Through these activities, the project will continue to broaden awareness of the iron and steel industry, strengthen industry-academic partnerships, support workforce development, and increase opportunities for students to engage with iron and steelmaking education and careers.

5. Student participation

Table 1. The number of Montana Tech students, K-12 students, industry and academia representatives, and community members impacted by the activities associated with the project

	Year 1/3				Year 2/3 (Projected)			
Project goal or activity/ The number of participants impacted by	Montana Tech students	K-12 students	Industry and academia representatives	Community members	Montana Tech students	K-12 students	Industry and academia representatives	Community members
Montana Tech I&S Days lectures and round table discussions	36		8	4	50		10	10
Montana Tech I&S Days demonstrations	32		6	12	50		10	20
K-12 I&S Days			3	3	5	50	5	5
M&ME Summer program demonstrations	1	30			2	30		
Advancement of the I&S Laboratory	5		2		7		4	
Senior design projects support	3		3	25	5		4	
Undergraduate and graduate research support	5		2		5		4	
Industry site visits	40		3		37		3	
Guest lectures	37		3		37		3	

6. Conclusions

The first year of the award included:

- Investment in the I&S Lab
- Outreach planning activities
- Guest lectures
- Round table discussions
- Networking opportunities
- Students showcase
- Successful launch of the Montana Tech I&S days
- Increased number of iron and steel-related research projects
- Opportunities for the students to present their work at AISTech

The accomplishments achieved during the first year demonstrate that Montana Tech and this project team are well-positioned to make a meaningful impact on every aspect of the student recruiting and retention pipeline.

Moving forward, efforts will focus on

- Planning activities for new course offerings, such as recycling and secondary recovery of metals and ferro-alloy production
- Efforts to improve and advance Montana Tech I&S days by targeting second-year attendance of at least 50 students, and 10 industry and academia representatives
- Preparing two demonstrations for the summer program
- Planning of iron and steelmaking days for grades 9 to 12
- Increasing the number of projects being conducted in the I&S Lab to at least 3 undergraduate and 2 graduate projects being carried out
- Preparing an EMET 420 Physical Chemistry of Iron and Steelmaking course notes book
- Advancing collaboration with other KDP award recipients

7. Project schedule

Table 2. Projected year 2 project schedule

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug
Site visits														
Proposal preparation														
Planning for the Montana Tech I&S Days														
Montana Tech I&S Days														
Planning for the K-12 I&S Days														
K-12 I&S Days														
M&ME Summer program demonstrations														
Summer undergraduate research project														
Senior design projects														
Undergraduate research project														
MSc project														
Guest lectures														
Curriculum improvement and I&S lab support														

8. Project budget

Year 1

Scope	Proposed cost	Actual cost
K-12 Iron and Steelmaking Day	$ 6,825	
Montana Tech Iron and Steelmaking Day	$ 7,825	$7,825
Senior design project support	$ 10,625	$ 14,475
Faculty summer salary (160 hrs.)	$ 11,250	$ 5,625
Site visits and other travel	$ 2,834	$ 5,136
Undergraduate student involvement	$ 10,639	$ 10,425
Contract services		$ 6,500
Total cost	**$ 49,998**	**$ 49,986**

Year 2

Scope	Cost
K-12 Iron and Steelmaking Day	$ 6,825
Montana Tech Iron and Steelmaking Day	$ 7,825
Senior design project support	$ 10,625
Faculty summer salary (160 hrs.)	$ 6,250
Site visits and other travel	$ 5,834
Undergraduate student involvement	$ 12,639
Total cost	**$ 49,982**

Year 3

Scope	Cost
K-12 Iron and Steelmaking Day	$ 6,825
Montana Tech Iron and Steelmaking Day	$ 7,825
Senior design project support	$ 10,625
Faculty summer salary (80 hrs.)	$ 6,250
Site visits	$ 5,834
Undergraduate student involvement	$ 12,639
Total cost	**$ 49,982**

9. Team members

About the PI

Professor Anameric is a metallurgical and chemical engineer with an additional engineering degree in mining and mineral processing engineering. She joined the Montana Tech M&ME department in 2023 after working for 16 years of working in industry in many roles, such as project and process engineer, project manager, research and development scientist, and quality coordinator. She has studied and worked on many aspects of project management, innovation, business model, and value proposition development. She worked 12 years in industrial research and development, focusing on iron and steelmaking, extractive metallurgy, ferrous and non-ferrous minerals processing, high-temperature processing, experimental methods development, evaluation of fundamental aspects of reduction and metal-slag interactions, improvement of sustainability attributes (energy and raw material utilization), and waste beneficiation.

Since joining the M&ME department, she has taught Kinetics and Mass Transport (EMET 340), Pyrometallurgy and Thermal Processes (EMET 402), M&ME Thermodynamics (EMET 307), Mineral Processing and Design (EMET 333), Mineral Processing and Design Laboratory (EMET 3335), Physical Chemistry of Iron and Steelmaking (EMET 420 and 520).

In addition to teaching traditional courses, Professor Anameric has contributed to mentoring and advising the Senior Design (EMET 489W and EMET 499W) course.

She has been working closely with industry to incorporate problem-solving and critical thinking into the classes she has been teaching. She understands and promotes the importance of hands-on experiences. Hence, she has been working on the development of an iron and steelmaking laboratory. For this laboratory's development, she was able to attain approximately half a million dollars in funding. She has been managing and facilitating renovations, purchasing, installation, and commissioning the equipment and auxiliary functions in this laboratory.

Professor Anameric also jumped into the ongoing research activities at M&ME. She has been advising two undergraduate students, a MSc student working on an industry-funded project. She has attained three individual Montana Tech faculty awards, and she has been actively preparing proposals for other funding opportunities.

2. Abigail (Abby) Clark, MSc student at Montana Tech, Metallurgical and Materials Engineering

   Ms. Clark completed her undergraduate degree in Metallurgical and Materials Engineering in 2025 and is currently working on her MSc project (Improving Properties of DRI briquettes). Throughout her undergraduate studies, she has completed three internships in the iron and steel industry. She will be stepping into a full-time position with Nucor Steel Berkeley in September 2026. She is a two-time AIST scholarship awardee, a Goldwater Scholarship nominee, and a 5x track and field All-American.

3. Addison Cross, BSc student at Montana Tech, Metallurgical and Materials Engineering

   Mr. Cross is a senior in the Metallurgical and Materials Engineering program. He has completed two internships in the iron and steel industry (Nucor Darlington, South Carolina in the Technical Laboratory, and Steel Dynamics Roanoke Bar Division, working in the melt shop)

4. Grace Ekness, BSc student at Montana Tech, Metallurgical and Materials Engineering

   Ms. Ekness is a third-year honors student in the Metallurgical and Materials Engineering. She has been fortunate to enjoy and excel at what she is learning regarding metallurgy and all the other good things in her life, through her internships and becoming a student leader.

5. Steven Foster, BSc student at Montana Tech, Metallurgical and Materials Engineering

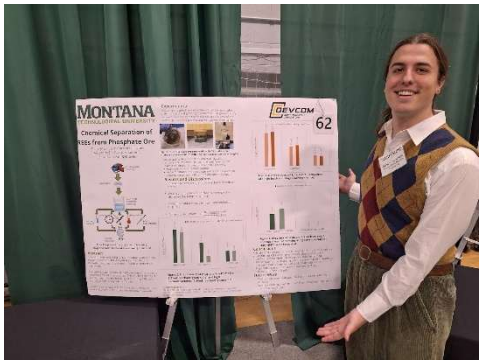
   Mr. Foster is a junior in the Metallurgical and Materials Engineering program and is interested in a career in the iron and steel industry. Last summer, he participated in Montana Tech's Summer Undergraduate Research Fellowship (SURF). He has previously worked at the Center for Advanced Materials Processing at Montana Tech.

6. Stephen Hanson, PhD student at Montana Tech, Metallurgical and Materials Engineering

   Mr. Hanson is a Ph.D. researcher focused on stainless steel additive manufacturing. His work examines how processing choices influence the internal quality and reliability of steel parts. Using laser powder bed fusion (L-PBF), he compares components produced from traditional pre-alloyed powders (based on porosity, microstructure, and material consistency) with those made from blended powder feedstocks.

7. Carson LeLacheur, BSc student at Montana Tech, Metallurgical and Materials Engineering

   Mr. LeLacheur is a senior in the Metallurgical and Materials Engineering program. He is the president of Club MET and chair of the Blacksmithing Club.



8. Gabriel Marquis, BSc student at Montana Tech, Metallurgical and Materials Engineering

   Mr. Marquis is a senior in the Metallurgical and Materials Engineering program. He is from Colstrip, Montana. He has interned in the gold and steel industries. He will work as a naval architect after graduation.

9. Justus Peterson, Highlands College - Machining & Welding

10. Daniel Ziesing, BSc student at Montana Tech, Metallurgical and Materials Engineering

    Mr. Ziesing is a senior Metallurgical and Materials Engineering student at Montana Tech. He has completed internships with Freeport-McMoRan, HECLA, and Newmont. His work spans from process optimization, experimental design, and data automation, with a growing focus on extractive metallurgy and metal casting. His senior design project includes commissioning an induction furnace, alloy and product design, and the casting of Montana Tech memorabilia.

Figure. Montana Tech, Iron and Steelmaking Laboratory (I&S Lab) team. From left to right, Dr. Basak Anameric, Abby Clark, Gabriel Marquis, Daniel Ziesing, Addison Cross, and Steven Foster.

11. Jerry Downey, PhD, PE, Montana Tech, Metallurgical and Materials Engineering, Professor, Department Head, Goldcorp Professor
12. Katelyn McNamee, Montana Tech, Metallurgical and Materials Engineering, Administrative Associate

13. Aaron Frale, Montana Tech, Director of Career Services
14. Quinn Kendall, Montana Tech, Career Services Employer Events Coordinator
15. Cynthia Wier, Montana Tech, Career Services Internship Coordinator



16. Amanda Badovinac, Montana Tech, Executive Director, Marketing and Communications
17. Lisa Sullivan Hibnes, M.S., Montana Tech, Graphic Arts Manager
18. Megan Strickland, Montana Tech, Marketing and Communications Specialist



19. Louis Mason, Montana Tech, Photographer, Videographer, Social Media Manager
20. Shannon Sullivan Panisko, Montana Tech Foundation, Vice President of Development and Philanthropic Engagement


21. Jon Kellar, PhD, South Dakota Mines, Materials and Metallurgical Engineering, Professor, Douglas Fuerstenau Professor, and Nucor Professor
22. Mario Buchely, PhD, Missouri University of Science and Technology, Materials Science and Engineering, Roberta and G. Robert Couch Assistant Professor


23. Jose Lujan, Opta Group, Vice President, Strategy, R&D
24. Drew Kofal, Nucor, District Technical Services


25. Victoria Morton, Nucor, Environmental Engineer
26. Daniela Perez, Nucor, Technical College Recruiter


27. Scott Christensen, Nucor Building Group, Design Supervisor
28. Bill King, Cleveland-Cliffs Inc., Principal Process Research Engineer

29. Thomas P. Battle, PhD, Extractive Metallurgy Consultant, 2020 President, The Minerals, Metals and Materials Society (TMS)
30. Thomas Cash, Nucor, Manager at Nucor Steel Louisiana, LLC
31. Paul Sanders, PhD, Michigan Technological University, Materials Science and Engineering, Professor