STEEL CURRICULUM DEVELOPMENT GRANT

Year-End Report.....2025-2026

Project Title: Virginia Tech Enhanced Steel Curriculum

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Team Members (include name, class and major)
1. Bethany Gansemer, Class of 2026, Materials Science and Engineering
2. Chandler O'Rourke, Class of 2026, Materials Science and Engineering
3. Emily Leonard, Class of 2028, Materials Science and Engineering

Project Summary:
Virginia Tech currently provides students with a basic understanding of steel and steel making and desires to expand its curriculum to include 1) an "Introduction to the Steel Industry" lecture class for freshman and sophomore undergraduate students and 2) an "Advanced Steel Making and Heat Treatment" lecture plus laboratory class for junior and senior undergraduate students.

Project Goals:
The Materials Science and Engineering (MSE) Department at Virginia Tech has a strong commitment to the metal casting industry, has developed a significant steel industry focus, and wants to grow its relationship with the steel industry. As pointed out by the AIST International Steel Academy, *"Today's steel industry is teeming with innovation and advanced technology. Many of the breakthroughs are the result of experienced personnel who have merged hard work with efficiency and opportunity. Young professionals, devoid of the industry experience beneficial to developing new technologies, must rely on the steelmaking curriculum from academic institutions, which in recent years has waned."* This goal of this proposal is to help address the lack of academic institution training.

Over the past fifteen years, the MSE Department at Virginia Tech has had over thirty undergraduate students participate in summer internships or co-ops at steel mills and many of these students accepted full-time employment at steel mills and primary metal producers. In general, VT students have been well received by the steel industry. Many VT students have received AIST Steel Intern scholarships, two students have received AIST Premier scholarships, and a few students have received AIST Southeast Member Chapter scholarships. VT undergraduate students were awarded 1st place in the AISTech undergraduate student project presentation competition in 2022 and 2023. We had a high school student join AIST and register to participate in the AISTech undergraduate student project presentation competition in 2026 but she was barred from competing at the last minute since she was not a full-time undergraduate student (she was taking college level courses at a local community college).

Virginia Tech would like to significantly increase the number of students considering careers in the steel industry by offering an “Introduction to the Steel Industry” lecture class for engineering and non-engineering freshman and sophomore undergraduate students. This class will target students that do not have a metallurgy background. This class will provide a somewhat non-technical introduction to the steel industry with the hopes of generating student interest in pursuing careers in the steel industry. A visit to a steel mill will be included in this class; Nucor-Hertford, Gerdau-Petersburg, and Steel Dynamics-Roanoke have all agreed to host student tours.

The Kroehling Advanced Materials Foundry at Virginia Tech is one of the few university foundries that is capable of producing steel alloys. The foundry at Virginia Tech has induction melting capability (Figure 1), vacuum/inert atmosphere, arc button melting capability (Figure 2), and an iron melting cupola (Figure 3). Molding capability includes green sand, chemically bonded sand and investment. The foundry also has a propane forge (Figure 4), a spectrometer calibrated for steel and steel alloys, three heat treatment furnaces (including a 1700^{o}C, controlled atmosphere furnace recently donated by Nucor-Hertford, Figure 5), grit blast equipment, metallography equipment, metallurgical microscopes, Brinell hardness equipment, and a state-of-the-art dust & fume collection system. The Virginia Tech foundry routinely produces plain carbon steels, alloy steels, tool steels, and stainless steels. The proposed “Advanced Steel Making and Heat Treatment” lecture plus laboratory class for junior and senior undergraduate students will provide students the opportunity to make steel alloys and evaluate the material produced. Student produced steel alloys and commercially purchased steel will be heat treated (spheroidized, annealed, normalized, quenched and tempered, etc.) and the structure and properties of the heat treated steels will be evaluated. This will provide the students with 1) a basic understanding of steel melting, molten steel handling & steel casting and 2) an understanding of steel heat treatment, the effect of heat treatment on microstructure, and the relationship between microstructure and mechanical properties. A visit to a steel mill and/or heat treat shop will also be included in this class.

Figure 1. Induction melting furnace (300 lb capacity) pouring steel directly into a mold.

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Figure 2. Vacuum/inert atmosphere, arc button melting (arc temperature up to 3500°C).

Figure 3. Iron melting cupola (12” inside diameter).

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Figure 4. Propane forge and anvil used in Bladesmithing class to teach steel forging.

Figure 5. 1700°C, controlled atmosphere furnace recently donated by Nucor-Hertford.

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Virginia Tech encourages interdisciplinary teaching and collaboration. The existing MSE "Metals and Alloys" elective class, which devotes six weeks to steel making and steel heat treating, is often taken by Mechanical Engineering (ME), Industrial & Systems Engineering (ISE), and Civil and Environmental Engineering (CEE) students. Virginia Tech takes a hands-on, engaging approach to education and the on-campus foundry allows the students to perform melting and casting.

Project Details:
The appropriate paperwork for both courses (Introduction to the Steel Industry and Advanced Steel Making and Heat Treatment) were submitted for governance approval, Appendix 1 & 2. Three students, Bethany Gansemer (senior who completed a co-op and a summer internship at SSAB), Chandler O'Rourke (senior), and Emily Leonard (sophomore) helped me to create lecture materials for the both classed. Jessica Barbish, Sophie Calandra, and Camden Holloway (VT alumni at Nucor-Hertford) worked with us to create lecture content and provide direct industry contact.

Nucor-Hertford donated a 1700^{o}C, controlled atmosphere furnace, with an 8"x8"x12" hot zone that will be used in the Advanced Steel Making and Heat Treatment class. This furnace needs new heating elements since they were broken during shipping. A 12 channel data acquisition system was purchased for performing thermal analysis during heat treatment. A 12" diameter, iron melting cupola was designed and built by one of my senior design teams last semester and is now available for student use.

The Introduction to the Steel Industry was offered as a "Special Studies" class in the Fall 2025 and Spring 2026 semesters ("special study" classes can be taught twice without full governance approval) and the Advanced Steel Making and Heat Treatment class was offered as a "Special Studies" class in the Spring 2026 semester. We need to better "advertise" these new classes since no one registered for them, which is, unfortunately, a common occurrence with new classes.

Appendix 1:
"Introduction to the Steel Industry" Course Description
Catalogue Description
Introduction to steel industry raw materials, manufacturing processes, final products, and career opportunities. Plant tours and meetings with industry representatives are emphasized.
(3 hours lecture, 3 credits)
Learning Objectives
Having successfully completed this course, the student will be able to:
1. Select the raw materials used in the steel industry
2. Describe the manufacturing processes used in the steel industry
3. Identify the products produced by the steel industry
4. Assess the engineering and non-engineering career opportunities needed by the steel industry

Justification
The steel industry has opportunities for both engineering and non-engineering students. This course provides students with an overview of the steel industry and encourages students to consider careers in the steel industry.

Level Justification: This course is offered at the 2xxx level
Prerequisites and Corequisites
none
Required Textbook
J. Schlegel, The World of Steel, downloadable from Springer Nature (free download for VT students), https://link.springer.com/book/10.1007/978-3-658-39733-3
Week 1: Introduction to the Steel Industry
- Overview of the course
- Importance of steel in modern society
- Brief history of steel production

Week 2: Raw Materials and Resources
- Iron ore, coal, and other raw materials
- Mining and extraction processes
- Environmental impact of raw material extraction

Week 3: Steel Production Processes
- Blast furnace process
- Basic oxygen steelmaking (BOS)
- Electric arc furnace (EAF) process

Week 4: Steel Refining and Alloying
- Secondary steelmaking processes
- Alloying elements and their effects on steel properties
- Quality control in steel production

Week 5: Steel Forming and Shaping
- Rolling, forging, and extrusion
- Casting and molding techniques
- Heat treatment processes

Week 6: Types of Steel and Their Applications
- Carbon steels, alloy steels, stainless steels, and tool steels
- Applications in construction, automotive, aerospace, and other industries

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Week 7: Plant Tour

- Preparation
  - Overview of the plant tour
  - Safety protocols and guidelines
  - Key areas to observe during the tour
- Tour
  - Guided tour of a local steel plant
  - Observation of production processes
  - Q&A session with plant engineers and managers
- Post Tour Discussion and Analysis
  - Reflection on the plant tour experience
  - Discussion of observations and insights
  - Connecting tour observations to course content

Week 8: Careers in the Steel Industry - Part 1

- Overview of career opportunities
- Roles in production, engineering, and management
- Required skills and qualifications

Week 9: Careers in the Steel Industry - Part 2

- Roles in research and development
- Careers in environmental and sustainability sectors
- Opportunities in sales, marketing, and business development

Week 10: Internships and Co-op Programs

- Internships and Co-op Programs
  - Importance of internships and co-op programs
  - How to find and apply for opportunities
  - Success stories from former students
- Scholarships and Financial Aid
  - Overview of scholarships available for students in the steel industry
  - Application tips and deadlines
  - Financial aid resources

Week 11: Steel Industry Economics

- Global steel market overview
- Supply and demand dynamics
- Pricing and trade issues

Week 12: Environmental and Sustainability Issues

- Environmental impact of steel production
- Recycling and waste management
- Sustainable practices in the steel industry

Week 13: Innovations and Future Trends

- Advances in steel production technology
- High-strength and lightweight steels
- Future challenges and opportunities

Week 14: Safety and Health in the Steel Industry

- Workplace safety standards
- Health risks and mitigation strategies
- Case studies of safety improvements

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Additional Resources

- Recommended readings and textbooks
- Online resources and videos
- Guest lectures from industry professionals

Career Development Activities (Throughout the Course)

- Resume and cover letter workshops
- Networking events with industry professionals
- Internship and job search strategies

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Appendix 2:

"Advanced Steel Making and Heat Treatment" Course Description

Catalogue Description

Producing high quality steel products requires appropriate steel making techniques and heat treatment. This class includes class discussion combined with hands-on experience in steel making and heat treatment. (2 hours lecture, 2.5 hours lab, 3C)

Learning Objectives

Having successfully completed this course, the student will be able to:

1. Describe steel making processes
2. Select the appropriate steel making process for a given product
3. Describe steel heat treatment processes
4. Select appropriate steel heat treatment process for a given product
5. Develop new steel heat treatment processes to produce required properties
6. Assess the quality of steel products

Justification

The steel industry has growth opportunities that require new production processes in the areas of melting and heat treatment. This course provides students with lecture and hands-on experience in steel making, steel heat treatment, and evaluation of steel products.

Level Justification: This course is offered at the 4xxx level due to required pre and co-requisites

Prerequisites and Corequisites

Pre – MSE 2034 or 2044, MSE 3324

Co – MSE 3354

Required Textbook

G. Krauss, Steel: Heat Treatment and Processing Principles, (1990) ASM International, Metals Park, OH, ISBN 10: 087170370X / ISBN 13: 9780871703705, 497 pages.

Recommended Resource Books

R.J. Fruehan, Making, Shaping & Treating of Steel – Steelmaking/Refining, (1998) Association for Iron and Steel Technology, Warrendale, PA, ISBN 978-0-930767-02-0, 767 pages.

H. Chandler, Heat Treater's Guide: Practices and Procedures for Irons and Steels, (1995) ASM International, Metals Park, OH, ISBN 10: 0871705206 / ISBN 13: 9780871705204, 904 pages.

Week 1: Introduction to Steel Making

- Course Overview
- Importance of steel
- History of steel production
- Lab -- Introduction to the VT foundry, foundry safety discussion

Week 2: Steel Making Raw Materials and Resources

- Iron ore, coal, and other raw materials
- Mining and extraction processes
- Lab – mold making, charge calculations, and preparation for melting and pouring steel

Week 3: Steel Production Processes

- Blast furnace
- Basic oxygen furnace (BOF)
- Lab – make iron in cupola furnace

Week 4: Steel Production Processes

- Electric arc furnace (EAF) process
- Ladle metallurgy furnace

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- Lab – melt steel in vacuum arc furnace

Week 5: Steel Casting Processes

- Continuous casting
- Foundry casting
- Lab – induction melt and pour plain carbon steel

Week 6: Types of Steel and Their Applications

- Overview of carbon steels, alloy steels, stainless steels, and tool steels
- Applications in construction, automotive, aerospace, and other industries
- Alloying elements and their effects on steel properties
- Lab – induction melt and pour alloy steel

Week 7: Steel Forging Processes

- Overview of forging processes
- Lab – forge commercial steel blanks

Week 8: Heat Treatment

- Iron-Carbon Phase Diagram
- Annealing
- Normalizing
- Stress Relieving
- Lab – thermal analysis (experimentally determine phase transformations)

Week 9: Heat Treatment - Alloy and Tool Steels

- Quenching & Tempering
- Multi-phase Heat Treatments
- Lab – heat treat commercial plain carbon and alloy steels

Week 10: Heat Treatment - Stainless Steel

- Grain Boundary Engineering (deformation plus heat treatment)
- Precipitation Hardening
- Multi-phase Heat Treatments
- Lab – heat treat commercial stainless steels

Week 11: Heat Treatment: Controlled Atmosphere

- Vacuum
- Carburizing
- Nitriding
- Lab – atmosphere heat treat commercial steels

Week 12: Final Project (small group projects)

- Design a steel chemistry and heat treatment to achieve specified requirements
- Lab -- melt and pour designed steel chemistry

Week 13: Final Project (small group projects)

- Design a steel chemistry and heat treatment to achieve specified requirements
- Lab -- heat treat designed steel chemistry

Week 14: Innovations and Future Trends

- Needed advancements in steel production technology
- High-strength and lightweight steels
- Future challenges and opportunities
- Lab – final project presentations

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Dissemination of Results: not applicable: this is not a research project

References: none

Project Schedule:

1. Create an "Introduction to the Steel Industry" lecture class for freshman and sophomore students that may or may not have a materials background.
   - Hire at least one undergraduate student that has completed an internship or co-op at a steel mill to be a teaching assistant. (completed – hired two undergraduate students)
   - Attend the AIST "The Making, Shaping and Treating of Steels 101" class to see how AIST teaches steel making and to develop contacts with AIST instructors. (not completed)
   - Work with local steel mills to arrange tours that will be included in the class. These tours will be publicized by our Materials Advantage Chapter to increase student attendance. (in progress)
   - Milestone 1: Create a new "Introduction to the Steel Industry" lecture class during the Fall 2024 semester. (completed)
   - Milestone 2: Pilot the new "Introduction to the Steel Industry" lecture class during the Spring 2025 semester. (completed - offered Fall 2025 & Spring 2026).

2. Create an "Advanced Steel Making and Heat Treatment" laboratory class for junior and senior students that will provide students the opportunity to make steel alloys, evaluate the cast steels they produced, and heat treat commercially available steels.
   - Hire at least one undergraduate student that has completed an internship or co-op at a steel mill to be a teaching assistant. (completed)
   - Gather the appropriate materials for a steel melting and heat treating laboratory class. (completed)
   - Attend the AIST "Specialty Alloy and Foundry" class (not completed)
   - Work with local steel mills and heat treat shops to arrange tours that will be included in the class. These tours will be publicized by our Materials Advantage Chapter to increase student attendance. (completed)
   - Milestone 3: Create a new "Advanced Steel Making and Heat Treatment" lecture plus laboratory class during the Spring 2025 semester. (completed)
   - Milestone 4: Pilot the new "Advanced Steel Making and Heat Treatment" lecture plus laboratory class during the Fall 2025 semester. (completed -- offered Spring 2026).

3. Develop on-line learning aids.
   - Hire at least one undergraduate student that has completed an internship or co-op at a steel mill to be a teaching assistant. (completed)
   - Identify industry experts willing to help develop course materials. (completed)
   - Visit steel making facilities and document (movies if possible) non-proprietary methods and practices. (completed).
   - Prepare course lecture materials. (completed)
   - Prepare "flashcards" for on-demand review and practice. (in-progress – need student input)
   - Milestone 5: Complete on-line learning aids for the new "Introduction to the Steel Industry" lecture class during the Fall 2024 semester. (in-progress)

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- Milestone 6: Complete on-line learning aids for the new "Advanced Steel Making and Heat Treatment" lecture plus laboratory class during the Spring 2025 semester. (in-progress – need student input)

4. Provide students with copies of lecture slides and class notes at no cost.
   - Milestone 7: Provide copies of lecture slides and class notes at no cost.

Project Cost: originally $25,000 over 3 years – ending project after 2 years at $20,000 due to retirement

Student Participation:
Bethany Gansemer (senior, completed a co-op at SSAB-Iowa and a summer internship at SSAB-Alabama) was my teaching assistant. She worked during the academic year and continued to work on this project while at SSAB during the summer. Bethany is currently looking for a full-time job. Chandler O'Rourke (senior) and Emily Leonard (sophomore) helped with this project during the 2025/26 academic year. Chandler O'Rourke has accepted a full-time position at ACIPCO in Birmingham, AL in their steel pipe shop.

Steel Plant Interaction:
Nucor-Hertford, Gerdau-Petersburg, and SSAB provided letters of support for this project.
Nucor-Hertford, Gerdau-Petersburg, and Steel Dynamics-Roanoke have all agreed to host student tours.
Three VT alumni at Nucor-Hertford are providing information, equipment, and will be providing real world steel mill contacts during the classes.
Nucor-Hertford donated a 1700°C, controlled atmosphere furnace for the steel heat treatment class.

Project Duration:
Originally, Aug 10, 2024 through Aug 9, 2027 – ending early on June 1, 2026 due to retirement

How many students from this university have accepted employment in the steel industry upon graduation?
more than 17 students have accepted employment in the steel industry upon graduation
(more than 30 students have participated in co-ops and internships at steel mills in the last 10 years)

Future of Grant:
- ✠ I have just completed year _2_ of the three-year grant.
- ❑ I hereby confirm that the plan contained in my original proposal will continue during the next academic year and request funding (US$10,000/Year 2, or US$5,000/Year 3) to continue the Steel Curriculum Development plan as submitted in my original proposal.
- ✠ The plans contained in the original proposal are now complete. I have $10,738.28 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 agree to the final results being posted to the website, shared with other universities, shared with AIST members, added to the AIST Library, or presented at a conference.

Alan P. Druschitz June 16, 2026

Alan P. Druschitz

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Note: I officially retired on June 1, 2026 but I am currently a non-paid affiliate in the VT MSE Department and I have been nominated for Professor Emeritus status. As an affiliate and/or Professor Emeritus, I can continue to teach classes at VT and use VT facilities and resources.

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