

# SFSA Cast In Steel 2026– Horseman's Axe Technical Report

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**HERRON SCHOOL  
OF ART + DESIGN**

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## **1. Introduction**

The Steel Founders' Society of America (SFSA) has created this competition to encourage students to learn about making steel products using the casting process and applying the latest technology available. This project focuses on the design, casting, and validation of a historically accurate Horseman's axe using modern casting and inspection techniques.

The objective of Team Herron was to design and manufacture an axe that meets competition specifications while demonstrating technical understanding of metallurgy, casting processes, and quality assurance.

## **2. Historical Background and Axe Authenticity**

The Horseman's axe, historically used by mounted warriors, was designed to be lightweight, compact, and effective in close combat. These axes typically featured a narrow blade, reinforced poll, and balanced weight distribution for one-handed use.

Our design process incorporated extensive historical research focused on weight, size, and visual characteristics. The Art Institute of Chicago served as a key resource, providing valuable insight into authentic forms, proportions, and decorative language. In particular, we centered our design around Germanic axe styles dated from approximately 1490–1535.

Key historical considerations included:

- Proportional balance suitable for mounted use
- Blade geometry consistent with late medieval Germanic axes
- Visual language reflecting period-accurate styling and craftsmanship

In addition to historical accuracy, the team incorporated personal design elements inspired by our identity as an Indiana-based art and engineering team. These stylistic decisions allowed us to maintain authenticity while adding a unique, modern interpretation.

The final design reflects both historical fidelity and intentional artistic expression, resulting in an axe that is both functional and culturally grounded.

## **3. Design Process**

The design process began with research and concept development, followed by iterative modeling and evaluation.

### **3.1 Concept Development**

- Historical research and sketching
- Identification of functional requirements

### 3.2 CAD Modeling

- Initial concept modeling was performed using Nomad Sculpt to rapidly explore form and aesthetics
- Final technical modeling and dimensioning were completed in Fusion 360
- Geometry was refined to ensure both historical accuracy and manufacturability

### 3.3 Simulation and Analysis

- Solidification and flow simulations to minimize defects
- Stress analysis to ensure durability

### 3.4 Final Design Selection

The final design balanced historical accuracy, manufacturability, and performance requirements.

## 4. Casting Process Selection and Implementation

### 4.1 Process Selection

A sand casting process was selected due to:

- Cost-effectiveness
- Suitability for complex geometries
- Availability of equipment

### 4.2 Casting Steps

1. Pattern creation
2. Mold preparation
3. Gating and riser design
4. Molten steel pouring
5. Cooling and solidification
6. Shakeout and cleaning

### 4.3 Process Improvements

Modern casting simulation software (MAGMA) was used extensively to optimize the design and reduce defects prior to production. The following parameters were analyzed:

- **Absolute Viscosity:** Evaluated to ensure proper metal flow characteristics and complete mold filling
- **Fraction Liquid:** Monitored during solidification to understand cooling behavior and identify potential hot spots
- **Porosity Prediction:** Used to locate and minimize shrinkage and gas-related defects through optimized gating and riser design

These simulations allowed the team to refine the casting design before pouring, significantly reducing trial-and-error and improving overall casting quality.

## 5. Metallurgical Decisions

Material selection and heat treatment were critical to achieving the desired mechanical properties for strength, toughness, and edge retention.

### 5.1 Material Selection

The axe head was produced using a chemistry equivalent to AISI 4320 steel, selected for its excellent combination of toughness, hardenability, and fatigue resistance.

#### Casting Chemistry (wt%):

- C: 0.20
- Mn: 0.90
- P: 0.0135
- S: 0.0094
- Si: 0.45
- Ni: 1.75
- Cr: 0.70
- Mo: 0.45

This alloy composition provides:

- Nickel (Ni) for improved toughness and impact resistance
- Chromium (Cr) and Molybdenum (Mo) for hardenability and strength
- Carbon (C) for achieving the desired hardness after heat treatment

### 5.2 Heat Treatment

The casting was heat treated using the following process:

- Austenitized at 1650°F for 2 hours
- Water quenched to achieve a martensitic structure
- Tempered at 1050°F for 2 hours

This heat treatment process resulted in a final hardness of approximately **30 HRC**, providing a balance between edge retention and resistance to brittle fracture.

### 5.3 Microstructure Considerations

The final microstructure consists primarily of tempered martensite, which offers:

- High toughness for impact loading
- Adequate hardness for cutting performance

- Resistance to crack propagation

Careful control of chemistry and heat treatment ensured uniform properties throughout the casting, minimizing residual stresses and distortion.

## **6. Use of Casting Technology to Add Value**

Advanced casting technologies were used to enhance product quality:

- Simulation software to predict defects
- Improved gating design
- Controlled pouring temperatures

These technologies reduced waste, improved yield, and ensured a higher-quality final product.

## **7. Inspection and Non-Destructive Testing (NDT)**

To ensure structural integrity, several NDT methods were applied:

### **7.1 Visual Inspection**

- Surface defect identification

### **7.2 Magnetic Particle Testing**

- Detection of surface and near-surface cracks

### **7.3 Ultrasonic Testing (if applicable)**

- Detection of internal flaws

These methods ensured that the axe met quality and safety standards.

## **8. Testing and Validation**

The axe underwent performance testing including:

- Dimensional verification
- Weight measurement
- Functional testing (cutting performance)

Results confirmed that the axe meets competition requirements.

## **9. Final Results**

The final axe meets all contest requirements:

- **Length:** 30.5 inches
- **Weight:** 2 pounds 11 ounces
- **Material:** 4320-equivalent alloy steel

The axe demonstrates both functional performance and historical authenticity.

## **10. Design Rationale and Craft Considerations**

When first introduced to this project, the team brought a strong enthusiasm rooted in prior exposure to casting and smithing processes, including familiarity with the SFSA Cast in Steel competition. This background informed both the technical and artistic direction of the axe.

### **10.1 Inspiration and Historical Influence**

The primary inspiration for the blade originated from a German-designed axe from the early 16th century, currently displayed at the Art Institute of Chicago. Direct observation of this artifact over time provided insight into its proportions, construction, and visual language.

A key realization during research was the widespread use of horseman's axes across multiple civilizations. This informed the design goal of creating a piece that is both historically grounded and adaptable to a modern interpretation.

### **10.2 Functional Design Philosophy**

The design aimed to balance historical authenticity with practical functionality. The axe was developed to not only meet competition requirements but also to function in realistic use scenarios. Emphasis was placed on durability, repairability, and modularity.

- The handle was designed to be replaceable in the event of failure
- The construction allows for maintenance and repair after extended use

### **10.3 Structural Design Features**

- The top spearpoint was filleted to reduce stress concentrations while maintaining sufficient mass to prevent fracture
- Material distribution was optimized to remain within weight constraints while maximizing durability at critical points

### **10.4 Handle Construction**

The handle utilizes a half-tang design, where the steel extends halfway through the handle. The assembly process included:

- Epoxy bonding to secure the tang
- Steel rivets to mechanically lock the handle in place

Traditional woodworking techniques were used to fabricate the handle:

- Oak stock was cut using a laser-cut template
- The handle was hand-planed and sanded for final shaping
- A black stain and protective wax were applied for durability and finish

### 10.5 Surface Treatment

The steel axe head was treated using a Presto Black patina and sealed with wax. This serves both aesthetic and functional purposes:

- Enhances visual appearance
- Provides corrosion resistance against moisture and oils from handling

### 11. Conclusion

Team Herron successfully designed and produced a Horseman's axe using modern casting techniques while maintaining historical accuracy. The integration of simulation, metallurgy, and NDT ensured a high-quality final product that meets competition standards.

### References

Horseman's Axe

<https://www.artic.edu/artworks/116956/horseman-s-axe>

Nomad Sculpt, Fusion 360, Magma, Procreate, Photoshop

Finalcut

Appendix



