

SFSA CAST IN STEEL 2026 - Horseman's Axe

Technical Report

Wentworth Institute of Technology - Horse Force



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Abstract

The horseman's axe, historically used by mounted soldiers, embodies versatility and compact design. This project, conducted by Team Horse Force for the Steel Founders' Society of America (SFSA) 2026 Cast in Steel Competition, aimed to design, manufacture, and evaluate a historically inspired axe using modern casting techniques. In collaboration with DW Clark, a CA6NM stainless steel axe head was produced using a 3D-printed sand casting process, followed by heat treatment and machining.

Design development prioritized historical accuracy and structural performance, utilizing finite element analysis (FEA) and casting simulations to optimize geometry and reduce defects such as porosity. A white ash handle was fabricated and assembled to meet competition weight and durability requirements. Performance testing through controlled cutting trials demonstrated the axe's strength, sharpness, and ergonomic effectiveness. The final product successfully integrates historical design with modern engineering practices, highlighting the value of casting technology and collaborative manufacturing.

Introduction

Forged in Medieval times, the horseman's axe was used alongside swords as a secondary weapon of mounted soldiers. Transitioning to being used as a tool after the renaissance era, the axe represents versatility and compactness in its design. Horse Force has designed, manufactured and tested a horseman's axe using modern casting technology for the SFSA 2026 Cast in Steel competition. Collaborating with DW Clark, this team gained valuable knowledge and first hand experience with the casting and fabrication processes over the course of the project.

SFSA Cast in Steel Competition Overview

Steel Founders' Society of America has created this competition to encourage and support university students to learn and engage with local foundries about making steel products using casting processes and applying the latest technology available. This opportunity allows for collaboration and creativity between students and foundry workers in a unique way.

Project goals

- **Historical Accuracy:** Create a horseman's axe that replicates the design and characteristics of an authentic axe seen in history
- **Metallurgical Innovation:** Utilize advanced simulation and testing methods to enhance the axe's performance and structural integrity.
- **Casting Proficiency:** Learn and master new techniques of casting by working with a local foundry to understand the full casting process

History of the Horseman's Axe

Known as a horseman's battle axe at the time, it commanded significant force which was especially useful for enemies covered in armor. The Axe head was commonly made of wrought iron during this time while the handle was carved with hardwood. The design of the axe head combined a stout battle-axe blade with a long spike or pick on the opposite side which allowed for multiple uses both in combat and as a tool. With much cruder forging methods, exact measurements of weight and length were not as standard, but the typical weight of the axe was about 1-2 kgs with a length of 60-80 cm.

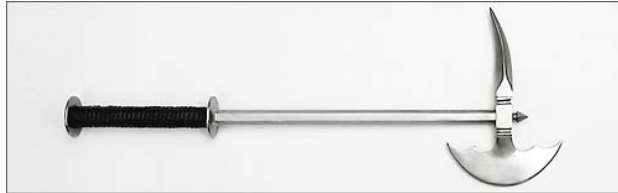


Figure 1. Replica of Circa 1540 Horseman's Axe

The earliest use of the horseman's axe was in Europe during the 14th century as a counter to break through plated armor. By the beginning of the 15th century, most cavalry in Europe and western Asia were equipped with a horseman's axe or a variation of the concept. This led to specialized forms of the from different countries developing, each with their own traits and customizations. By the late 17th century, the use of the horseman's axe declined and served its purpose as a tool rather than a weapon as by this time battle shifted towards firearms and other ranged weapons.

Guidelines and Restrictions

The Steel Founders' Society of America's Cast in Steel competition is a distinguished event hosting a multitude of college students under set guidelines in order to cast a tool seen in history. The 2026 competition centers on recreating a horseman's axe, which challenged competitors on blending historical authenticity with modern engineering innovations.

- Weight - The axe should weigh no more than 1.5 kg (3.3 lbs)
- Length - The axe should not be longer than 0.8 meters (31.5 in.) in overall length
- Manufacturing - The axe must be cast with an industrial partner rather than forged or machined from stock material
- Historical Inspiration – The design must be inspired by and have all functions and characteristics of a horseman's axe

To ensure all requirements were met, weight distribution studies, finite element analysis (FEA), and casting simulations were performed. These assessments informed the mold design, structural reinforcements, and overall casting strategy, ultimately contributing to a high-quality final product.

Final Specifications and Dimensions

Component	Length	Thickness	Weight
Axe Head (bottom lug to toe)	2 ¾"	1 7/32"	1.57 lbs
Handle (where shoulder meets lug)	24 7/8"	1 9/32"	0.62 lbs
Overall	27 5/8"	1 9/32"	2.19 lbs

Table 1. Horseman's Axe Measurements

Design Considerations & Iterations

When designing the axe, several designs were initially considered. There was considerable time researching and understanding the different characteristics of a horseman's axe. The initial objective was to cast the entire axe with the handle as seen in our preliminary plan. After some discussion between our team and other teams in the competition, it was decided that it would be more logical to cast only the axe head and use a type of hardwood as a handle. This decision would allow for a lighter axe in order to stay under the weight requirement. This also allowed for an easier cast as there was a 5 lbs weight restriction at DW Clark for the cast that was being performed.

One of the most important decisions that our team made was the materials for both the axe head and for the handle. For the axe head, there was discussion with our foundry sponsor DW Clark as they held significant expertise about what would and wouldn't work for this project. From the start, the plan was to cast with a high strength stainless steel as that would hold up for this type of project. Due to slight restrictions on the foundry side, the decision was made to cast with CA6NM Stainless Steel. This allowed for high strength and hardness after heat treatment which is ideal for the horseman's axe as it would be experiencing heavy impacts during testing. For the handle, the initial decision was to use hickory as it has a great strength to weight ratio which is critical for keeping the assembly under the weight requirement while maintaining durability as a whole. Unfortunately due to supply issues and time constraints, the decision was made to use white ash as a substitute for hickory. White ash is lighter than hickory which gives us plenty of leeway when worrying about the weight restriction. Although a trade-off was less strength in the handle.

However, there were certain design choices that ended up being changed by the time the final design had been chosen. One of these changes was altering the back spike to have a wider blade, as there were concerns that it would break upon impact. Another change that was made later in the project was removing the top pike in order to allow for an easier attachment of the axe head to the handle. This allowed for a wedge to be used with the addition of rivets in order to keep the axe secure on the handle when dealt with significant impact force.

Manufacturing process

Mould:

In collaboration with the engineering team at DW Clark, the project embarked on the intricate process of designing and fabricating a casting mold specifically for the horseman's axe. The mold they made was a 3D-printed sand mold, where they took the CAD model and printed it as negative space. There are a few benefits to this, such as the fact that it's usually faster to print the mold than to make the mold by hand. Additionally, since they were only casting 3 of these axe heads for us, it was more beneficial to them to make a mold that did not cost them as much to make.

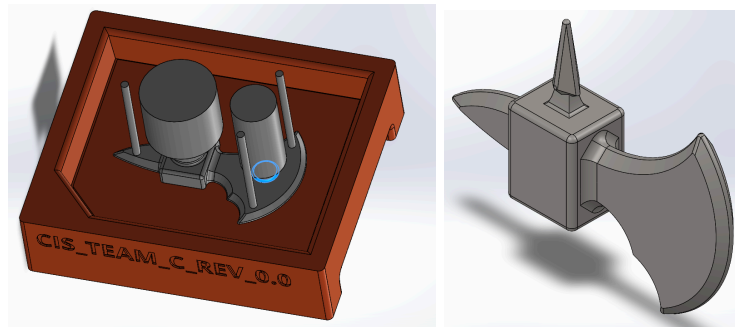


Figure 2. & 3. CAD models of Axe head and Cast

Cast:

Each of the axe heads came out pretty well, with each having a small amount of porosity but otherwise came out well. Unfortunately, due to time constraints, DW Clark was unable to do the radiology testing to show where all the porosity was specifically but they did help do the shot blasting once the axe cooled. The only additional work they did on the axe was cutting off the additional material from the risers and the heat treatment. The heat treatment they did was tempering, a process where the metal is reheated to just below its critical temperature. This is traditionally done to hardened, brittle materials to increase the toughness of the casting. The axe heads were reheated from 400°F to 1150°F, then soaked at that temperature for 4 hours, then air cooled.

Machining:

The axe head machining process involved multiple attempts across different facilities to achieve the desired bore and fitment. The initial attempt at a local machine shop utilized a milling machine with high-speed steel (HSS) drill bits at elevated RPMs; however, excessive heat generation led to rapid tool wear, particularly given the practice of reusing and regrinding bits on a grinding wheel. This approach allowed only limited progress, including drilling approximately a 1/8" through-hole and a 1/4" diameter hole to a depth of roughly 1/4" before material resistance and tool degradation made further advancement impractical.

A second attempt conducted at the Wentworth Institute of Technology Projects Lab began on a drill press using a ¼” HSS carbide bit, successfully penetrating the axe head with significant mechanical resistance and liberal application of cutting fluid. The operation then transitioned to a South Bend milling machine, where a ½” cobalt drill bit was employed at speeds exceeding 200 RPM, yielding substantially improved cutting performance and chip evacuation.



Figure 4. & 5. Before & After of the axe head

Despite encountering material inclusions, steady feed pressure enabled continued progress without catastrophic tool failure. The bore was subsequently enlarged to the target diameter of ¾” using a cobalt drill bit under low RPM conditions with ample lubrication, maintaining consistent cutting efficiency aided by the relatively new tool condition. Additional machining included drilling ¼” diameter holes into the cheeks of the axe head using a cobalt bit to accommodate anti-rotation pegs. Following assembly, ⅛” holes were drilled through the handle peg and axe head after the head was wedged with cherry wood and allowed to dry. Final retention was achieved by driving 7/32” roll pins through the aligned ¼” holes, securing the head to the handle.

The handle fabrication process began with the procurement of two 34” ash baseball bat blanks from Woodcraft of Woburn. Initial shaping was performed in a home workshop using a combination of a table saw, miter saw, belt sander, and an angle grinder fitted with a 40-grit flap disc to rapidly remove material and establish the desired profile. The handle was progressively refined using the angle grinder until the target ergonomic geometry was achieved. Additional contouring, including the curvature near the distal end

The formation of the eye interface— specifically the tenon (or “tongue”) that fits into the axe head—was accomplished using both a band saw and a dremel for finer detailing and fitment adjustments. For finishing, the handle was stained using brewed coffee and coffee grounds, imparting a darker, aged appearance. This method evokes pre-industrial finishing techniques, contributing to an aesthetic consistent with historically inspired tools and suggesting a resemblance to finishes that may have been achieved prior to the advent of modern chemical stains.

Simulations and FEA

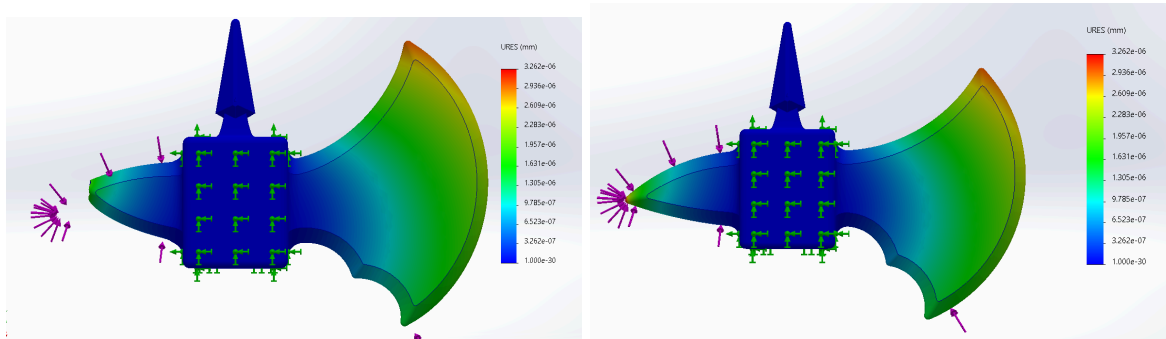


Figure 6. & 7. FEA analysis of the axehead in SolidWorks

When conducting the FEA simulation in Solidworks, the axe head displays some deformation to both the head and the back spike when force is applied to both. The center connection was fixed in place as that part would not be experiencing any force directly applied to it and since the pike was cut off, no force was applied to it. As shown in the pictures above, the head experiences very little deformation with it only bending backwards slightly, whereas the back spike begins to “cave-in” on itself when force is applied to it.

The pictures below show the magma simulation that DW Clark did for one of the earlier interactions of the CAD model. The cyan colored highlights show the porosity of the model after solidification, and the orange highlights show what portion of the cast would remain molten after a certain amount of time had passed for cooling. As this was an earlier model, there were several things that were changed to lower the porosity such as making the head and the back spike gradually grow thinner, going from $\frac{1}{2}$ an inch at the thickest point to $\frac{3}{8}$ an inch at the thinnest point.

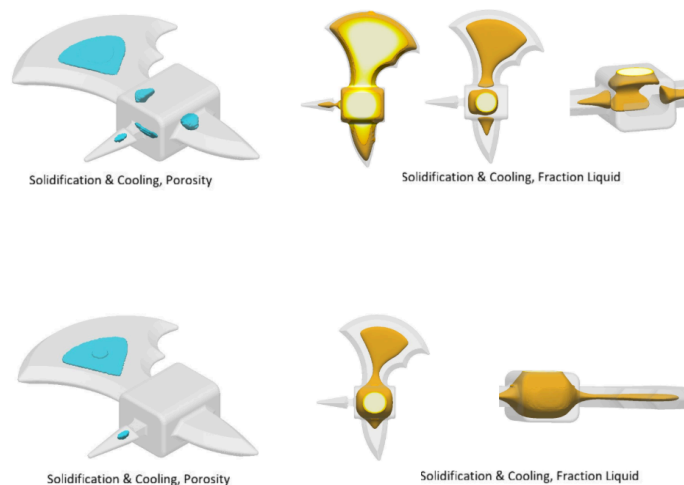


Figure 8 - Magma Simulation of the axe head

Testing

The main method of testing the axe was cutting various fruits or vegetables to test the sharpness of both the head and the back spike. Due to the limited budget, the axe was tested on a total of 2 watermelons, 4 pineapples, a squash, a turnip, and a can of Sprite. The testing went great, despite the limited options, with the axe cleanly cutting through each of the various objects the axe was tested against. The team was careful to clean up any and all fruit pieces that were left on the ground after the testing. The results of our testing showed that our horseman's axe was made durably and practically. The horseman's axe itself felt comfortable to hold and required very little additional force to cleanly cut the fruits we used. Inspecting the axe afterwards showed no damage or issues which gives confidence in structural integrity.

Conclusion

The Horseman's Axe created by Horse Force during the SFSA Cast in Steel 2026 Competition provided this team excellent hands-on experience with casting and collaborating with a local foundry. Starting with a simple CAD model, this axe has come a long way over the past few months. Although there were a multitude of setbacks, design changes and time constraints during the project, this team persevered and was able to deliver a final product that not only met the requirements of the competition but far surpassed our expectations for the project.

Given the opportunity to start this project from the beginning again there would be a few key differences that would have helped the creation of the axe. One of these would be the team's time management as there were places where time could have been used more effectively which would have allotted more time for polishing and finishing our axe to a higher standard. Another would be planning our different fail safes in case of various issues that could happen during the duration of the project.

Overall, the horseman's axe that was created by Horse Force proved to be both historically accurate and practical as a tool and weapon. Ensuring that the final product had all the characteristics of an authentic horseman's axe while staying within the restrictions of the competition. From data in our FEA analysis and our physical testing of the axe, it performed greater than anticipated proving our horseman's axe is a Horse Force to be reckoned with.

Appendix A - Pictures

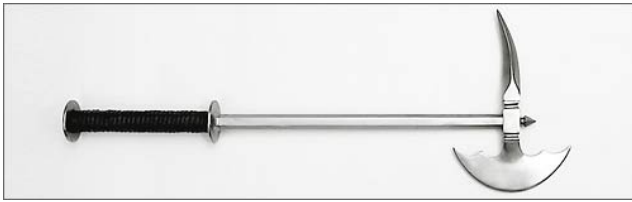


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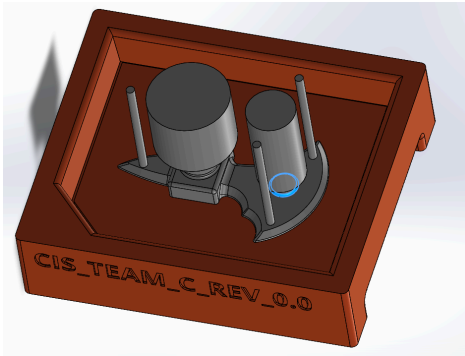


Figure 2. CAD models of casting of axe head

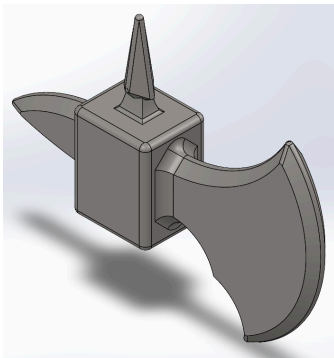


Figure 3. CAD models of Axe head



Figure 4. Picture of the axe head post cast



Figure 5. Picture of the axe head completed

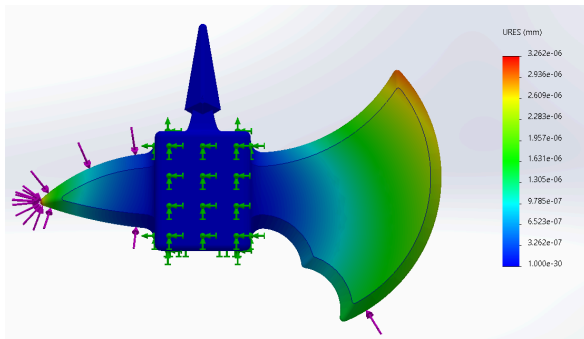
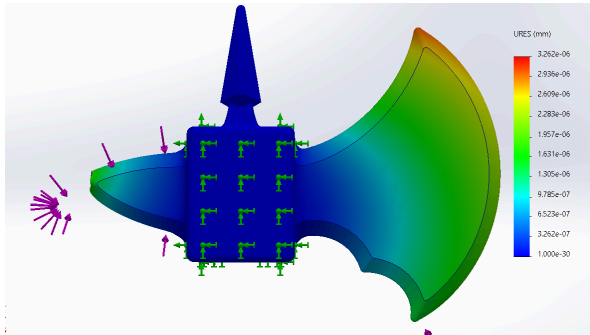


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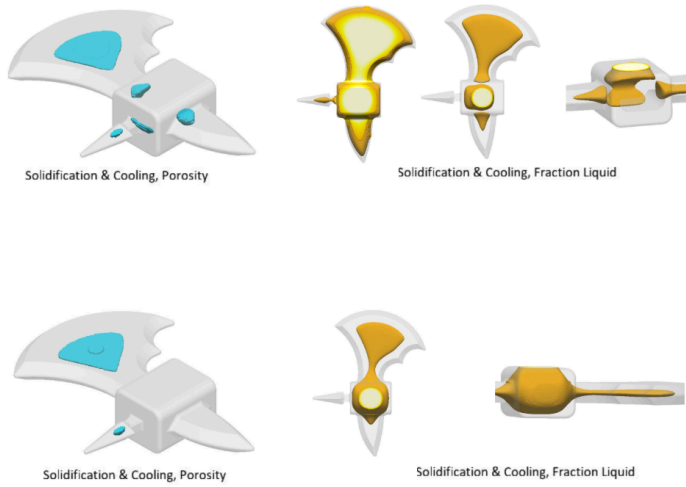


Figure 8 - Magma Simulation of the axe head

Appendix B - Tables

Component	Length	Thickness	Weight
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