

Happy Axecidents – Horseman’s Axe

Jacob Worden, Kyle Brown, Etienne Dolezal

Cast in Steel – Technical Report

March 27th, 2026

Introduction

For the competition, a horseman's axe was designed and manufactured. This process involved 3D modeling, sourcing materials, collaborating with foundry professionals, finishing operations, and final assembly. The goal through these processes was to produce a durable, aesthetically refined product that adhered to the guidelines and rules of the competition. This report outlines the design process, material selection, casting considerations, and final assembly.

Design Process

The beginning of the design process involved preliminary research into horseman's axes and medieval weaponry. To design a horseman's axe, it was important to understand the principal characteristics of a horseman's axe. After preliminary research, hand-drawn sketches were made to decide size specifications, thicknesses, and general dimensions. The decision to have a wooden handle and large top spike came from this point in the process.

The hand-drawn sketches were used as a framework for the 3D models. SolidWorks was used to create the first official models and assemblies. Shortly after creating the first model, it became more apparent that the top spike should be cast separately from the blade and back spike. It was thought that casting the top spike and axe head as separate components would be simpler to manufacture and ensure a strong connection of the axe head assembly to the wooden handle. The idea was to place the top spike over the axe head and pin the top spike to the wooden handle. This is illustrated in Figure 1 below.



Figure 1. 3D Model of Axe head, Top Spike, and Handle (authors' own image)

Objectives, including the competition guidelines, were boldly outlined for the design of our horseman's axe. The axe must meet all competition standards, must be based off a specific culture and time, and must represent the city of Milwaukee. Different horseman's axes from different points in history all had their own unique character, ornamentation, utility, and theme. Inspiration was found in a few historical examples of horseman's axes from history.



Figure 2. German Horseman's Axe (source:[1])

The axe shown in Figure 2 is a horseman's axe from the early 1500s. It was made in Germany. The length of the top spike and shape of the blade directly inspired the design of the competition axe. The top spike was not always present for other axes from other periods in history, but it seems to outwardly define the horseman's axe. This is not a Viking axe, a hatchet, or war axe but rather a horseman's axe, defined by the top spike.

The shape of the blade also served as inspiration for the competition axe. Other, more ornamental, axes have a curvier blade which bends closer to the handle. We liked how this blade was not as curvy and remained more vertical.

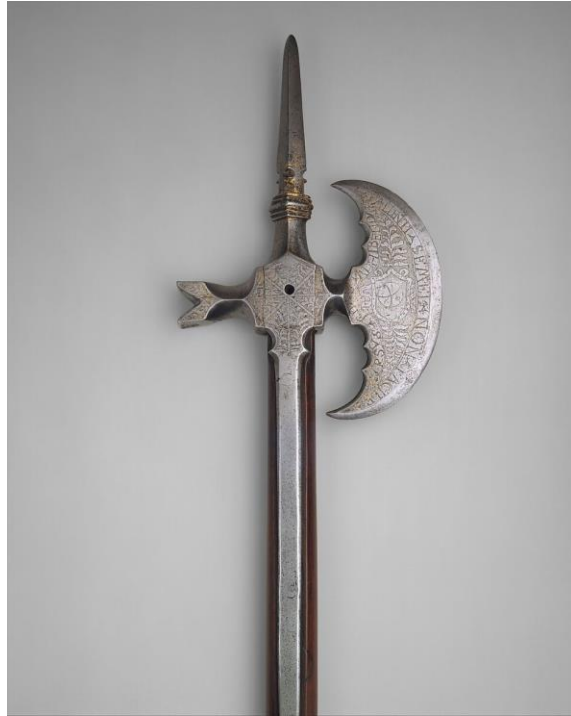


Figure 3. Italian Horseman's Axe (source:[2])

The axe shown in Figure 3 was created in the early 1500's in Italy. This specific horseman's axe was owned by a Cardinal Ippolito de' Medici, a powerful family from the 16th century in Florence, Italy. The designs and the top spike inspired the competition axe. The elaborate designs from the Italian axe represented the place where the axe came from. On one side of the blade is the coat of arms of the Medici family. The design of the competition axe was directly inspired by the Italian axe to represent where the axe is from.

The design of the competition axe was intended to represent the city of Milwaukee. The Milwaukee Art Museum was selected as the primary source of inspiration due to its distinctive architecture and significant symbol of the city. This influence is reflected in the decorative cutouts in the blade and rear spike.



Figure 4. The Competition Axe (authors' own image)

Manufacturing Process

Casting

There were several options for casting in the area; sand, investment, and centrifugal. Sand would be the easiest in terms of price and availability as there are many sand foundries in the area. Investment has the best surface finish and dimensional accuracy, which would be beneficial for a small object like an axe head as it reduces machining required for the casting (Viswanathan et al., 2008). Centrifugal, while not practical, would be a good challenge.

The selected casting process was an investment. This was due to the MetalTek investment division being the group that offered to sponsor the casting, providing access to industrial grade precision and high level of detail for the axe perforations.

Our group visited the site and added the four axe heads and spike PLA parts to wax trees. This process was performed by roughing the PLA surface and adding extra wax gating before glueing the parts to 2 wax trees.



Figure 5. Group member inspecting wax tree (authors' own image)

Heat Treatment

The as-cast structure of T6 tool steel is brittle and uncommon to cast into shape. So, our group had the heat treatment of the casting sponsored by ThermTech. Before the heat treatment, straightening was performed with an arbor press and a copper hammer.

The heat treatment began with an austenitizing stage where the axe head and spike were heated and soaked to 1650F and soaked for 2 hours. To prevent decarburization, the

furnace atmosphere was controlled with a carbon potential of $0.48\% \pm 0.10\%$. (ASM International, 1991)

Following the soak, the parts were put into an oil quench at 140 F for 8 minutes. To ensure uniform cooling and formation of soft spots, the quench tank agitators were operated at 25% capacity. The process concluded with one temper cycle at 700 F for three hours to allow for stress relief and increase ductility.

Machining & Finalization

When our team received the axehead and spike, it came to 1.8 lbs. After receiving it, we grinded and sanded them as well as sharpened the edge. A significant challenge occurred with the pinning holes designed to secure the top spike to the axehead. During the casting process, these holes were filled in, and the subsequent hardening during heat treatment made the steel incredibly difficult to drill. We attempted to drill the holes to the correct size, but due to the hardness of the T6 steel and our looming time constraints, we made the final decision to submit the axe without the spike.

For the handle, we selected ash wood and cut it from a larger stock to ensure the best grain orientation. The handle was shaped straight and then wedged into the axe head to create a secure final assembly.



Figure 6. Axe before removal of spike (authors' own image)

Conclusion

The design and manufacturing of the Horseman's Axe was a successful exploration of history using modern metallurgical engineering. Our team was able to take a conceptual design with complex geometries, such as the decorative perforations in the blade, and realize them through the precision of investment casting and controlled heat treatment. Choosing investment casting was a key part of our strategy because it allowed us to maintain the fine architectural details inspired by the Milwaukee Art Museum that likely would have been lost in a standard sand mold.

By collaborating with professionals at MetalTek and ThermTech, we were able to use industrial-grade technology to work with T6 tool steel. This material is typically brittle and uncommon to cast into shape, but the specific heat treatment cycle we followed turned the as-cast structure into a tough, durable product.

Even though we ran into significant challenges with the top spike and the pinning holes during the final assembly at the UWM foundry, the process of troubleshooting those issues was a major part of our learning experience. While we ultimately decided to submit the axe without the spike due to time and sizing constraints, the final head still met all weight and dimensional guidelines. Overall, the entire process of 3D modeling, casting, and finishing provided our group with a much deeper understanding of the steel casting industry and allowed us to see a complex project through a hand-drawn sketch to a finished, heat-treated tool.

Works Cited

- [1] Art Institute of Chicago, *Horseman's Axe*, Art Institute of Chicago, c. 1490-1535, [Online]. Available: <https://www.artic.edu/artworks/116956/horseman-s-axe>
- [2] The Met, *Horseman's Ax of Cardinal Ippolito de' Medici (1511–1535)*, The Met, c. 1511-1535, [Online]. Available: <https://www.metmuseum.org/art/collection/search/26548>
- [3] Viswanathan, S., Apelian, D., Donahue, R. J., et al. (Eds.). (2008). *ASM Handbook: Volume 15: Casting*. ASM International. Materials Park, OH.
- [4] ASM International Handbook Committee. (1991). *ASM Handbook: Volume 4: Heat Treating*. ASM International. Materials Park, OH.