



**SFSA Cast In Steel 2026 – Horseman’s Axe  
Technical Report  
Texas State – Bobcat Gussmeisters**



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**Foundry Partner:**

Henderson Manufacturing Co.



## **Abstract:**

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 year's challenge was to create a historically accurate and fully functional horseman's axe using metal casting processes. Our team gained inspiration from 16th century German style horseman's axe designs. Our team name "Bobcat Gussmeisters" is German for Bobcat Casting Masters, showcasing our commitment to embracing the German style of Horseman's Axe that we created.

## **Historical background and accuracy:**

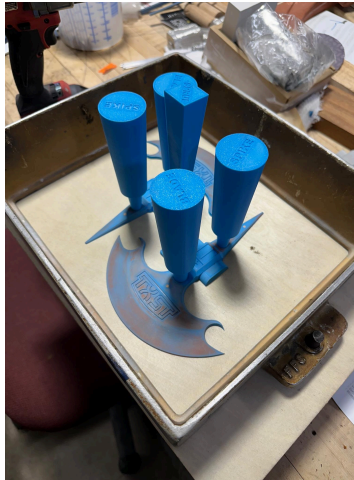
The design inspiration chosen came from 1600's germanic "Raven's peak" axes that would have been carried and used by a "Schwarz Reiter," a 16th century German mercenary cavalryman first appeared around 1546. The name Schwarzreiter means "Black Rider", a name they earned from their lower quality steel armor treated with acid to blacken it as rust prevention. Their horsemen's axes were not only a great sidearm to use instead of their wheel-lock pistols but, it was often a decorative insignia for them. They were commonly made of steel, with a wooden handle, with beechwood being a popular choice. Much like the one on display at the Art Institute of Chicago, which dates between 1490 and 1535. This sidearm was commonly carried on the belt or saddle. The spike on the back of the axe was referred to as the "Beak", or for these German mercenaries the "Schnabel." The length was between 45-75cm (18-29.5in), we made ours 20in (51cm). Instead of the era's popular beechwood, true shagbark American hickory (50-78 pounds per cubic foot) was used for the handle.

## **Use of Metalcasting Techniques/Technology:**

The casting process that was selected for our production is the traditional no bake sand molding. Our foundry on campus is very well equipped for this process. Through this process, a matchplate pattern was created with which to make copes and drags in order to set up the flaskless molds. The pattern was created via 3D printing the cope and drag side of the mold. The ingates, runners, and sprue well were all printed as one piece with the axes themselves, and holes were printed in so that alignment pins could be used to ensure the cope and drag met up exactly. Before the 3D printed pattern was attached to the matchplate, an acrylic grain filler was used in order to fill in the print lines, and the pattern was sanded until smooth. The risers and corebox were also 3D printed, and alignment holes were fitted so that the risers could be placed exactly where intended. Mold alignment pins were also fitted so that the sand molds could be exactly aligned. The pattern, risers, corebox, and sprue were coated using a clear pattern coating in order to avoid resin corrosion on the PLA plastic used to make the 3D print. The molds were washed using a zircon mold coating in order to improve surface finish and mold strength against the very high temperature steel. The zircon wash was suspended in 99% isopropyl alcohol and measured using a Baume gauge until a value of 65 (as recommended by our industry partner) was obtained. Cores were also dipped in the same zircon mold coating, sanded around the coreprint locations to ensure a tight fit, and set in place before closing and gluing the molds.



1. Matchplate pattern



2. Risers and sprue shown



3. Molds after being washed



4. Coating the pattern



5. Spraying on mold wash.

5160 spring steel was selected as our material of choice for this project. Our melting stock was partially purchased from McMaster-Carr, and partially leaf spring steel that was purchased from a junkyard. The leaf spring steel was tested for chemical composition in order to verify carbon content and alloy material concentration. A weighted average was taken, and very minimal adjustments were made during the melt in order to meet the specifications of 5160 steel. A small amount of aluminum was used just before tapping the furnace in order to deoxidize the steel, and an argon hose was placed on top of the furnace underneath a kale wool blanket in order to minimize gas pickup during melting. The furnace used was an Inductotherm VIP 125 induction unit, which is capable of melting about 250 pounds of steel. The total charge weight was about 160 lbs of steel, and our team was able to pour 3 molds, for 6 total castings made. The melt was superheated to 3175 °F in order to reduce the risk of misrunning defects, and the castings were poured. Preliminary chemical composition analysis was taken using a spectrometer during the melt, adjustments were made, and a final chemistry was taken (see tables below).



Meas.	C	Si	Mn	P	S	Cr	Mo
	%	%	%	%	%	%	%
	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
1	0.564	0.165	0.512	<0.00050	0.0146	0.771	0.0249
2	0.584	0.168	0.532	<0.00050	0.0179	0.792	0.0254
3	0.567	0.169	0.513	<0.00050	0.0152	0.780	0.0249
<x>	<b>0.572</b>	<b>0.168</b>	<b>0.519</b>	<b>&lt;0.00050</b>	<b>0.0159</b>	<b>0.781</b>	<b>0.0251</b>

### 6. Preliminary Chemistry

Meas.	C	Si	Mn	P	S	Cr	Mo
	%	%	%	%	%	%	%
	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
1	0.640	0.161	0.646	<0.00050	0.0081	0.776	0.0250
2	0.552	0.158	0.649	<0.00050	0.0134	0.782	0.0254
3	0.539	0.155	0.649	<0.00050	0.0110	0.771	0.0252
<x>	<b>0.577</b>	<b>0.158</b>	<b>0.648</b>	<b>&lt;0.00050</b>	<b>0.0109</b>	<b>0.776</b>	<b>0.0252</b>

### 7. Final Chemistry

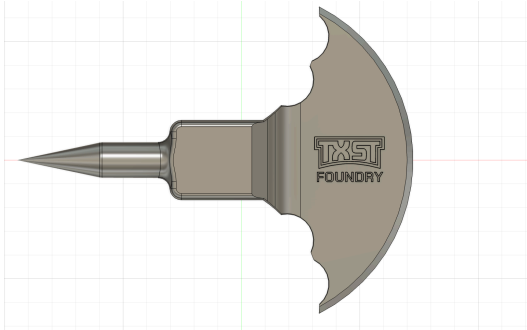
After the axe castings were solidified and removed from the mold, the ingates and risers were cut off, ground flat, and prepared for normalization. The castings were packed into stainless steel pouches and flushed with an inert atmosphere before normalization and quenching in order to counteract the decarburization of the surface layer, as well as limit scale formation. The axes were allowed to normalize in a 1580 °F furnace for 1 hour, and air cooled thereafter. After normalization, the rough edge profile was ground, and the axes were repacked in stainless steel pouches to prepare for austenization and quenching. The axes were austenitized at 1520 °F for 1 hour, and immediately quenched in water upon removal from the furnace. When removed from the furnace, the stainless steel pouch was quickly sliced open in order to get the castings in direct contact with the quenchant.

### Design Process:

The design was accomplished in three main phases: basic casting geometry and style, casting/gating and risering, and handle design. Our design went through many different iterations until the team came to an agreement on a final axe profile design. Sticking to our 16th century German Style inspiration, the decorative wings on either top and bottom of the axe were added. The tail spike was designed with a slight taper downwards from the middle line, allowing for greater accuracy when in use. From there, the Texas flag located on the middle section near the eye, and the Texas State logo on the cheeks of the axe were added. Fusion 360 CAD software was used in order to generate all design iterations, as well as design the gating system. Our design focused on castability, strength, and staying lightweight, all while still representing our creativity and school spirit. InspireCast simulations were run in many different phases of the design in order to determine our best possible outcome, and make adjustments to our gating and risering system. The figures below show several different iterations of the axe profile itself.



## Phase 1: Casting Geometry and Style



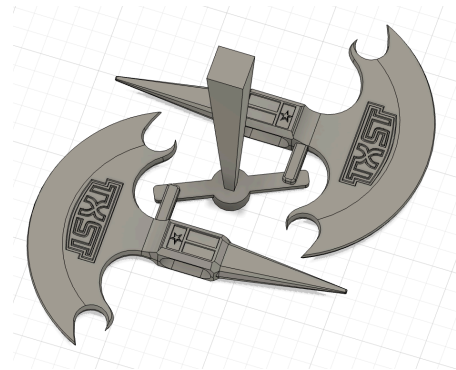
8. Preliminary design #1



9. Preliminary design #2



10. Agreed upon profile



11. Final design featuring the Texas flag

## Phase 2: Casting Simulations/Gating and Riser

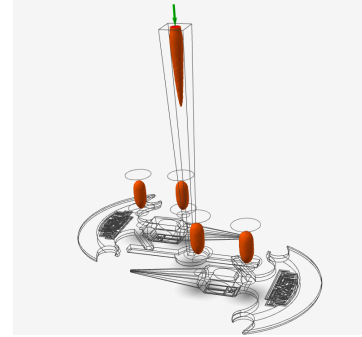
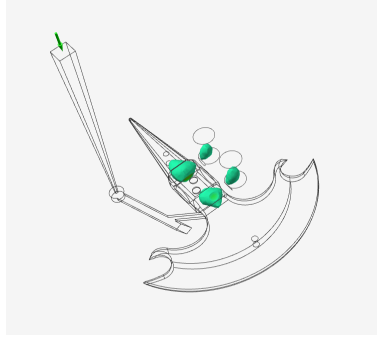
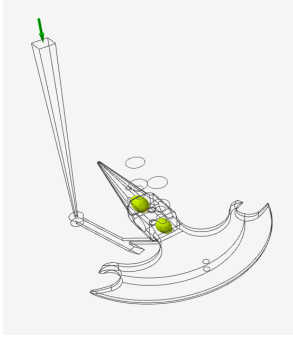
The casting design is related to the alloy being poured, so Altair InspireCast's high carbon alloy steel preset was utilized in order to run simulations. One ingate was selected after analysis of using a double ingate on the castings yielded no improvement. We expected to see shrinkage porosity in the thick section of the axe around where both the blade and spike meet the middle section, so risers were utilized in order to counteract the solidification shrinkage. The flasks utilized to make molds were 13in x 11in x 4 in. Fortunately, the flask size available allowed for 2 mold cavities per mold. We utilized a central pouring basin with sprue, runner, and ingate sizes that were designed to feed 2 castings per mold. A gating ratio of 1:6:4 was selected for our castings in order to have an unpressurized system where the sprue controls the flow of liquid metal into the mold. Side risers were also modeled in order to make the cleaning of the castings easier, but deemed ineffective at eliminating the porosity. Direct top risers were selected, since they counteracted the porosity most effectively.



12. First gating design iteration

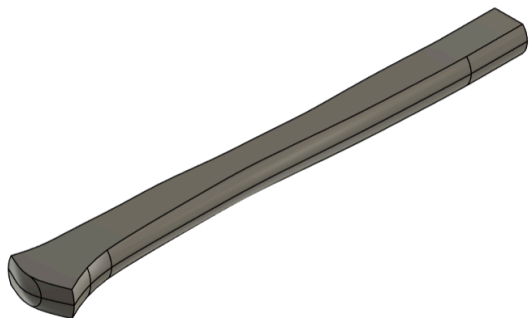
13. Using side risers

14. Final gating design

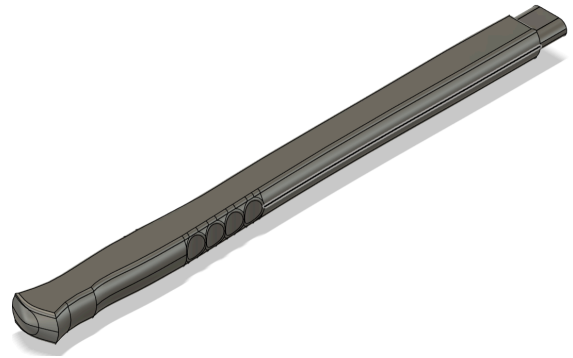


Phase 3: Handle design

Multiple handle designs were considered that ranged from historically accurate to modern. The final design is a mix of both, with finger grooves and semi-swept grips enhancing the usability. A custom brass Texas State Bobcat logo branding iron was also machined using a tabletop 4th axis CNC mill, and the handle was branded on both sides at the bottom to further showcase our school spirit. For the manufacturing of our handle, a ShopBot router was used with a 4th-axis rotary indexer to carve a 21 in long by 2 in diameter hickory dowel. After the handle was machined, sanded, and torched, 3 coats of linseed oil were applied to seal the wood. The handle was attached to the axe head using G-flex epoxy, a mahogany center wedge, and 2 brass cross wedges on either side of the center.



15. Initial handle design



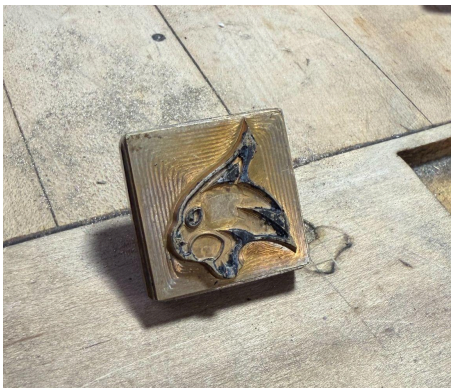
16. Finalized handle design with finger grooves added



*17. Roughing Pass*



*18. Finishing Pass*



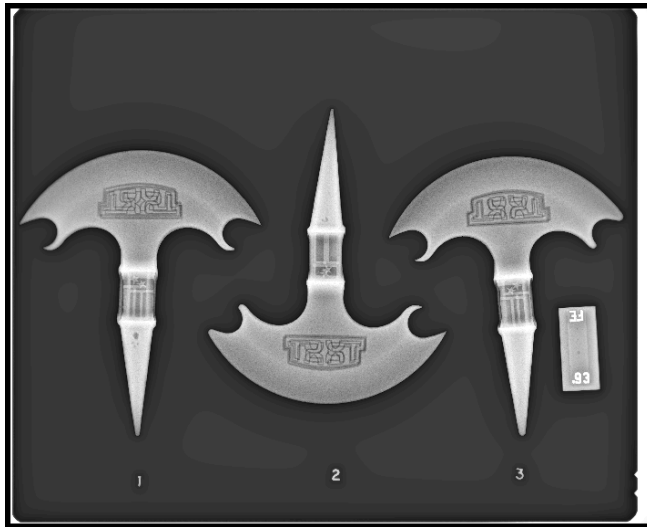
*19. Custom Bobcat branding iron*



*20. Torching the handle*

### **NDT and results:**

Three main methods of NDT were utilized in the inspection of our axes in order to verify their structural soundness. These methods include X-ray inspection, dye penetrant testing, and harness testing after the heat treatment. X-ray inspection and dye penetrant were achieved thanks to the Southwest Research Institute in San Antonio, Texas. Our X-ray shots indicated minimal porosity in areas that were expected. Weld repair was considered but ultimately decided against due to the risk of forming quench cracks, and the difference in hardenability of the stainless steel filler material with the high carbon base metal. The dye penetrant test revealed no cracking in our castings, ensuring the structural soundness of the axes. Minor surface porosity can be seen in areas that were expected upon visual inspection of the castings, however deemed not to affect the structural integrity or function of the piece. Hardness testing was completed after quenching on a rockwell hardness tester to validate the efficacy of the heat treatment. Hardness was measured at an average value of 58 RC after three readings, which was acceptable to us. The axes were then allowed to temper in a furnace at 500 °F for two hours in order to increase the toughness of the steel.



21. X ray shots of the castings



22 & 23. Dye penetrant testing



24: Hardness testing



### Final Results:

The total piece weighs in at 1.8 lbs, making it a light and fast sidearm piece, just as intended. The edge geometry selected was a relatively wide grind, maximizing the strength of the hardened edge while maintaining sharpness. The total length of the axe, from the top of the handle to the bottom, is just under 21 inches, making it suitable to have on a belt sheath like it would have been used in history, while comfortable to use.



*25: Finished Product*



### Acknowledgements:

Our sincerest gratitude extends to the professionals and educators that have assisted and advised us throughout this project. Without their guidance, professional experience, and immense knowledge, we would certainly not have accomplished our goals.

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