SFSA Cast in Steel 2025 Technical Report: Alte Presentation Broadsword

Pittsburg State University – Silverback Swords

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Executive Summary

The SFSA Cast in Steel competition of 2025 is in honor of George Washington and his armory of swords. Students form universities around the world will compete to create a replica sword, or one inspired by George Washingtons swords. These swords will be made using casting processes and must be able to withstand a battery of trials in competition.

This report details the Silverback Swords design process, choosing and modeling a sword, the process of casting the blade, and the associated challenges and solutions with the project. The team chose the Alte Presentation Broadsword in September of 2024, and immediately began modeling the blade, hilt and associated components in SolidWorks. From there pattern and gating models were created and refined in MAGMASOFT. In January 2025 the hilt component patterns were sent to Dal-Air Investment Castings, out of Point Texas, where they were cast in bronze, and returned in February. Shortly thereafter in February of 2025 the final blade pours were done with Monett Metals, out of Monett Missouri, after serval fast passed pattern design changes were made. The month between pouring and March 21, 2025, was spent shaping, refining, and heat treating the blade. Final blade etchings and assembly were applied in Brilliance Laser Inks, after the blade was sharpened to perfection.

The Silverback Swords team representing Pittsburg State University is proud to present their finished cast replica of the Alte Presentation Broadsword at the 2025 SFSA Cast in Steel competition in Atlanta GA, in April of 2025.

Problem Statement

The Steel Founder's Society of America (SFSA) has tasked university students to produce functional steel cast items that are traditionally made with forged processes since 2019 through their Cast in Steel competition. This year, the SFSA has challenged university students to make a replica of one of George Washingtons swords. The team's sword will need to be capable of withstanding expected use cases such as slashing and piercing strikes, along with unexpected use cases. In addition, students will face many challenges in adapting the traditional sword smithing process, particularly in design, process, and safety.

The blade must be designed with such casting challenges in mind as, misruns, heat tears and porosity. Misruns and heat tears are both results of the casting process favoring a high volume to surface area ratio. Unfortunately, in the case of a long thin object, such as a sword, which has a relatively high surface area to volume, cold shuts, a variety of miss run, where the material solidifies before it can fill the mold is a likely occurrence. Tearing in the metal as it cools unevenly, or heat tearing is common in areas around risers which are designed to feed metal into the mold as the material cools. Finally, probably the most dangerous of the challenges of casting is porosity, or air pockets in the casting, can't be easily identified if it is under the surface of the blade. These air pockets cause weak points in the blades structure that could be the difference between a functional sword, and a sharp projectile when struck.

To start it is important to understand the traditional process for sword smithing. The forging process for a sword starts with a portion of the desired stock metal that is heated to a malleable temperature, typically when the material has a yellow appearance. The metal is shaped through repeated hammer strikes and reheated to maintain malleability. The compressive forces in forging eliminate any porosity that may have been present in the original stock. Once the blade is roughly shaped, it is heated to its non-magnetic temperature then left to cool at room temperature. This step will be repeated twice more before the blade goes through a reductive process of sanding and shaping to achieve its final shape. After this, the blade is reheated and quenched in a bath, typically with oil but sometimes with water. Quenching hardens the material in the blade, giving it significantly more strength. At this point the blade is very hard, but is also holding a lot of internal stress, so the blade will be slowly and gently heated to relax the stresses and remove a significant amount of brittleness.

In the case of casting a sword, a pattern needs to be made for which a mold is formed. This will make a cavity to fill with molten metal of a chosen alloy. Molten metal shrinks as it solidifies and cools down, so the patterns used would need to be scaled up depending on the shrink rate of the metal that would be used. This extra space accounts for shrinkage, allowing the metal to fill the mold then shrink to the designed shape. Once the casting has cooled to room temperature, it needs to be broken out of the mold to remove the gating. With the gating removed, the casting will go through reductive process similar to forging where the blade is ground and shaped to its final dimensions before being heat treated. The heat treatment will facilitate the balance of toughness, hardness, and tensile strength that the sword requires.

This competition was intentionally designed with as few constraints as possible to allow for as much creativity as students can come up with, so the minimum requirements they put forth are as follows:

- Secure an industrial partner familiar with steel castings.
- The sword's overall maximum length cannot exceed 1.09m (43 inches).
- The sword's overall Maximum weight cannot exceed 2kg (4.4 pounds).
- The length of the sword and blade respectively must be within 2 inches of the original sword.
- Create a single edged replica (ruling out the small swords) that either match the replicas within a tolerance of 2 inches, or produce an original sword that would be in the style and appropriate for Washington (with an explanation and defense of the design in the technical report) that is more than 25 inches long overall with at least 20 inches of blade length and less than 43 inches overall with a maximum blade length of 35 inches.

(SFSA Cast in Steel, 2025)

Initialization

With the constraints of the competition established, the team acquired the book *The Swords of George Washington* (Goldstein, Mowbray, Hendelson, 2016) and compared the various swords George Washington had in his collection to determine which ones had the necessary qualifications. After some deliberation on the qualifiers, the team considered three different swords: The Silver Lion-Headed Cuttoe, the Bailey Silver & Ivory-Hilted Cuttoe, and the Alte Presentation Broadsword. With the creative freedom allowed for sword designs, the team considered the Silver Lion-Headed Cuttoe thinking to make a "Gorilla-headed Cuttoe" instead, to represent Pittsburg State University. The sword was not chosen, however, because of the concern for the thinned cross section along the fuller of the blade. The tooling needed for the pommel would also be especially complex for the tools available to them. The Bailey Silver & Ivory Cuttoe was almost chosen for its aesthetics and historical presence. However, just like the Silver Lion-Headed Cuttoe, the team was concerned about the fuller reducing the thickness of the cross-section, as well as their abilities to replicate the handle's design, and the tang construction. The sword was ultimately not chosen, which leaves the Alte Presentation Broadsword. It does not have a fuller, allowing for a thicker cross-section, and it has a handle the team was confident in replicating.

The Alte Presentation Broadsword has a mysterious history. The sword was crafted by Theophilus Alte in 1975, in the sword making center of Solingen, Prussia. According to a letter received by George Washinton after it happened to be found in a pawn shop in Alexandria, some nine miles from his home in Mount Vernon, it was sent to George Washington with Theophilus's son, Daniel, whose whereabouts are still unknown (Explore the Museum Collections, 2025).

Most of George Washington's swords were designed for slashing or piercing, as seen with the Bailey Silver & Ivory Cuttoe, and the Silver Lion-Headed Cuttoe. The Alte Presentation Broadsword was different, however. This sword was unwieldy, and George Washington never wore it, as it was more of a curiosity to him than a functional sword to be used. As its name entails, it was meant to be a presentable art piece of a sword instead of a practical one. With the intent to produce a functioning replica for the competition, the team opted to redesign the sword to match their needs while keeping the features as identical as possible to the original. According to the Mount Vernon Ladies Association, the Alte Presentation Broadsword has a cross guard that was cast integrally with the knucklebow, and the pommel & backstrap were also cast as a separate, singular component, which holds the leather & wire-wrapped handle to the cross guard with a metal ferrule ("George Washingtons Mount Vernon," 2025). While not mentioned in Mount Vernon's description, their images of the handle appear to suggest the knucklebow and pommel were joined together from a forge weld. Refer to Figure 1.1 below.

Figure 1.1: Images (A, B, and C) of the original Alte Presentation Broadsword depicting the decorative engravings of the blade and the ornate design of the hilt. Theophilus Alte. (1975). Alte Presentation Broadsword. Mount Vernon, VA

1.1(A)

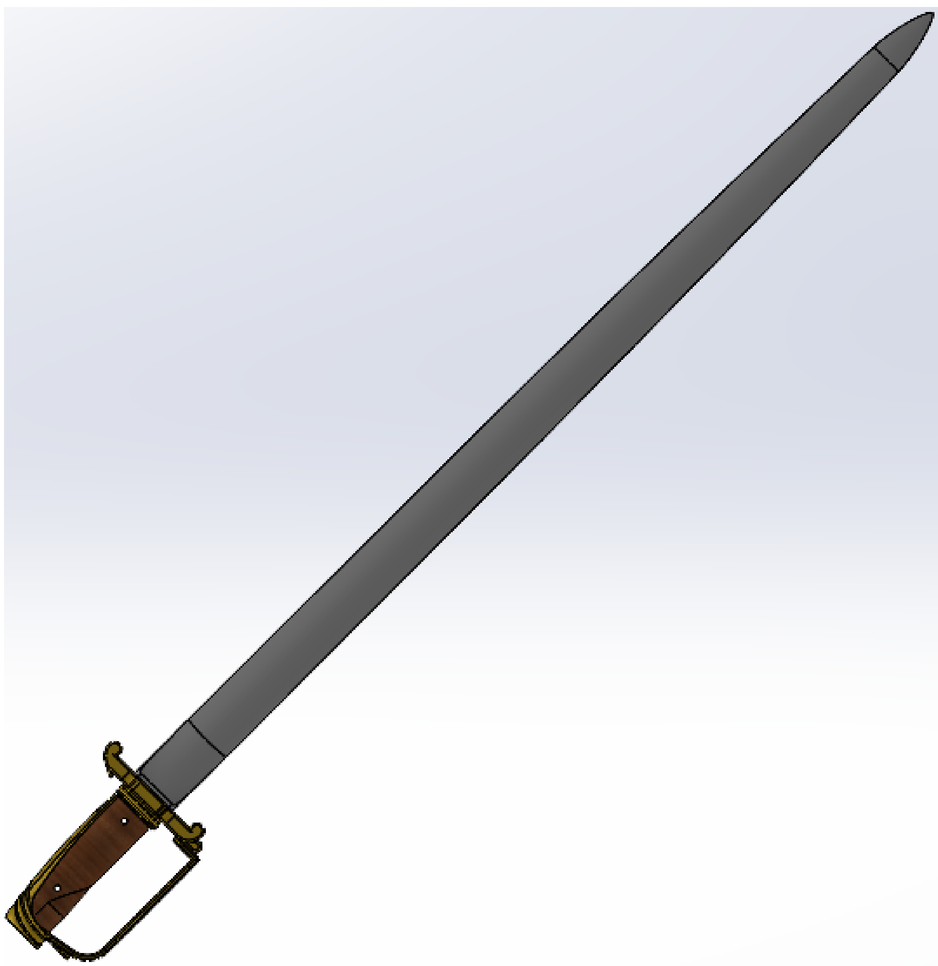
1.1(B)

1.1(C)

This blade is known as a “Horseman's Broadsword” (George Washingtons Mount Vernin (2025), designed such that the weight of the blade is used to create a forceful impact as part of the cutting swing. According to Matt Easton, from the YouTube channel *scholagladiatoria*, swords designed for chopping swings tend to have a point of balance further from the cross guard than other swords. He continued, saying such a sword would have a point of balance about 6” to 8” from the face of the cross guard (Easton, 2023). Since the Alte Presentation Broadsword is a heavy, chopping blade, the optimal point of balance would be 7” plus or minus 1”.

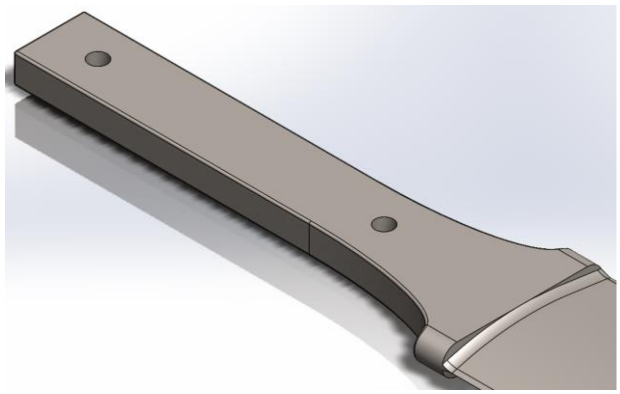
Modeling

Figure 1.2: A CAD model of the fully assembled sword using components with basic geometries. This model excludes the pins that would hold the grip together, the leather and wire wrap that would go around the handle, and the engraving detail on the blade.



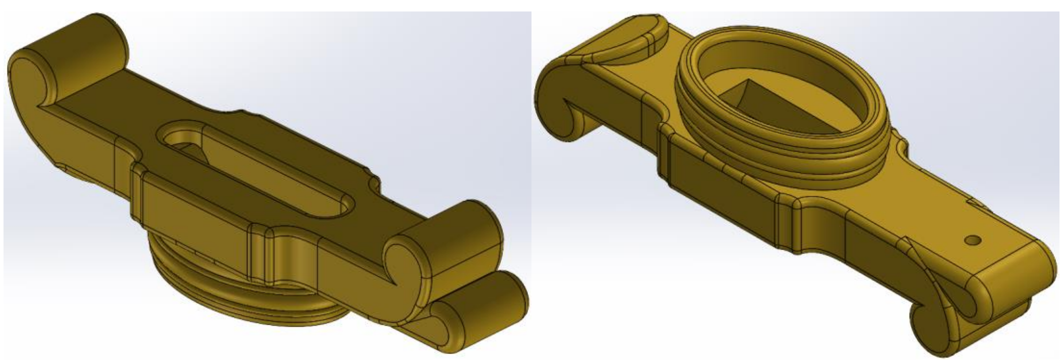
Above is a 3D model of an assembly with the basic geometries of the sword, provided to give visual to the design. The other excluded features of the sword will be addressed with greater detail below. With the technology and processes available to them, the team decided on the sand mold method for the casting of the blade for their replica. The sand mold method was chosen because it would allow for multiple molds to be produced with a modifiable core box, expecting changes would need to be made during prototyping. The team's partner foundry, Monett Metals of Monett Missouri, primarily produces bonded sand molds, which was also a contributing factor to the team's decision. There would then be two holes drilled into the tang post-cast to pin everything together. Refer to Figure 2.2 below.

Figure 2.2: A screenshot meant to better illustrate the features of the tang and the neck that transitions into the blade.



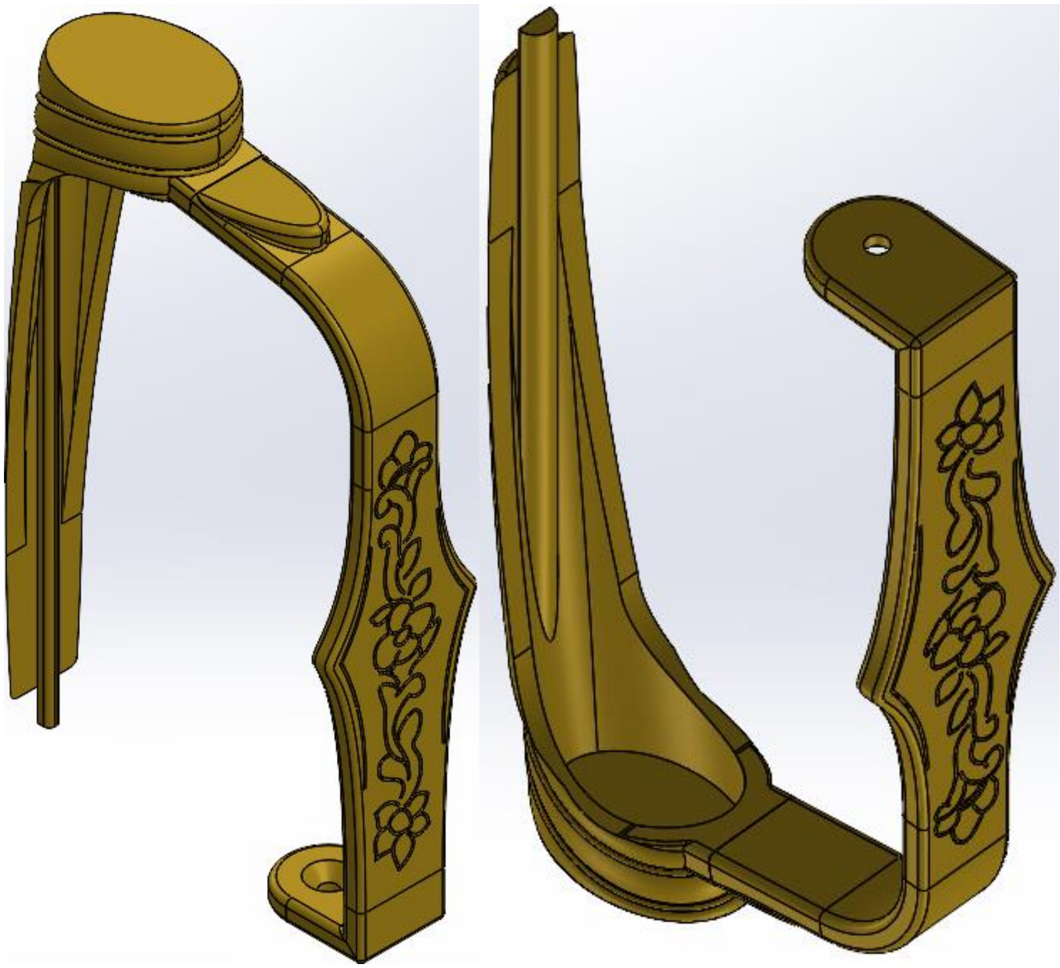
The engravings would not be applied to the blade as they were on the original. This is to preserve the structural integrity of the blade by reducing potential stress risers and to better keep track of the point of balance for the duration of modeling. The tooling needed for such a precise operation on a contoured surface would also be cost prohibitive. Instead, the engraving detail would be applied with a coating that will get burned on by a CO2 laser engraver. The blade would be cast with 5160 alloy steel, then put through a heat treatment.

Figure 2.3: A & B images of the cross guard (referred to as Casting A) in an upright and upside-down orientation.



2.2(A) 2.2(B)

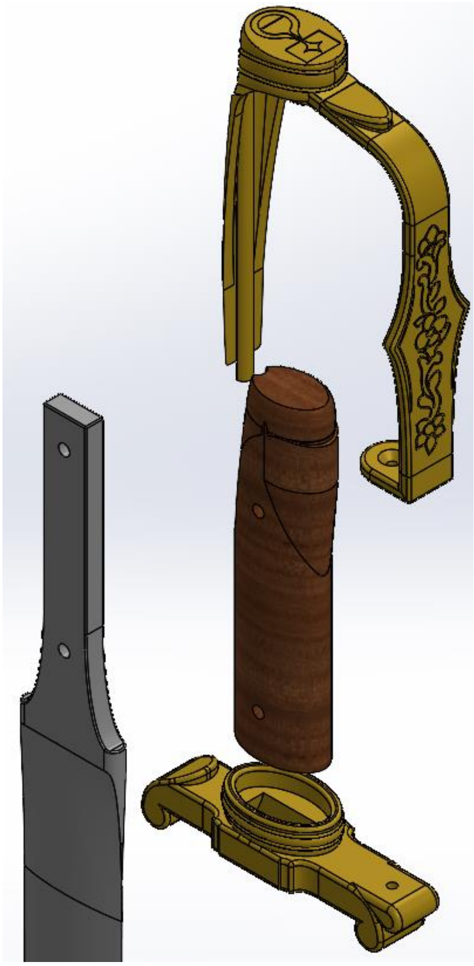
Figure 2.4: A & B images of the model with the pommel, knucklebow, and backstrap (referred to as Casting B) in an upright and upside-down orientation.



2.4(A) 2.4(B)

Excluding the handle, the hilt would be cast as two separate components through investment casting; The cross guard with its ferrule in one casting, then the pommel, backstrap, and knucklebow in the other casting. Refer to Figure 2.3 and Figure 2.4 above. Below, Figure 2.1 provides a close-up of the individual components that would make the hilt. Casting A and Casting B would be made of a CDA875 brass alloy which is cheaper than the gold castings of the original Alte Presentation Broadsword. This is the primary brass alloy that Dal-Air uses, which is why it was chosen for our components.

Figure 2.1: A screenshot of an exploded assembly view from SolidWorks to provide a visual of how the pieces come together. The "Pitt" font is not included on this model as it was added to the model as late addition to the team's replicant sword.



The pommel, knucklebow, and cross guard would each be engraved post-cast. The cross-guard center faces would have the signature "*Pitt*" font engraved onto it to represent the team's university and the pommel would have the SFSA logo engraved onto it to represent the momentous opportunity the Cast in Steel competition provides to students. Neither feature provides authenticity, but the knucklebow would have the floral pattern engraved onto it which is identical to the original and provides the authentic factor the previously mentioned features lack. The handle will be 3D printed for easy rapid prototyping throughout the project and while the model of the handle seen above has a wooden appearance, it is only to reflect the brown colored leather that would be wrapped around a 3D printed handle bound with a spiral wound metallic wire akin to the original design. Using a 3D print instead of a wooden handle, the design of the handle's shape and appearance still remains identical to the original, retaining the authenticity factor. Below, Figure 1.3 provides a visual of the first prototype handle with leather and wire wrapped around it.

Figure 1.3: First assembled prototype which includes the leather & wire wrap concept but still excludes the markings originally depicted on the blade of the Alte Presentation Broadsword.

For assembly, the cross guard (Casting A) would first be placed up against the contours of the tang, which should match that of the cross guard. The handle, 3D printed in two halves, would then be pushed into the ferrule of the cross guard and align with the holes of the tang on both sides. Refer to Figure 2.5A below.

Figure 2.5: A & B images depicting the handle of the sword, which was derived using the cavity function within SolidWorks.

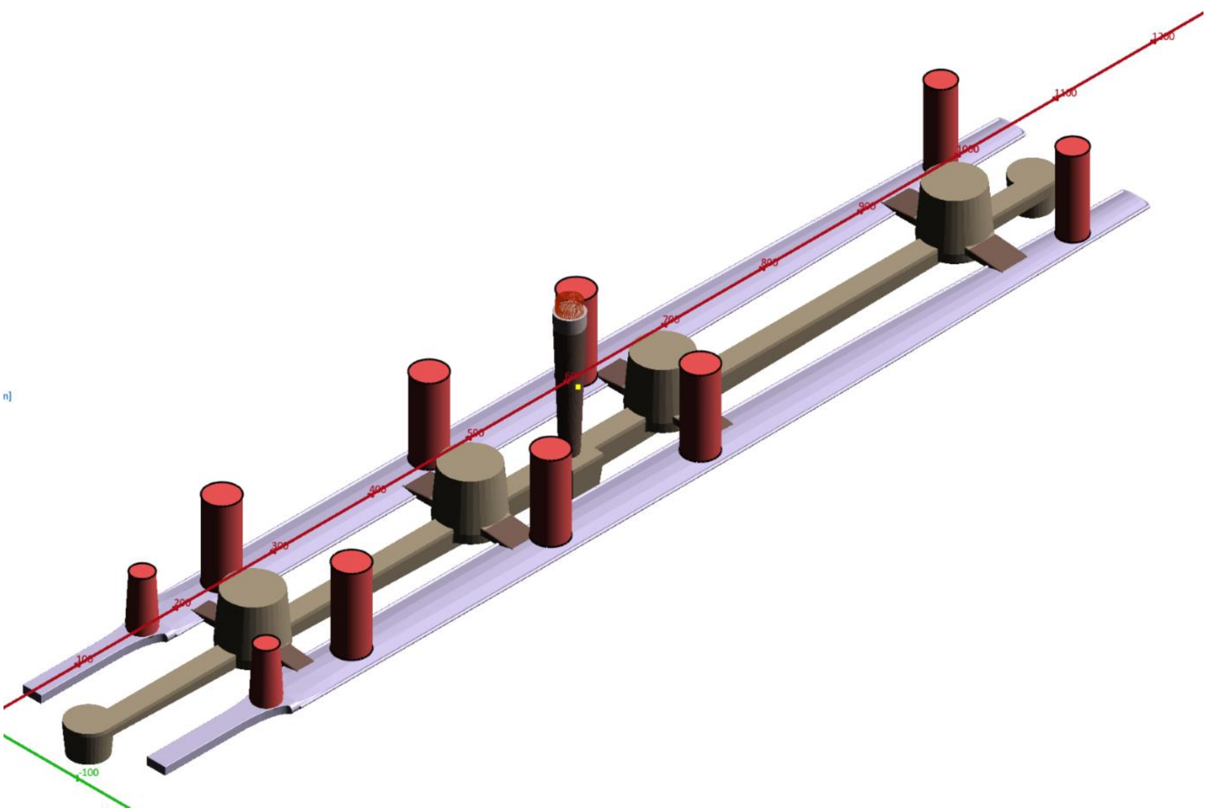
2.5(A) 2.5(B)

Once the handle halves are in place, roll pins would be pressed through the holes to secure Casting A and the handle to the tang. With the handle secured around the tang, the leather and wire wrap would be applied next. The backstrap on Casting B would then align with the groove along handle seen in Figure 2.5B above as it slides into the gap in the ferrule of Casting A. The pommel on Casting B should fit around the end of the handle at the same time, then the knucklebow would be secured to Casting A with a set screw, fully securing all components of the sword.

Simulations

Before modeling the gating system, the team used the American Foundry Society (AFS) gating calculator to determine a few basic dimensions for critical features in the gating system. This included the top and bottom diameters of the sprue, sprue height, then the height & width of the runner and gates. The calculations were based on a given number of castings at an estimated weight. These calculated values gave the team a baseline or "ground zero" to start with. The team went through several iterations of MAGMASOFT simulation until their designs started showing porosity results within the blade under 15%, which was a target value suggested by their professors. The first gating design the team was confident in can be seen in Figure 3.1 below.

Figure 3.1: An image depicting the first gating system that yielded promising results within the mentioned tolerance of 15% porosity.



Risers were placed near each outlet to improve feeding into the blades and hot risers were added to the runner between the outlets to encourage the metal to cool evenly. The tips of the blades were remodeled with a consistent thickness and cross section to improve filling & solidification. This design yielded no porosity at or above 15%, which meets the team's requirements. Refer to Figure 3.2 below.

Figure 3.2: An image depicting porosity results from a MAGMA simulation for the first core box sent to Monett. As seen in the image, there is no porosity within the blade that exceeds 15%, which is a critical factor for ensuring sufficient soundness of the casting.

Tooling & Casting Production with Monett Metals

Monett Metals is the partner foundry the team will be working with during is phase of the project. Below are Figure 3.3 and Figure 3.4, which represents a 3D model of a cope & drag style core box design. The team worked with Nathun Manuth of the wood tech department, who is now an alumnus, to produce the two frames for the core box. Nathan won last year's competition with his Halligan bar, so the team was able to get some insights on what to expect from the testing to be conducted for this year's competition.

Figure 3.3: An image depicting the cope half of the initial core box design with a portion of the cope walls silhouetted for a better view of the layout.

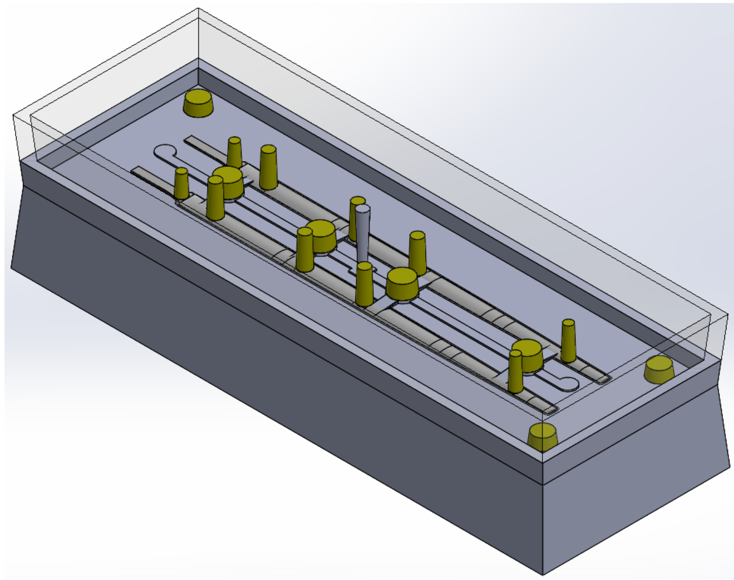
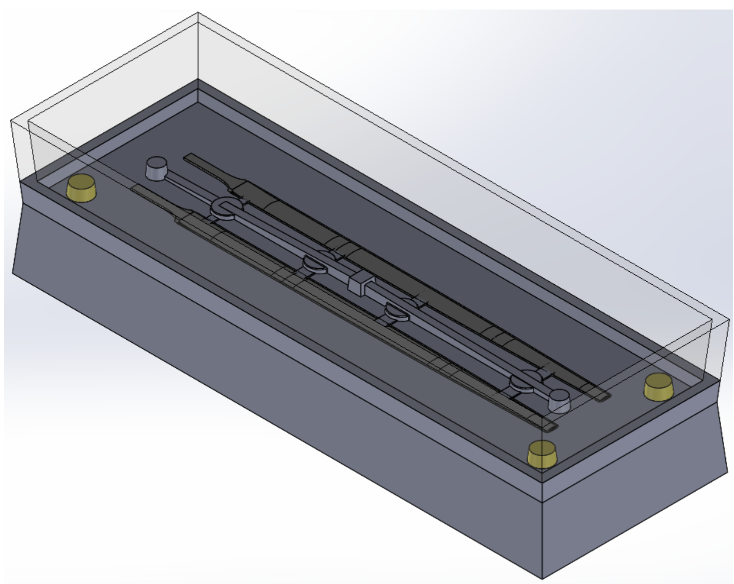


Figure 3.4: An image depicting the drag half of the initial core box design with a portion of the drag walls silhouetted for a better view of the layout.



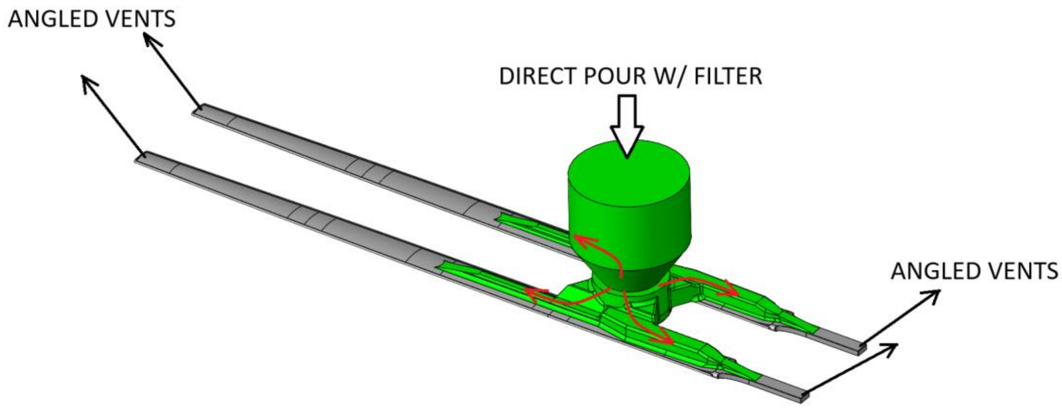
Meanwhile, the pattern was being 3D printed in sections to be assembled on the core box. Pin holes were included in the core box design to allow for efficient construction, and reconstruction of the pattern. Recessed slots were also included in the 3D patterns to accommodate for the risers that needed to be placed on the pattern. Once the pattern was fully assembled, bondo was applied to fill any gaps and then sanded down to smooth out the rough surfaces before being handed to Monett Metals for a test pour. The team was not expecting a perfect casting since the MAGMA simulations were focused on porosity and solidification, but the castings produced with the initial gating design came out of the mold with defects that were not considered when designing the gating. Below are the results of the test pour done with the core box the team provided to Monett Metals.

Figure 3.5: An image of the resulting pour using the first core box sent to Monett. The casting is upside down since the majority of the weight is from the pouring basin Monett added to their mold before pouring. Notice the blade to the left encountered a misrun.

Figure 3.6: The same image as in figure 3.5 but zoomed in to provide a better visual of the resulting pour using the first core box sent to Monett. Notice the heat tears near the runner outlets.

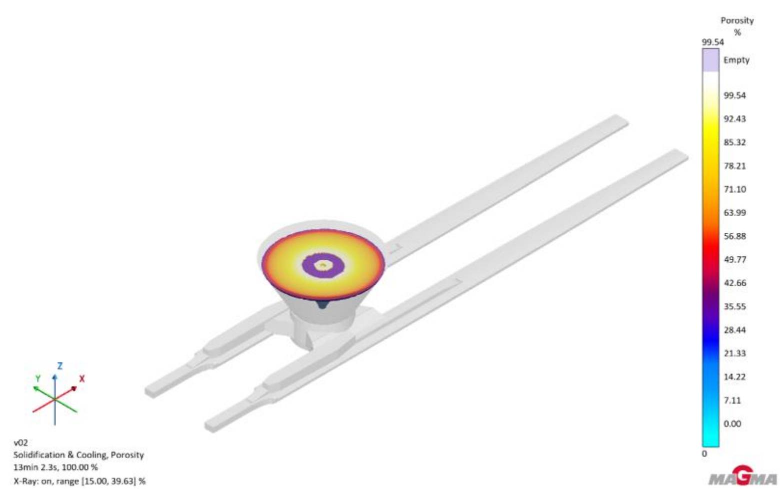
The mold didn’t fully fill, and the molten metal encountered a cold shut. According to Monett Metals, this was likely due to the small size of the sprue in proportion to the mold. Additionally, heat tears are present near the outlets. Their assessment informed the team that the heat tears were due to the hot risers in the gating system. The hot tears kept the outlets of the runner hotter for longer, as intended, but it also caused the metal to cool in opposite directions which made the metal pull itself apart. Below, Figure 4.1 represents the revised gating system Monett Metals provided to the team.

Figure 4.1: An image depicting Monett Metals' revision of the gating system



Their approach was much simpler in design than the initial gating system. They did not have the MAGMASOFT simulating software, but they had something with similar capabilities which they used to run their own simulations. According to their simulations, the vents and significantly larger sprue will allow for proper filling while also encouraging the metal to cool at the outer edges first. The ribs of the gating system should also reduce the likelihood of heat tears. They also recommended the team to make the blade pattern thicker to increase the success rate of the pours. The post processing phase would be extended as the blades will require additional machining to remove the ribs and extra layers of material. They also provided a SolidWorks model of the revised gating system so the team can run their own simulations with MAGMASOFT for reference (See Figure 4.2 below) and to print & install the new pattern.

Figure 4.2: An image depicting MAGMASOFT simulation results for the revised gating design.



Below is Figure 4.3 and Figure 4.4, which represents a 3D model of the revised cope & drag style core box design.

Figure 4.3: An image depicting the cope half of the new core box design following the results of a test pour at Monett with the first core box design.

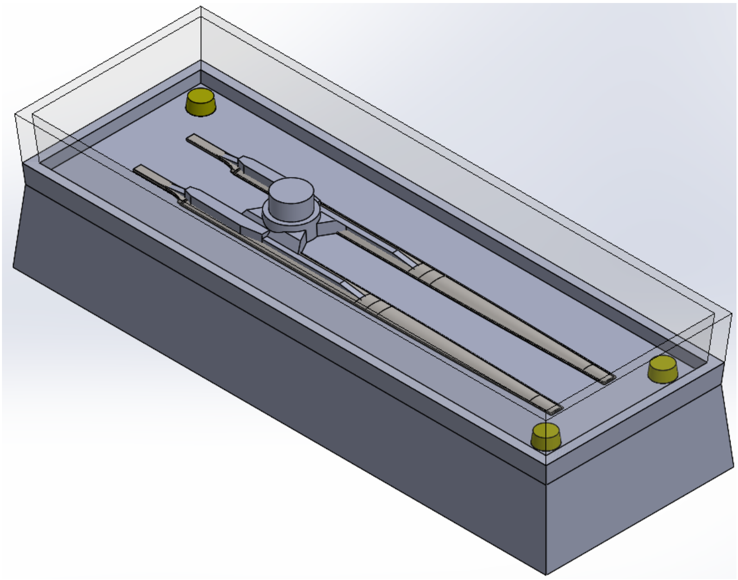
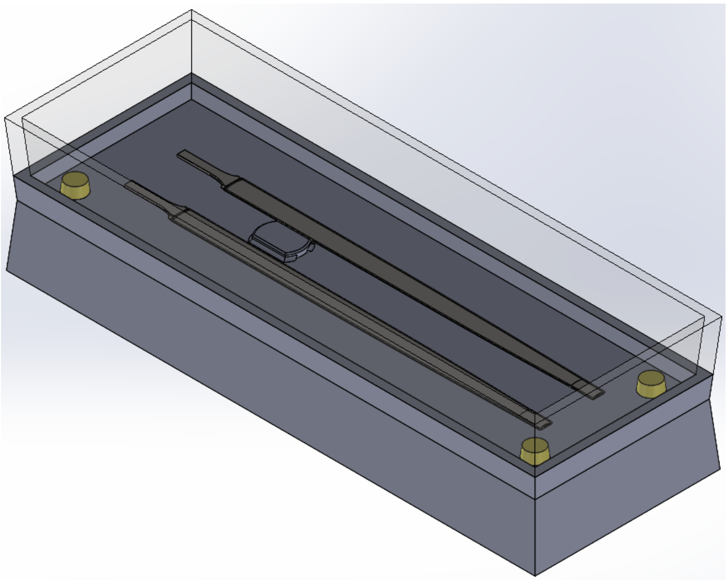


Figure 4.4: An image depicting the drag half of the new core box design following the results of a test pour at Monett with the first core box design.



Once Monett Metals received the revised core box design, they did a test pour and both blades within the casting appeared to form with little to no defects. As requested, they poured 5 more molds to give the team a total of 12 blades to work with. Only 4 of the 12 blades were unusable, where 5 blades had minor defects from faulty tip fill to heat tears small enough to fix with a weld, and 3 blades had no visible defects.

Tooling & Casting Production with Dal-Air

Dal-Air is not a partner foundry that works with SFSA, but they were an integral part producing quality castings of the cross guard (Casting A) and the pommel, knucklebow, and backstrap (Casting B). A member of the Silverback Swords team used to work at Dal-Air for an internship, and they were able to get in contact with the company to request their knowledge and processes to get Casting A and Casting B produced through investment casting. Wax injection tooling was made for both Casting A and Casting B, which is seen in Figure 5.1 and 6.1.

Figure 5.1: A wax injection die designed with cores to produce wax patterns of Casting A.

Figure 6.1: Pommel & knucklebow wax injection die

After contacting Dal-Air and showing the engineer there the 3D models of castings A and B they responded with the tree templates that would likely be used. Wax injection tooling was manufactured based on the advice from the engineer, then the wax patterns were made and sent to the foundry for them to tree up and cast. Below

Figure 5.2: A, B, & C images of Casting A molds as it progresses through the investment casting process.

5.2(A) 5.2(B) 5.2(C)

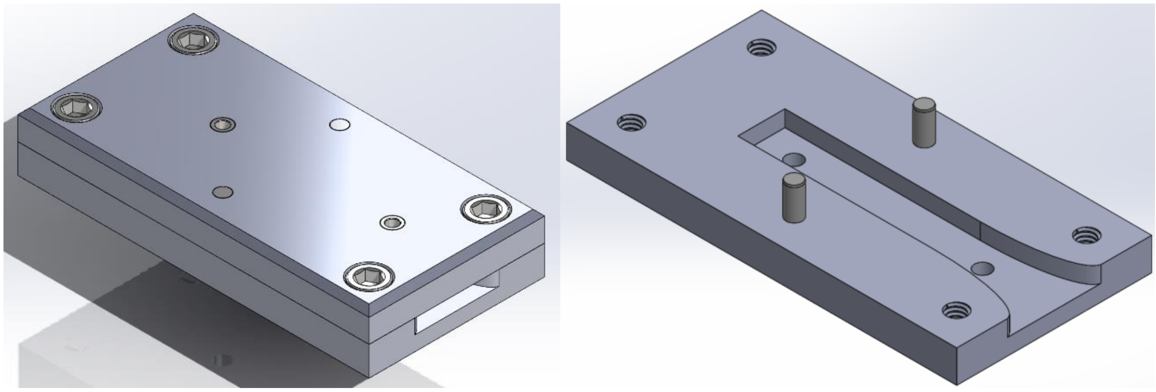
Figure 6.2: Images of Casting B molds as it progresses through the investment casting process.

6.2(A) 6.2(B) 6.2(C)

Post Processing

Due to the changes that needed to be made to the design of the blade molds, the team had a lot of grinding to do. It was a huge setback as it required 2 of the 5 members to continuously grind the blades down to the designed shape. The tang of each of the blades were fitted into the jig shown in Figure 7.1 like a go-no-go fixture until the tang fits the fixture. Once the tang was the right size, the jig would secure the tang in place as the 2 holes were drilled with the bushings in the jig.

Figure 7.1: A & B images of a jig that clamps around the tang for a drill press drill the 2 holes needed to pin everything together.



7.1(A) 7.1(B)

Once the tang holes were drilled, the blades were mounted onto the grinding fixture, which was designed to aid in the grinding process, helping to produce a consistent surface finish. Refer to Figure 7.2 below.

Figure 7.2: Blade grinding fixture

The blades were then ground down to shape with a sufficient weight but not exceeding 3 pounds (because the handle with its leather and wire weighs about 1.15 pounds). Upon reaching an ideal shape, the blades were then sanded by hand to smooth out the remaining rough patches. When the blades were at the desired shape, they were sent to Trojan to get their heat treatment. The heat treatment would consist of heating the blade to 1580 degrees Fahrenheit, quenching in oil to 160 degrees Fahrenheit, then tempering it twice at 500 degrees Fahrenheit to achieve around 51 Rockwell C.

At the same time, Casting A and Casting B needed to be engraved. Fixtures were made to accommodate for the various part orientations of each engraving project. Refer to Figure 5.4, Figure 6.4, and Figure 6.5 below.

Figure 5.3: Casting A fixture for the "*Pitt*" engraving operation.

Figure 5.4: Finished product of Casting A with the designed engravings and shiny polish.

Figure 6.3: Casting B fixture for the floral engraving operation on the knucklebow.

Figure 6.4: Casting B fixture for the SFSA engraving operation on the pommel.

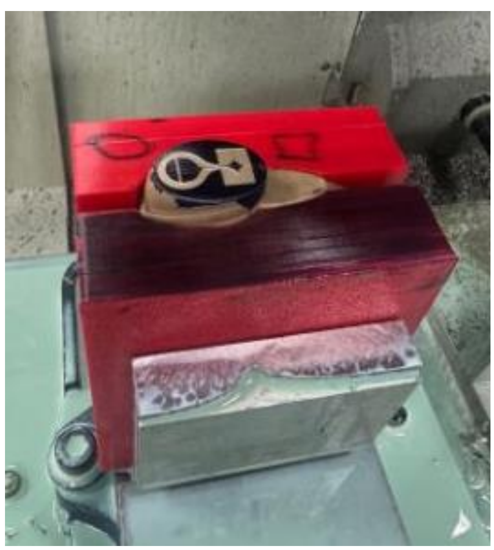


Figure 6.5: Finished product of Casting B with designed engravings and shiny polish.

Final Touches

The blades were then wet sanded to clean off the residue from and to start sharpening the hardened edge without heating the blade and ruining the heat treatment. To achieve the desired edge the blade was taken to a 120-grit wet sander at a roughly 25-degree angle. After the wed sander an A100 Trizac belt was used to hone the edge, and a red Scotch Brite belt was used to begin the deburring process. The deburring process was finalized using a strip of leather to finalize honing the edge. Once the blades were sharp enough to cut taught paper just by its own weight, the blades were then cleaned and polished to prepare for the final feature that provides the authenticity factor. Refer to Figure 7.3 below.

Figure 7.3: A & B images from a demo run of the blade’s engraving details with a CO2 laser on masonite.

7.3(A) 7.3(B)

The images in Figure 7.3 showcase the general design of the engravings, which are identical to the original design with the exception to it being an actual engraving. The team chose not to engrave the markings into the blade because they were concerned the large quantity of engravings across the blade would create stress risers that could negatively impact the functionality of their replica. The idea of designing the engraving details to be cast in was considered, but the details are so fine that the blade would need to be cast through investment casting purposes. Since the Senior Project of Pittsburg State required a manufacturing process that allowed for mass production of the sword, investment casting the sword would be impractical. The team still wanted to get the details on the blade though, so it was decided that the engraving details would be implemented as laser markings using the CO2 laser the team has access to. With an even coat of “Brilliance Laser Inks” the engraving decorations of the blade can be laser marked onto the replica with precision detail. This laser marking is akin to embossing and it does not come even when a sharp knife is used in an attempt to scratch it off. There was no gold color to purchase, so the team acquired a black metal color and red metal color with a copper tone. The red metal color with a copper tone had a similar color to the originally guilted engravings, but that spray was meant to be used on stainless steels, so the black metal spray was the only option to put the engraving detail on the sword.

Figure 7.4: Demo runs of the blade’s engravings with a CO2 laser on a test sword. Two colors of *Brilliance Laser Inks* spray were used as a medium for laser marking; black markings (A & B), and red copper markings (C & D).

7.4(A) 7.4(B) 7.4(C) 7.4(D)

Figure 7.5: A & B images of the finished blade with a sharp edge, shiny polish, and laser marked engravings on both sides of the blade.

7.5(A)

7.5(B)

Final Results

1) Secure an industrial partner familiar with steel castings
    a) Pittsburg State has a long-standing relationship with Monett Metals, and they were happy to participate in pouring the castings for this competition, fulfilling the above requirement.
2) The sword's overall maximum length cannot exceed 1.09m (43 inches)
    a) Refer to answer in prompt 4.
3) The sword's overall Maximum weight cannot exceed 2kg (4.4 pounds)
    a) The replica also weighs about 3.65 pounds, which satisfies the weight requirement.
4) Create a single edged replica (ruling out the small swords) that either match the replicas within a tolerance of 2 inches, or produce an original sword that would be in the style and appropriate for Washington (with an explanation and defense of the design in the technical report) that is more than 25 inches long overall with at least 20 inches of blade length and less than 43 inches overall with a maximum blade length of 35 inches.
    a) The Alte Presentation Broadsword is 39 3/8" overall with a blade of 33 1/2". The team's sword measures at 38 5/8" overall, which satisfies the 2" tolerance. Their blade length also satisfies the 2" tolerance, which is measured at 32 5/8". The original sword is also a double-edged blade, but the rules require a single-edged sword. SFSA provided a video which discussed various aspects of George Washington's swords and in that video, they provided clarification on the rule for the double-edged swords. They were asked if the double-edged swords needed to be redesigned to accommodate the rule and Raymond Monroe replied at time stamp 2:15, "Yeah, that's absolutely fine. The double-edge is fine." (Monroe,2025). The team interpreted this to mean their sword can be double-edged just like the original sword, which means their replica meets the requirements of the competition.

Thank You's and Honorable Mentions

Throughout the process of creating our sword for the Cast in Steel competition it would not have been possible without a group of industry sponsors and organizations that help us raise the funds to be able to participate. We would like to take the time to thank each one of them for the contributions they made to our project. The three companies who made project changing donations were Monett Metals of Monett, MO, Dal Air Investment Casting of Point, TX, and Trojan Heat Treat of Joplin, MO. We would not have a viable product to submit without these three companies. Monett Metals was our SFSA affiliated partner foundry who cast our blades, Dal Air Investment Casting cast all our high detail hilt components, and Trojan Heat Treat preformed the heat-treating process on our blades. The other companies that made major donations in the way of material donations or fund-raising events include Brason Pattern of Branson, MO, Changing Hands Book Store of Joplin, MO, Peerless Products of Fort Scott, KS, Matcor Metal Fabrication of Independance, KS, Acme Foundry of Coffeyville, KS, and Thomas Manufacturing of Girard, KS. All of the previously mentioned companies made donations in the way of materials for manufacturing tooling or hosting fundraising events. We would also like to extend a thank you to Aaron Sounder for donating a handmade knife that we were able to raffle off to raise project funds. Finally, we would like to extend a thank you to anyone else who made a greatly valued donation to this project. Without the efforts of all these companies and individuals, this project would not have been possible.

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