The Ohio State University
College of Engineering
Department of Materials Science and Engineering

SFSA Cast in Steel 2025
George Washington's Sword

Ohio State University – Brutal Brutus

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EXECUTIVE SUMMARY

George Washington's sword, the Bailey Silver and Ivory-Hilted Cuttoe, was acquired by Washington between 1778 and 1779 [1]. The sword was manufactured by John Bailey and was worn by Washington as his battle sword during the Revolutionary War. The sword is known for its silver-mounted cross guard and pommel and green ivory grip [2]. The sword is a traditional cuttoe with its curved profile and single edged blade. The Ohio State team's sword is a replica of the Bailey Silver and Ivory-Hilted Cuttoe. The sword has a long, curved, single edge blade, a red handle wrapped with silver, and a cross guard casted pictures of a buckeye leaf and Brutus the Buckeye in similar style to Bailey's designs.

The design process involved the selection of sword shapes and aesthetics, blade and hilt materials, processing and assembly methods. This involved extensive team brainstorming, drawing and CAD modeling of sword components. 15-5PH stainless steel was the blade material of choice to optimize hardness, toughness, heat-treatability and machinability. The blade was cast using chemically bonded sand, then heat treated to a H1050 temper. The cross guard was cast out of brass in green sand. The handle was turned from buckeye wood and wrapped with steel wire. The blade was ground and polished, and the hilt was assembled using pins, epoxy, and wire. The sword had a final length of 32 inches, width of 4 inches, and a weight of approximately 3 pounds, or 1.4 kilograms.

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INTRODUCTION

The following is an overview of the Brutal Brutus team's George Washington sword design and casting process, which was created for submission to Steel Founder Society of America (SFSA)'s Cast in Steel student competition. SFSA has created this competition to encourage students to learn about making steel products using the casting process and applying the latest technology available.

The prompt and objective of this year's competition is the design and production of a sword inspired by George Washington's swords, which he had custom crafted for him in the Revolutionary War era and notably wore into battle on several occasions [1]. The competition guidelines require student teams to make a sword that relies on cast components. Requirements for how much of the sword and what components must be cast are not quantitatively defined. Student teams are encouraged to take advantage of casting capabilities to improve the mechanical strengths of their submission and the efficiency of part production. Other quantitative limitations are outlined; the sword's length can be no longer than 43 inches, and it must weigh no more than 4.4 lbs. The quality of the team's sword will be judged by the historical accuracy and authenticity of its aesthetics, its performance in a series of destructive tests, and the merit of the design process.

In 2024, students at Ohio State designed and cast a Halligan bar for the Cast in Steel competition but struggled with materials selection and casting quality. Two attempts were made to cast a Halligan bar from D2 tool steel in 3D-printed sand molds. The first casting attempt experienced a critical misrun, resulting in an only partially formed bar. The second casting resulted in a fully formed bar with a hot tear, which is where brittle fracture occurred on impact during preliminary testing. The bar was submitted late with no heat treatment. It fractured during official competition testing due to the brittle, low-strength condition of the as-cast steel, and possibly major porosity. Last year, the team started project work late, did not readily seek industry assistance with heat treatment, and failed to create a realistic project timeline, let alone honor it.

Brutal Brutus approached this challenge with a desire to improve significantly from the failures of the Halligan bar project. They planned for major changes – such as starting the design process in the Fall semester instead of waiting until Spring, and obtaining industry help with the project through their local AFS regional chapter. They made a concentrated effort to improve and learn from the previous year's struggles in timeline management and resource acquisition. The minimum objective this year was to have an intact and aesthetically pleasing sword, project report, and video ready for submission by the deadline. Beyond this, the team aimed to have a justifiable materials selection and heat treatment process for the blade, as well as a plan for their use of resources and tools on and off campus to machine and craft the sword components.

PROCEDURE

The pattern was designed with a central runner with two sabers, one 3/8 inch thick and one ¼ inch thick. The swords were 32.5 inches long with a curved blade and a full width tang. Gates were 2.4 inches wide and tapered from 1.5 inches to ¼ inch in thickness toward the blade. Gates were spaced 2.75 inches apart for a total of 7 gates. The material chosen for the blade was 15-5PH stainless steel.

All runners and gating were 3D printed with PLA and mounted onto a ½ inch thick sheet of plywood. The mold was formed with chemically bonded sand and left to cure for 20 hours. Cross guard patterns were 3D printed with PLA and mounted on plywood. The molds were formed with green sand for immediate use.

The sword assembly was propped up on one end by 2 inches. The pour weight of the assembly was 70 pounds. The steel was poured at 2930 degrees Fahrenheit, and the pour time was 7 seconds. Once cooled, all gating was removed, and preliminary grinding was done. The sword was normalized at 1900 degrees Fahrenheit. Aging was conducted per H1050 temper specification for 4 hours with air cooling.

The cross-guard assembly pour weight was 3.5 pounds. The brass was poured at 1150 degrees Celsius. Once cooled, all gating was removed.

The sword was ground with 80, 120, 180, and 320 grit sandpaper and a compressed air angle die grinder. The blade was polished with a polishing wheel. The tang was cut to fit the cross guard. The cross guard was slid onto the tang and secured with epoxy. The hilt was carved from Buckeye wood and grooves were carved into the surface for wire affixation. The hilt was cut in half, stained with wood stain, and secured on the top and bottom sides of the tang with pins and epoxy. The hilt was wrapped with steel wire.

Casting simulation was performed with Magmasoft software at a temperature of 1600F to test for porosity and fill quality. Hardness tested was conducted immediately after casting, after heat treatment, and at completion. Weight of the sword was taken as cast, after preliminary grinding, post heat treatment, and at completion. Ultrasonic testing was conducted after heat treatment to test for predicted porosity from simulation.

RESULTS

The pattern for the swords was broken into multiple pieces for easy printing and assembly. Figure 1 shows the CAD models for the sword pattern.

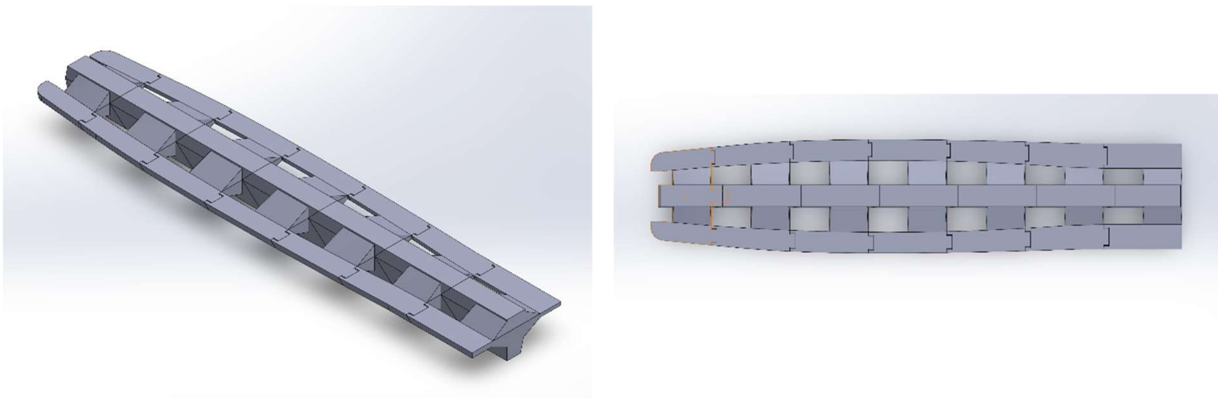

Figure 1 . Isometric and top views of the sword pattern assembly.

In Figure 2, the cross-guard faces are shown. One side depicts a buckeye leaf, and the other is an illustration of Brutus the Buckeye, the school mascot.

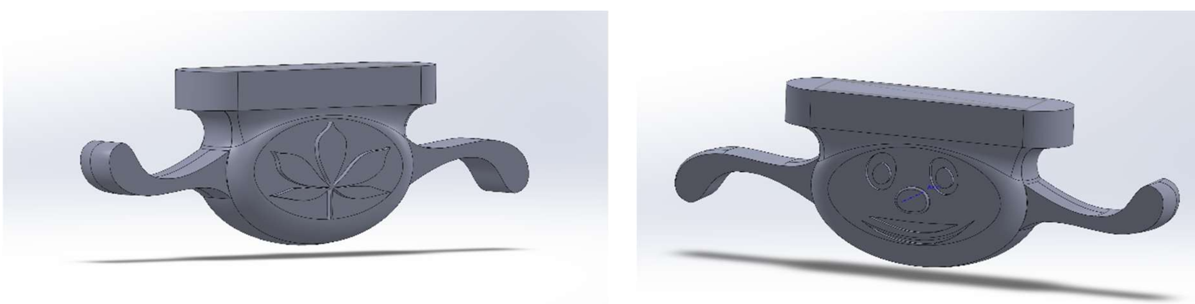

Figure 2. Face views of the preliminary cross guard CAD model showing a buckeye leaf and Brutus the Buckeye.

The original design of the hilt included a casted pommel piece. The grooves were carved to allow space for wire to be wrapped. In Figure 3, the original design of the hilt is shown.

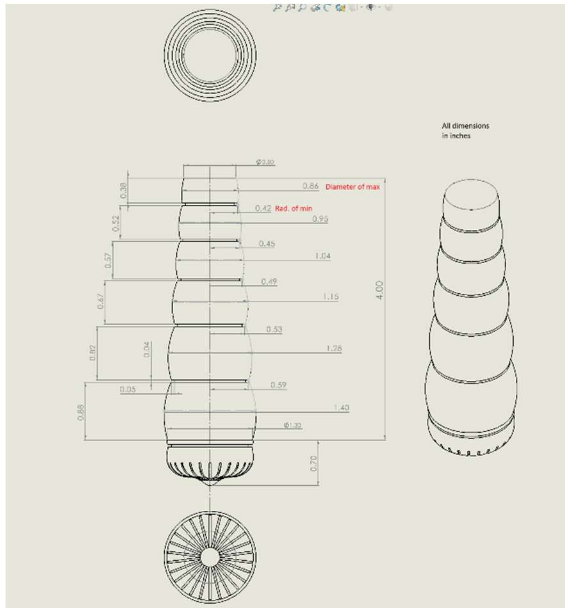

Figure 3. Design of the buckeye wood hilt.

In Figure 4, the prepared pattern and mold setup is shown. The pattern was coated for easy removal, and the red dots indicate locations of vents and/or risers. The sand was chemically bonded and compacted one day prior to casting.

Figure 4. Pattern and chemically bonded sand molds before casting.

The swords as cast are shown in Figure 5. The swords casted as predicted, and the excess material was machined off to expose potential defects.

Figure 5. As cast swords (left) and lightly machined cast product (right).

The sword was heat treated in an electric furnace. The sword was able to be heat treated in its entirety, allowing for consistency in mechanical properties.

Figure 6. Sword product in heat treatment furnace.

While casting the cross guard, the team encountered three difficulties. The primary power source for the induction furnaces was flooded and rendered unusable, causing the team to acquire a small electric furnace. During the first casting, the brass broke through the sidewall of the sand and leaked onto the floor. During the second attempt, the crucible was dropped, and it shattered and caused brass to spill onto the foundry floor, as shown in Figure 7.

Figure 7. Mishap with cross guard castings. Mold broke through the side (left) and brass spilled onto the foundry floor (right).

In Figure 8, the completed sword is shown. The sword was polished, and the cross guard and hilt were attached and secured.

Figure 88. Finished sword with polished blade, cross guard, and red stained and wire wrapped hilt.

The sword increased in hardness with heat treatment. The hardness data collected is shown in Table 1.

Table 1. Average hardness recorded of the sword throughout the manufacturing process.

Hardness (HRC)		
As Cast	Post Heat Treatment	At Completion
30.5	37	35

DISCUSSION

The team chose to cast the blade rather than forge a piece of bar stock steel to practice casting and to learn more about the casting and sword making processes. While swords are traditionally made through forging, the selected production method for the blades posed a more meaningful challenge relevant to metal casting.

The sword was molded and cast using chemically bonded sand rather than green sand due to its ability to maintain its shape while being time efficient and cost effective. Chemically bonded sand provided a better surface finish than green sand, saving the team time within the project. The sword was cast with the curve built in to lessen the amount of metal working necessary after casting.

Heat treatment was a necessary choice for the sword. It increased the hardness and improved the strength of the sword. The team chose a H1050 heat treatment based on information from data sheets of 15-5PH stainless steel and its comparative hardness and toughness across tempers.

A brass cross guard rather than aluminum was chosen to correct the balance of the sword. Brass is heavier than aluminum which caused a larger correction of the center of mass. The hilt was made from buckeye wood to decrease weight on the sword and to acknowledge the team’s origins. The wood was soft which allowed material to be easily shaped.

Before shipment, the sword was checked for hardness, porosity, weight, and sharpness. Hardness is indicative of strength and was used to verify the quality of the casting and heat treatment. Porosity was checked through ultrasonic testing and compared to simulations. The swords were poured at 1000° F higher than the temperature of simulation, which caused a decrease in porosity relative to predictions. The blade of the final sword was qualitatively evaluated for sharpness by slicing through a corrugated cardboard box, which it achieved cleanly.

To improve this casting in the future, the team would be benefitted by starting mock-up and prototyping work much earlier. Although a thorough design and brainstorming process started early in the Fall semester, the team felt behind because patternmaking, casting and shop work were delayed into the Spring. Casting the blades sooner would allow for more time to recast the blades, and it would have provided more time for finishing and assembling the sword.

CONCLUSIONS

The goal of this project was to recreate one of George Washington's Swords with steel and one cast element. The sword chosen was the Bailey Silver and Ivory Hilted Cuttoe. The design was reimagined by adding an Ohio State theme. The blade was cast of 15-5PH stainless steel and heat-treated using an H1050 specification. The cross guard was cast out of brass and the handle was made from buckeye wood and stainless-steel wire. The sword was cast using chemically bonded sand and the cross guard was cast using green sand. The sword was assembled using pins and epoxy and sharpened before being packaged and shipped. Prior to shipment, hardness testing and other tests were performed. Some mishaps occurred throughout the process, such as misaligned patterns and spilled metal. Overall, a complete sword was designed, made, and sent on time.

ACKNOWLEDGEMENTS

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REFERENCES

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[2] "George Washington's Battle Sword and Scabbard". National Museum of American History. https://www.si.edu/object/nmah_434865