Cast in Steel – George Washington's Sword

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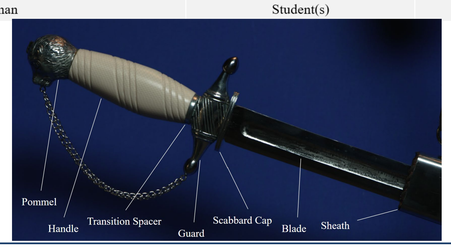
Abstract

The Cast in Steel competition, hosted by the Steel Founders' Society of America (SFSA), encourages students to explore the casting process and apply modern engineering technologies to produce functional steel products. For the 2025 challenge, Trine University's team designed a replica of the George Washington sword, using simulation tools such as liquid metal flow analysis and finite element analysis to validate the design. The final sword was cast in the university's foundry using a medium-carbon steel alloy. After casting, the blade underwent a series of post-processing steps including cleaning, heat treatment, polishing, and coating. The finished sword features a 30-inch blade with an accurately styled handle and weighs approximately 2.2 lbs (0.998 kg). To ensure the sword could withstand the rigors of the competition, strength and durability testing was conducted prior to the event. The team then traveled to Atlanta, GA, to participate in the 2025 Cast in Steel competition, where their sword competed against other universities in a series of functional and durability tests.

Customer Needs and Requirements

Requirement	Unit	Value
Weight	Kilograms	≤ 2
Length	Meter	≤ 1
Casting Material	Pass/Fail	Steel
Sharpness	BESS	≤200
Hardness	HRC	≥48
Toughness	J/cm^2	AUS
Industry Partner	Pass/Fail	Steel Foundry
College Student Status	Student(s)	≥ 1
Video Documenting Processes	Minutes	≤ 5
Report Detailing Design and Processes	Pages	≤ 30
Underclassman	Student(s)	≥2



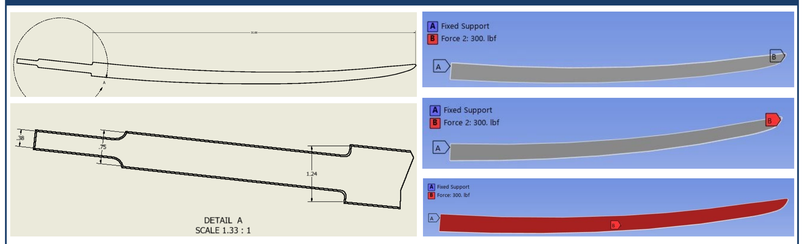
Material Selection

Because of the effects of the additives on the steel characteristics, this concentration of alloying elements were added.

For the competition, the alloy was engineered to prioritize high impact resistance, strength, and toughness, aiming to closely replicate the properties of 5160 steel. Molybdenum, chrome, and carbon were added to enhance strength and wear resistance, while nickel helped maintain toughness as strength increases. Additional elements improved metal purity and further boosted toughness.

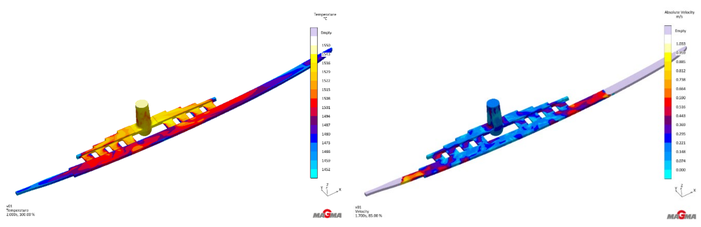
	Additives	C	Si	Mn	Ni	Cr	Fe
Goal	Wt%	.56-.61	.15-.35	0.75-1	<	.7-.9	96-97
Actual	Wt%	.53	.305	0.151	0.096	.68	98

Design Solution



CAD drawing of final Sword design

Finite Element Analysis (FEA)



MAGMA analysis conducted with MAGMASOFT.

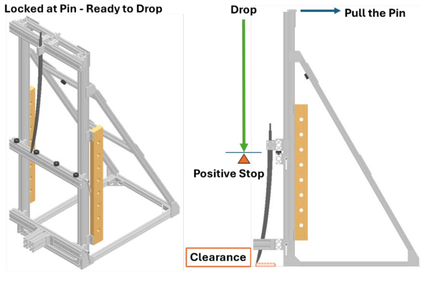
Manufacturing

The sheath cap, guard, transition piece, and lion head pommel were cast using investment casting with Polymaker polycast filament, allowing for flexibility in design adjustments. These parts were cast using metals such as brass, tin-bismuth, and zinc, with careful attention to gating, burnout, and pour quality to reduce defects. After casting, each piece was cleaned, polished, and finished to achieve desired appearance for later assembly.

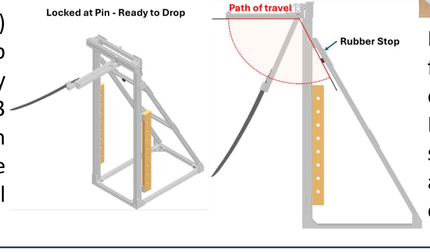
Green sand molds were packed and poured at the Trine University Foundry. Three iteration of the sword were cast in steel. The rough as-cast surface finish was ground smooth. Excess material and flash was also removed during this time. 3 swords were ground to the desired weight and shape.

These 3 swords underwent 3 stages of heat treatment at Trine University: normalizing, quenching, and tempering. The blades were then polished and assembled to create the final masterpiece.

Testing and Validation



The swing test (below) showed that the blade could cleanly cut pool noodles before and after striking wood, demonstrating durability and consistent sharpness along most of its length.



The stab test (above) confirmed the blade's tip strength and edge durability by consistently piercing 1.5 to 3 inches into thick aluminum sheet metal without damage across three successful repetitions.

Blade sharpness ranged from 245 to 300 grams of resistance using a BESS-certified tester, showing a consistent and durable cutting edge.

Arc spectroscopy was conducted using a SPECTROMAXx Metal Analyzer (left). This machine uses an arc to determine the identity and number of atoms of an element in any given metal.

Hardness testing was performed using a LECO LR310 Rockwell Hardness Tester (right). This machine applies a large load on the specimen with the necessary indenter to determine the hardness of the material.

Tensile testing was performed at Metal Technologies in Auburn, IN. MTI received the as-cast tensile specimens, machined them to specification, and pulled them on their tensile testing machine (left).

Acknowledgments

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