SFSA Cast In Steel 2025 - George Washington's Silver Lion Cuttoe

Technical Report

Arkansas State University Red Wolf Steel

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Dr. Rajesh Sharma

Foundry Partner: Southern Cast Products

Summary

A Modernized Approach to Colonial Metal Forging Using Steel Manufacturing Casting

The task is no simple one, the team has elected to work on the Silver-Lion Cuttoe crafted by John Bailey around 1770 in Philadelphia, with the Goldsmith, James Perry, crafting the hilt and likely pommel as well. and acquired by Washington around 1778 or 1779. It was George Washington's first American-made sword, likely a gift from the Marquis de Layfette. Both metal workers were known for their craft in London, and both had tried truly innovative new methods, that seem to have paid off.

Red Wolf Steel are tasked with casting what had been forged steel, and believe they are up to the challenge. Red Wolf Steel has the creative minds of Arkansas State University, and a team with experience in steel manufacturing and design from Southern Cast Products, and the drive to see this done. The team is confident that a sword that George Washington would proudly wield can be crafted with modern methods.

The team is tasked to use modern methods to produce results of older methods, and is being judged on authenticity. There is limited availability and time in terms of materials and craftwork, but the team explore every option available.

This technical report will cover the journey from concept and material selection, to the processes we selected to craft our sword.

Red Wolf Steel, is excited and honored to present our work for the SFSA Cast in Steel 2025 Competition.

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Introduction

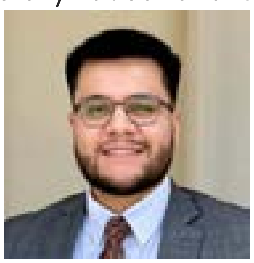
Red Wolf Steel and the Cast in Steel Competition Team

RED WOLF STEEL

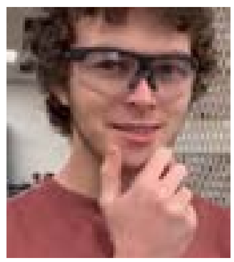
Mr. Timothy Arquitt, Arkansas State University Educational Sponsor

Henry Selig, Southern Cast Products Contact

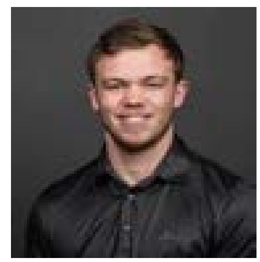
Doug Imerie, Foundry Owner/ Partner: Southern Cast Products



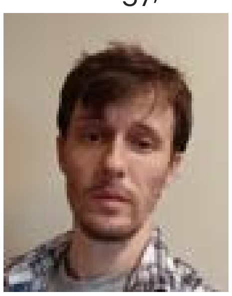
Juan Montoya, Engineering Technology, Senior



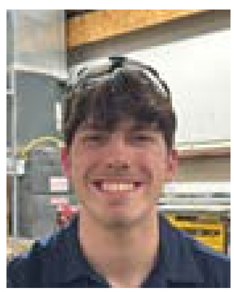
Caden Grimmet, Material Science, Freshman



Ramsey Brower, Mechanical Engineering, Senior



Andrew “Bo” Grace, Engineering Technology, Sophomore



Gibson Hance, Engineering Technology, Senior

Dalton Galloway, the Carburizinator

Red Wolf Steel is a material fabrication team formed by Arkansas State University to compete in the SFSA Cast In Steel competition for 2025. The following will illustrate Red Wolf Steel’s design and material fabrication processes for recreating the Silver Lion Cuttoe owned by George Washington, while using modern technology and materials to do so.

The team will explore our conceptual choices in design, material selection, and process management considering the original sword for authenticity. After explaining the material choices and considerations, the next step will be to discuss the design process, and preparing the materials and their respective necessary processes. Then finally, this report will illustrate the actual steps of the processes used in succession and the final results.

Concept

A Modernized Approach to Colonial Era Swordsmithing

Different components of the sword would clearly be changed, but early-on, it was undecided which ones would and would not remain true to the original process. Some elements of the competition would also change the design choices.

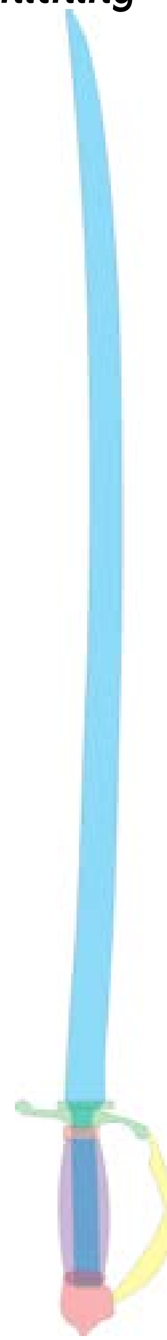
Each part of the sword would present conceptual challenges;

the Blade: The team is casting the steel, rather than forging it, but does have access to many techniques to make blades retain their edge, and absorb impacts well. The testing shown in the Forged in Fire example uses the sword as a hacking utensil, rather than a slicing weapon, used from horseback. This could mean the counter-balancing is less critical, and the durability and shock-absorption of the materials may be due for maximization.

The Guard: The guard has limited details on it’s composition, and there’s no specifications about it’s material, other than that it needed sufficient durability from the tests we’ve seen, and that attaching the chain in a useable manner could be a challenge.

The Grip: The original material was American-sourced, but is only stated to be a bone-like material. The grip is one solid piece, with a spiral cut lathed down the length of it. This could prove a difficult material to replicate in today’s modern world authentically. The team will consider real animal bone materials sourced in the US, but may need to use a synthetic material.

The Pommel: The original would have been made with silver for the sake of density, used as a counterweight, and likely tightly threaded and perfectly dimensioned to hold the grip assembly together. The team may not have access to silver, nor a comparably dense material. The pommel needs to be a machinable material to facilitate the ornate design. The team’s first considerations are Bronze and Copper, but our window of opportunity for it is extremely limited.

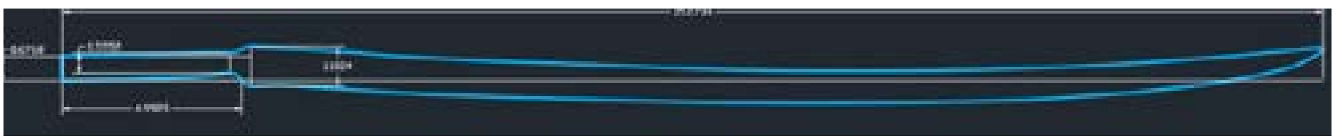


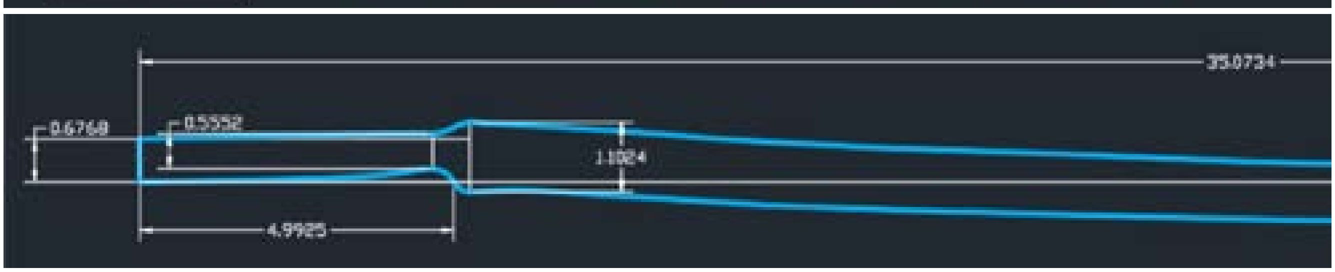
There is also a lack of details on the final thickness of the blade, and no views of the blade from any angle that would give us dimensions, but it was possible to find out what would be normal for a british cuttoe, the likes of which John Bailey would have crafted.

Concept

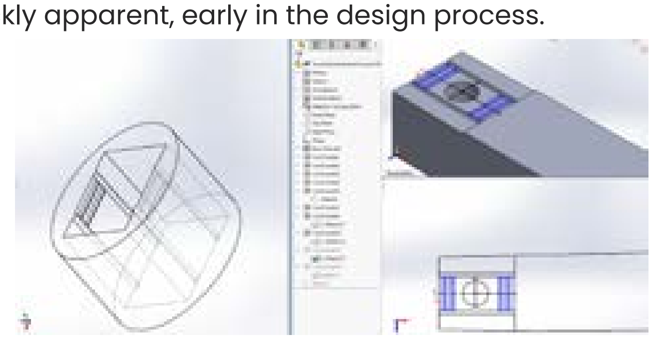
Sword Designs

To get a relatively accurate estimate of the blade's dimensions, many of the team had the same idea; create an overlay, stretch it to the prescribed dimensions listed by the competition, then try to create a model of it from there, preserving the curvature of the blade, which is created by a part of the original forging process that casting wouldn't allow the team to mechanically mimic.



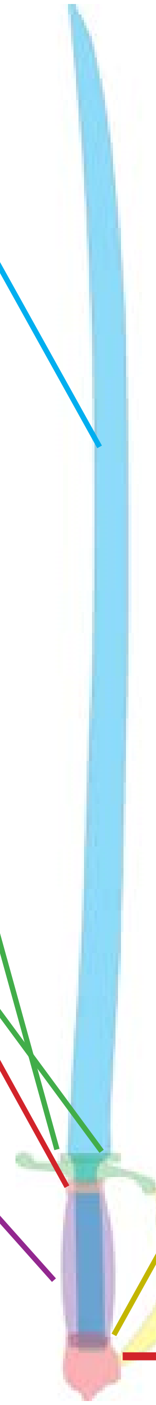


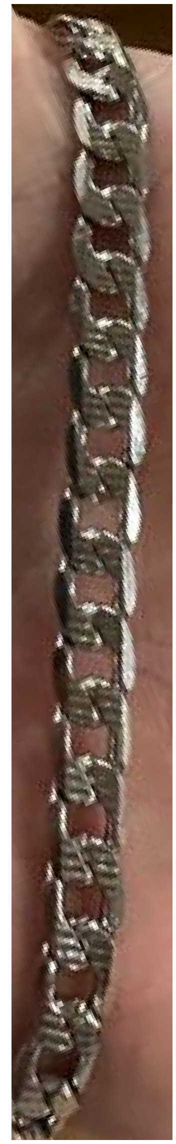
The team also had hoped to introduce a sort of modularity to the pommel, and guard, so that we could submit a silver Lion-headed pommel for the competition, but create a custom, Red Wolf-headed one for the team. For the prototype, this would be aesthetically pleasing, but it didn't prove practical for the end-design, and this became quickly apparent, early in the design process.



Material Selection

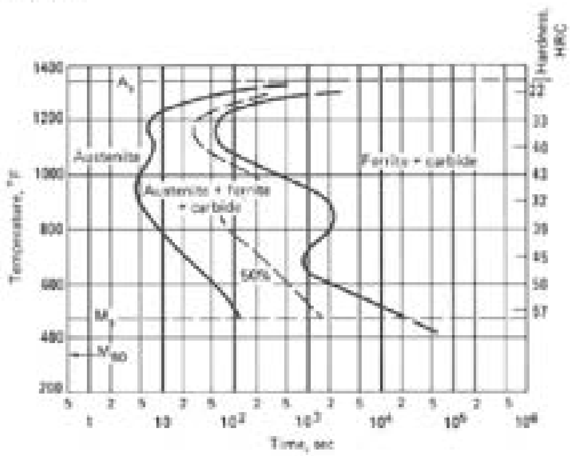
Our Final Choices





5160 High Carbon Spring Steel Blade

5160: Isothermal Transformation Diagram. Composition: 0.61 C, 0.94 Mn, 0.88 Cr, 0.22 Mo. Austenitized at 845 °C (1555 °F). Grain size 7



5160 High Carbon Spring Steel Guard

5160 High Carbon Spring Steel Caps

Above: Oak Dowel Rod Grip Core with Faux Bone formed grip, prior to application.

Faux-Bone, Oak wood and G/Flex 650 Epoxy

Using a dowel rod as a core, the team will attach two mirrored wooden cores via a through-tang pin and epoxy adhesive, which will be coated with formed faux bone after lathing it into shape.

Chain - Etched-Stainless Steel

Cast Aluminum alloy 319 Wolf-Head Pommel

Alloy type	Average composition, wt %										
	Si	Cu	Fe	Mg	Mn	Zn	Ti	Sr	Ni	Sn	Pb
319	7.70	3.38	0.38	0.27	0.23	0.08	0.12	0.0007	0.018	0.0033	0.012

Grip Material Selection

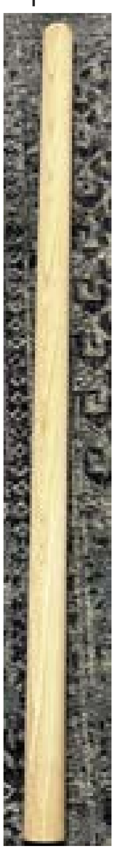
The original grip material choice isn't very perfectly known, but it's known to be American-sourced, and a natural, animal-bone material, functionally similar to ivory. As John Bailey was an established swordsmith in London, it's hard to know if he directly sourced this element, or if it was perhaps something that James Perry, or a third, unknown proprietor had crafted. Regardless, it appears to have been very finely crafted, though the uneven lines, suggest it was possibly whittled and formed by handcrafted methods, rather than machined. (Impressive)

Initially, for the sake of authenticity the team had intended to ensure as similar a material as possible, seeking out antlers and bone materials large enough to facilitate a single-piece grip such as this. Not only was it terribly difficult to source a large enough piece of material that anyone was willing to part with, but we already knew that the inconsistent-nature, and unexplored territory of animal-bone-machining wouldn't be wise to experiment with in the heat of this limited-time competition.

The team instead chose to utilize dowel rods for shock absorption, and synthetic bone material known as Faux bone, and a binding epoxy material known as G/Flex® 650.

The dowel rods will be dimensioned to cushion around the tang. Faux bone will form the exterior surface of the grip. The Faux bone material will be heated in an air fryer using

Faux bone is a non-toxic, high grade PVC that becomes mallable above 250 ° F without out-gassing when heated properly. It boasts a high impact resistance as well.



Pictured Below: Air Fryer used to heat Faux Bone material for forming.

Left: Oak Dowel Rod, Top Above: G/Flex 650 packaging, Above: Juan Montoya demonstrates how the wooden dowel fits around the grip on simulation sword.

Design

Casting Molds

The team utilizes the Voxeljet VX2000 Sand-Casting Printer at Southern Cast Products to create 4 copes and 4 drags containing the casts for a total of 8 castings of our finalized design for the sword.

The design is a direct pour with 4 risers, and a central gate.

The sand-casting system will be dismantled to retrieve the molds after they've been cast.

During casting, the team will run tests on samples of the material to ensure that the metal alloy meets the standards desired.

Above: Henry Selig, and Juan Montoya demonstrate the VX2000 for the Red Wolf Steel team, prior to casting.

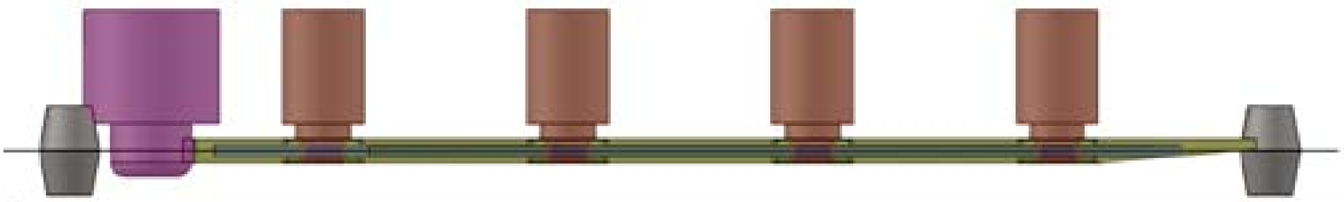
The molds are created using Alumina bonded ceramic sand (Carbo-Ceramic Sand) and acidic binding agents which are layered in tandem to create the cavities for the steel to be poured into, to cool and reach solidification. The team will run simulations to ensure desired results in terms of filling the cavities, and cooling the material at the the proper rates for the material to have the properties needed for a quality sword blade.

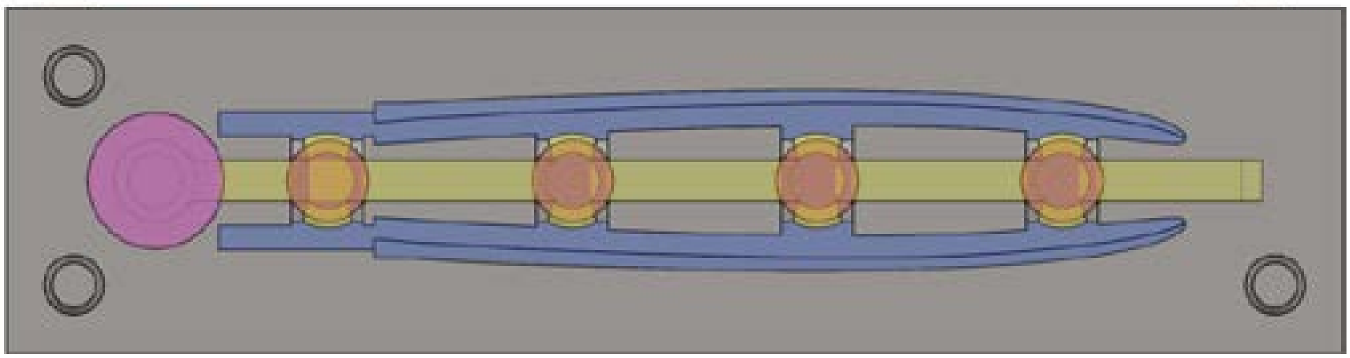
The maximum printing envelope for the VX2000 is 2000 X 1000 X 1000 MM (78.74 X 39.37 X 39.37 IN) which is more than enought accomodate the dimensions needed for the sword's design.

Above: Final sand-cast molds for the blade, with copes and drags laid out for visibility.

Design

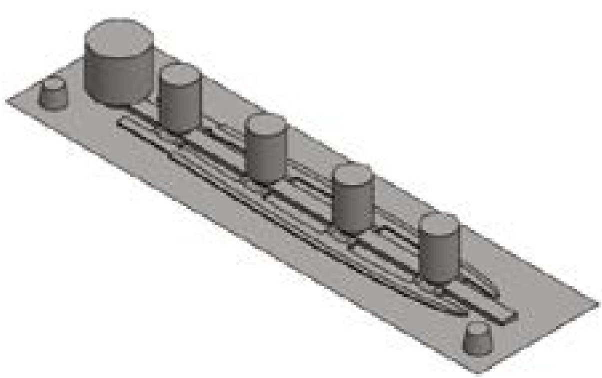
Sword Cast Design





Above: A color-coded diagram of the team's casting design that utilizes the flow of the material as gravity pulls upon it to evenly fill the cast, and risers that assist with preventing the formation of cavities during cooling, and compensate for volumetric shrinking that will occur during solidifcation. As the central gating feeds the risers, it's material will be of a similar quality, and will be used for various steel components of the blade including the guard and guard rings.

Below: The casting cope and drag are show, and the internal contents of the mold illustrated.



Design

Pommel

The team knew that the pommel design's mass was important, but wanted to print out the pommel design at various sizes to test which might feel too cumbersome, or look awkward on the final design, in a more tactile manner. Ultimately a slimmer , longer model was chosen.

Though the team had access to scanners, the time spent cleaning up the scanned files, to create symmetry and simplicity was deemed wasteful. The team instead elected to purchase a wolf-head bust STL license, and use this to create our initial prototypes, and final design.

The wolf's head was selected for considerations of connecting the chain to the guard, and weight distribution.

Above: Resin casted molds are created to decide the team's preference on the dimensions of the wolf's head pommel.

Above: Prototype Aluminum Pommel at sunset, looking unusually handsome.

Above: Later designs cast in 319 Aluminum for use in the final sword

Testing (5160 Steel)

Prior to the mold pouring, alloying testing is conducted to ensure that the material properties that are desired will be present in the material poured into the molds. There are many different functional alloys of steel, and the team is specifically seeking the ranges seen in 5160 High Carbon Spring Steel.

Above: Red Wolf Steel Team Member: Henry Selig holding a steel

Above: Testing site without a sample introduced.

Above: Example of a sample placed in testing mechanism.

Above: Test sample of the Blade's casting

Above: The Blade's test sample being tested in alloying diagnostics.

Casting

Casting Mold Preparation

Southern Cast Product's facility houses the team's molds, which await the material pouring while alloying of the metal is being tested

The molds are sealed and compressed with weighted objects. The molds are insulated to retain heat. Each mold is a direct pour design, utilizing a slanted gating system with 4 centralized risers. The direct pour entry is noted by the orange mesh debris catching hoods covering the port.

Alloying

Alloying is done by adding in the proper ratios of the proper materials. Various metals are measured by mass for addition, and compiled to adjust the ratios found within the sample intended for casting.

Left: The final alloying mixture for the Red Wolf Sword prior to being put into the crucible after testing the initial material's sample.

Above: Various buckets of isolated materials for alloying.

Casting

Alloying

The final ranges fo the material were as follows:

Aluminum 0.0711%, Carbon 0.552%, Chromium 0.797%, Iron 97.0%, Manganese 0.851%, Molybdenum 0.0196%, Nitrogen <0.0005%, Nickel 0.161%, Phosphorous 0.0154%, Sulfur 0.00588%, Silicon 0.354%, Tin 0.00632%, Titanium <0.0002.

Jeff from Southern Cast Products does the honor of tossing our alloying materials into our molten casting material as the team films, photographs, or works diligently in the material analysis shop.

Thank you Jeff! and Thank you Southern Cast Products!

As the alloying material is throw into the crucible, the flames lowered and solid forms of material that has not yet melted can be seen.

This material is used to cast 8 swords, in 4 casting molds, which are lined up with many other molds in a designated casting area. The casting material will be lifted in the crucible via specialized forklift, and carried to the molds, then directly poured into the direct pour holes of each respective cast, using the forklift to angle the pour.

Casting

Pouring the casting molds

The molds are directly poured into from the crucible with specialized forklifts at Southern Cast Products Jonesboro, Arkansas Facility.

The molds are allowed to set overnight, for a period of 18 hours until they're properly cooled and ready to be removed.

Cutting

Removing the castings from the sand molds

Once the casting molds have had sufficient time to cool, they're broken open and the steel casting within is removed. Each mold will contain 2 castings of the sword's blade/tang component, which will be connected by a gating system, that was used to pour the metal. The blades must be cut free of the casting, and portions of the gating system will be used as material for the guard.

Above: The 5160 steel sword material in full cast form, before cutting.

After freeing the 5160 Steel blades from their sand molds, they're then transported to the cutting station to have the risers, direct poor, and gates removed and dimensioned away. At this step, the sword has undergone no heat treatments, and only superficial material removal will occur before those processes occur.

Above: Henry Selig removes gating, risers, and direct pour attachments of mold, free the sword casts to be processed

Guard Cutting/Grinding

Ramsey Brower cuts, grinds, and sands the guard component into form from a section of the 5160 gating for the sword cast, so that it can be engraved at Gotay's Jewlery.

Normally, Gotay's would have needed more time to complete this, but given the circumstances, Gotay's elected to squeeze the team's project into their schedule to support their local college and community.

Above: the guard rings are initially machined from the section of the gating runners.

Above: The guard upon completion of initial fabrication, before being sent to Gotay's for hand-engraving.

Above: the guard with engraving by Gotay's Gallery of Jewelry Design

Shout out to: GOTAY'S GALLERY OF JEWELRY DESIGN

Grinding

Above: Dr. Timothy Arquitt assesses and advises Juan Montoya on the grinding processes for further material removal before a series of heat treatments will begin.

Above: Cut-Sword-Casts in transit to Arkansas State Univesity.

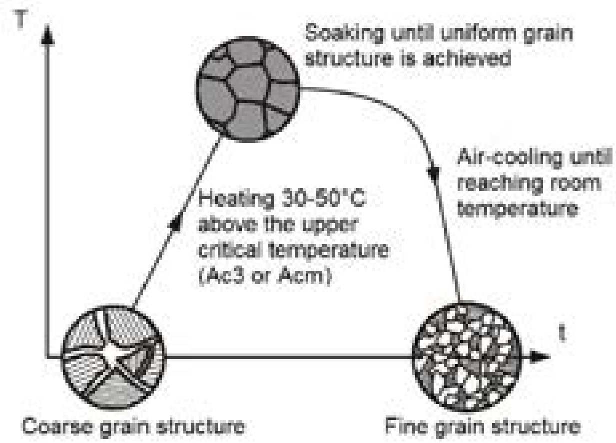
Above: Juan Montoya grinds the blade component

Using Zirconium Sandpaper Flap Wheel Grinders, Juan Montoya meticulously grind the blade in full-passes by hand to try to ensure it retains it’s symmetry. Much of the original casting material will be grinded away, the goal is to maintain the symmetry of the blade, and gradually work to finer grain grinding then the final polish and sharpening

Normalization

Following the casting, the blade and the tang were normalized. Normalization requires the steel to be raised above the critical temperature and then air cooled. This process refines the grain structure of the steel, relieves internal stresses, and also homogenizes the steel's microstructure by evening out the material inconsistencies.

The normalization temperature of the steel was set to 1650 ° F. This temperature is common practice because it is slightly above the critical temperature for 5160 steels. Typically, time calculations recommend one hour per inch of thickness. The blade and tang had a thickness of one quarter of an inch at its thickest point during the normalization process. Using this calculation, the piece was normalized for 15 minutes at 1650 ° F. The piece was then air cooled back to ambient temperature.



the above figure illustrates the effect of normalization on the grain structure of the steel.

Above/Left: Henry Selig removes the swords from the normalization processing.

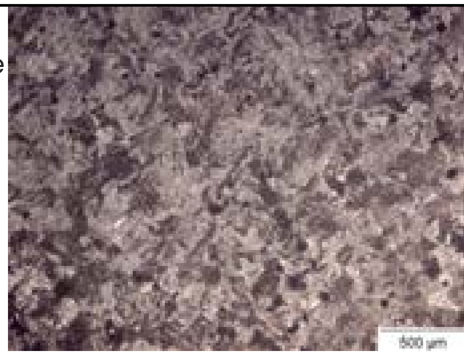
Normalization

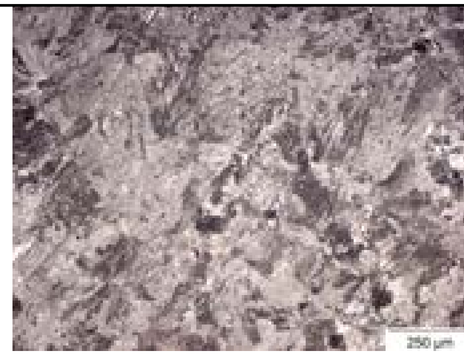
Grain Structure Microscopy of Samples from Sword Steel

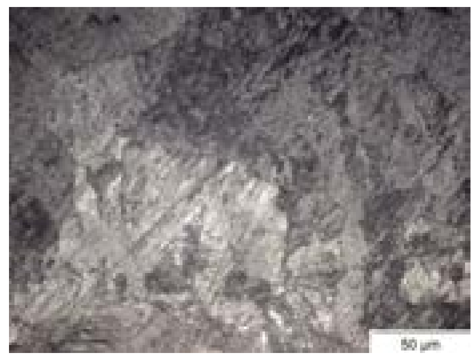
Before Normalization

Microscopy images are created of samples before normalization, to assess surface grain structure, and make comparisons.

Images Taken with: Olympus microscope inverted gx41 on Paxit imaging software. Acid etching was performed with 5% nital acid HNO3. Samples were taken from the center of runner bars of casting due to similar section thickness.







After Normalization

Images of the material after normalization have an expected improvement in surface grain size, area, and structure. Seeing this result suggests that our normalization process has been successful and yielded the desired result

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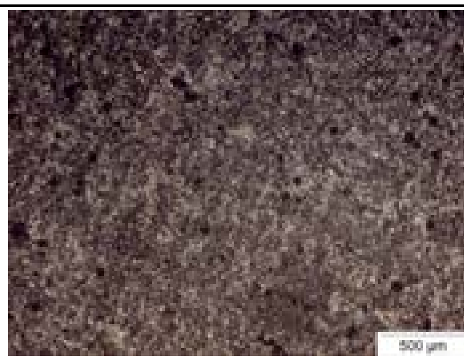
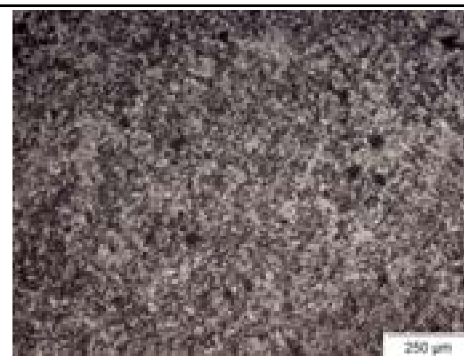
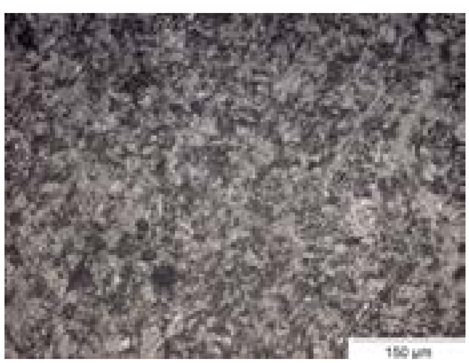






Carburization

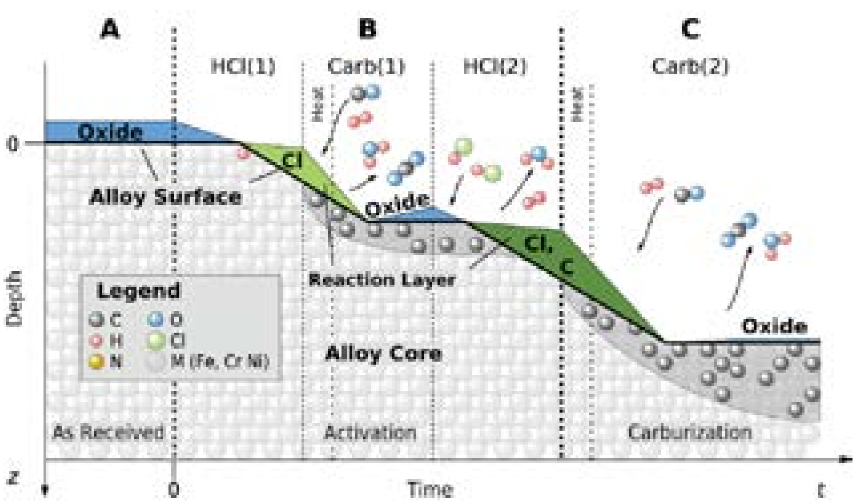
The team elected to carburize the blade and tang following the normalization process. Carburization exposes the steel to a carbon-rich environment at high temperatures to diffuse carbon into its surface, increasing hardness and wear resistance while maintaining a tough core.

To carburize, a carburization tube had to be fabricated. Dalton Galloway of Southern Cast Products fabricated an air tight tube with a flanged end. The flanged end was insulated with a gasket that was rated air tight up to 1850 ºF. The carburization tube allowed the sword and tang to be tightly packed with carbon rich materials and exposed to high temperatures.

In order to maintain a ductile spine, the scale that was remaining from normalization was only removed from the blade. Also, the oxidation layer left from casting was still intact on the spine and tang of the piece. These were left behind in hopes of creating a layer that was more difficult for the carburization process to get through, therefore giving a harder blade with a more ductile spine and tang.

The carbon heavy material that was chosen to pack with the sword during carburization was graphite. The graphite was packed in tightly with the sword before the flange was bolted down on the carburization tube.

Above: Carburization chamber resting in gravel outside of the machining shop.



Left: Example Diagram of carburization of an alloy with an oxidized surface, illustrating where carburizationg takes place and at what depths. (this is an example, and the data represented does not reflect the exact material used within the Red Wolf Steel Sword) (retrieved from mdpi.com)

Carburization

Calculations for the Process of Carburizing the Blade

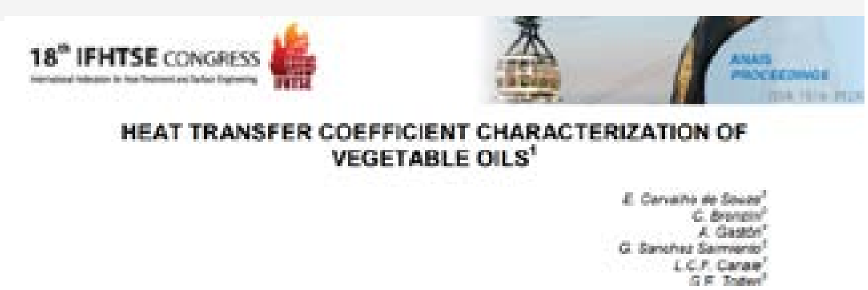
The team drew up calculations for times and temperatures for the treatment, however the software used didn't allow for carrying over the equations and variables. So screenshots were made of a ready-for-print version of this portion of the technical report's data to resolve the issue.

Calculations were performed to determine the required time and temperature to reach the ample carbon deposit depth. Equation 1 shows the Arrhenius equation for the standard diffusion coefficient. Equation 1) $D = D_0 e^{\frac{-Q}{RT}}$

In equation 1, D_0 is the pre-exponential diffusion coefficient, found to be $1.28 * 10^{-4}\ m^2/s$ for 5160 steels at a temperature higher than the critical temperature. Q is the activation energy, again a material and temperature property. It was found to be 140,000 J/mol. R is the universal gas constant and T is the temperature in Kelvin.

Following the calculation of the standard diffusion coefficient, the effective diffusion coefficient was calculated, taking into account the surface reaction. Equation 2 shows this calculation. Equation 2) $\frac{1}{D_{eff}} = \frac{1}{D_0} + \frac{1}{k_s * x}$

In the equation, k_s is the surface rate constant in m/s, a material property. X is the goal depth of carbon deposition. For the sake of the blade and tang, it was determined that a goal depth of 1.5 mm would meet the requirements. Prior to normalizing the blade was machined to a thickness of approximately 3 mm. The team determined that a depth of 1.5 mm would guarantee a fully carbon blade.


18th IFHTSE CONGRESS

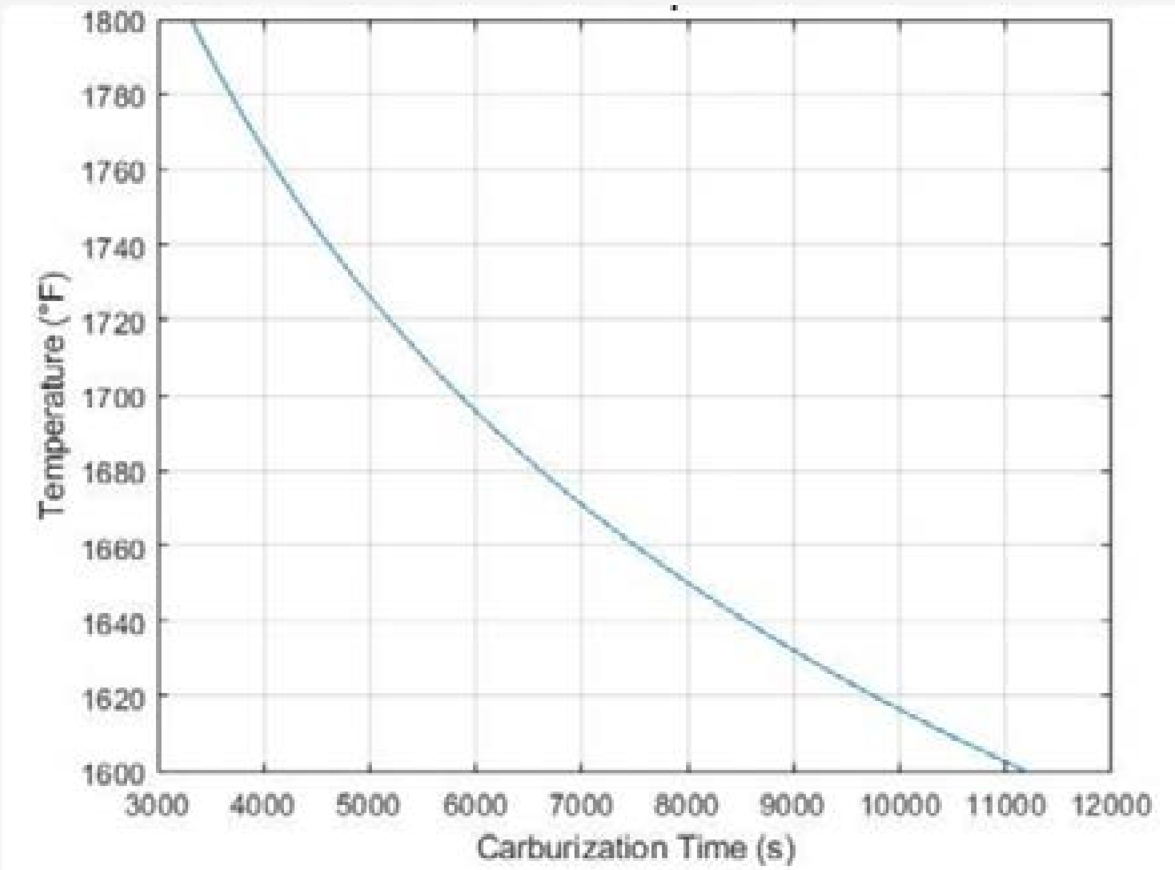
ANAIS PROCEEDINGS

HEAT TRANSFER COEFFICIENT CHARACTERIZATION OF VEGETABLE OILS[1]

Carburization

Equation 3 calculates the time required for carburization dependent on the effective diffusion coefficient and the depth of carbon deposition. Equation 3) $t = \frac{x^2}{4 * D_{eff}}$

A plot was formed for temperature versus time to determine the required time and temperature to reach a carbon deposit depth of 1.5 mm. The diagram below displays the plot.



The furnace used had an over-temperature emergency shut off at 1750 degrees Fahrenheit. Because of this, it was determined that the carburization temperature would be just below at 1740 degrees Fahrenheit. The graph was used to calculate the required carburization time to be one hour and sixteen minutes.

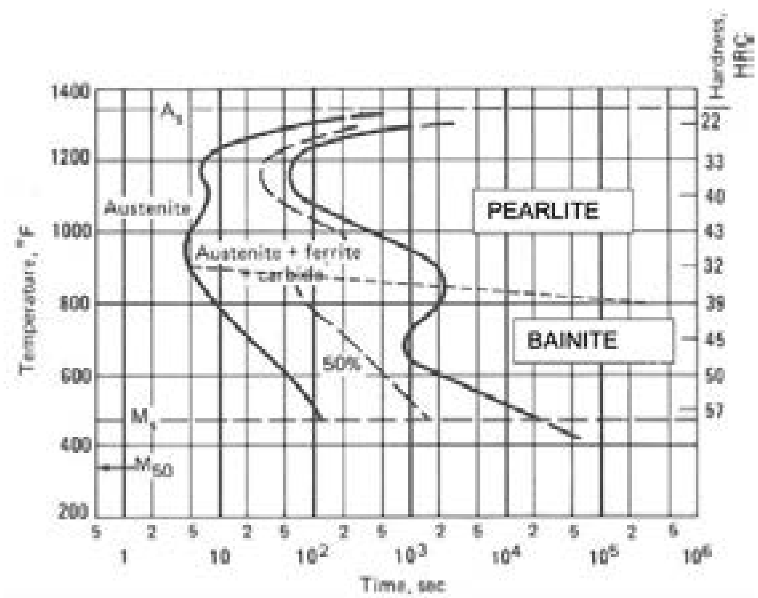
Quenching/Tempering

1550 °F - 15 minutes - Then quenched in Canola oil. This process will rapidly cool the steel to harden it, while the following step; Tempering, will relieve the internal stresses and adjust the hardness to a more ductile and resilient state.

This process will be followed by our final machining processes.

Following carburization, the steel and tang piece were quenched and tempered to further improve the hardness and strength of the piece. Quenching is the process of rapidly cooling a piece to transform its microstructure, ideally into martensite because of its strength and hardness. For the quenching process, a time-temperature-transformation, or TTT, diagram for 5160 was used to find the required time and temperature to produce pure martensite.

This diagram displays the TTT diagram for 5160 steel. Using the diagram it was determined to produce pure martensite the piece would have to be cooled from above the critical temperature to approximately 900 degrees Fahrenheit in less than 4 seconds. To find the quenching oil required, Newtons Second Law of Cooling was used.



Equation 4 shows this equation.

$$T(t) = T_\infty + (T_0 - T_\infty)e^{\frac{-hA}{mc}}$$

The calculations were performed to solve for h, the heat transfer coefficient for the quenching medium. The remainder of the variables in the equation were temperature or piece specific properties. The properties were determined used the TTT diagram and the SolidWorks model of the piece.

Performing the calculation found that the required heat transfer coefficient for the quenching medium was 1384 $\frac{W}{m^2K}$. According to a study by the International Federation for Heat Treatment and Surface Engineering, Canola oil was found to have a heat transfer coefficient of 1548 $\frac{W}{m^2K}$ at 450 degrees Celsius. It was determined that this value would be satisfactory because it is larger than the required heat transfer coefficient, offsetting the temperature difference.

Quenching/Tempering

For the quenching process, a quench tank was fabricated by Dalton Galloway of Southern Cast products. The quench tank was deep enough for the sword and air tight to avoid oil leaks.

To give the spine of the sword the ductility required to meet physical demands, refractory was packed along the back. The refractory insulates the spine, creating a slower cooling rate during quenching. This keeps the spine from becoming complete martensite. Ideally this gives the blade a hard edge and a ductile spine.

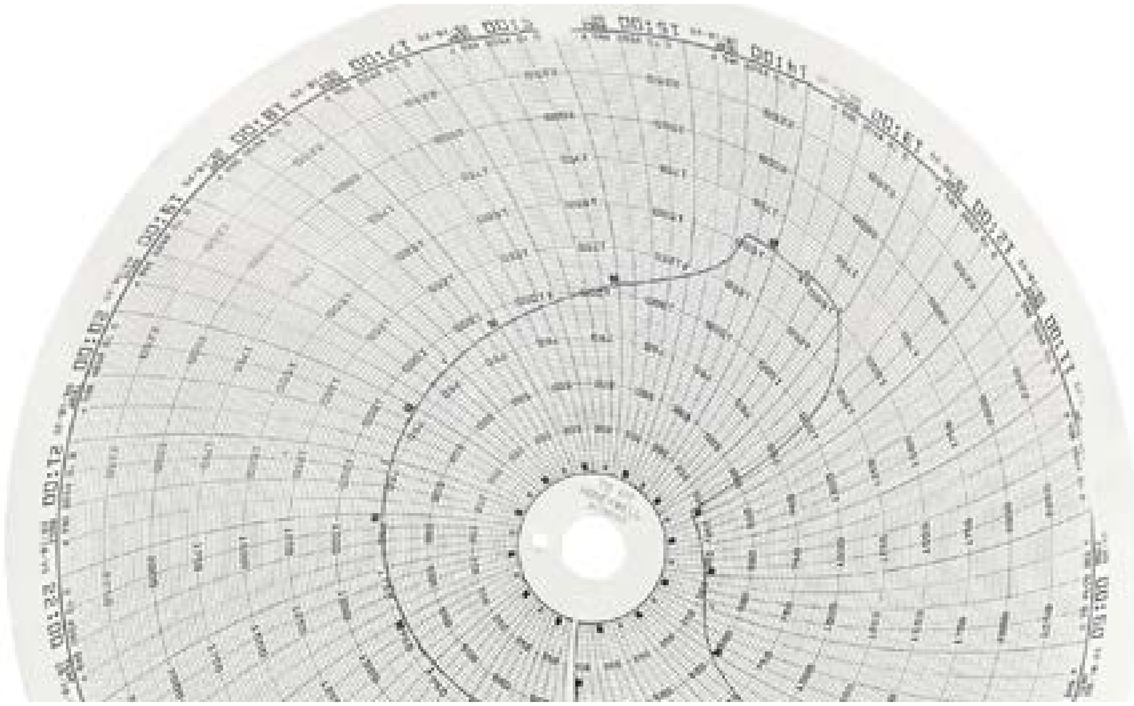
The blade and tang were heated above their critical temperature and held for an hour per inch of thickness, similar to normalizing. The piece was heated to 1600 degrees Fahrenehit for 1500 minutes. Following the heating process, the sword was immediately removed from the furnace and quenched into the canola oil quench tank, quickly cooling the blade.

For the tempering process, the team intended to have two tempering cycles. The first would be heating the blade and tang assembly to 400 °F for an hour and thirty minutes. The piece would then be allowed to air cool before the process was repeated at 350 °F. Unfortunately, because of an error with the furnace, the first tempering cycle reached a temperature of nearly 550 °F for an hour and a half. It was determined that the increase in temperature would create the required tempering and that a second cycle would not be necessary.

Following tempering, hardness tests were conducted to verify the results of the differential hardening. Hardness tests revealed a hardness of 59 HRC on the blade, within the target range. Hardness tests also revealed a hardness of 39 HRC on the spine of the blade. The different hardenings were within the target range and confirmed that validity of the differential hardening during quenching.

Also following the tempering, an OES, Optical Emission Spectroscopy device, was used to find the carbon content on the surface of the blade and verify the carburization attempt. The OES confirmed that the carbon content of the blade was 0.65%. This value was 0.10% higher than the original test performed before heat treating, therefore confirming the validity of the carburization process.

Heat Treatment Table



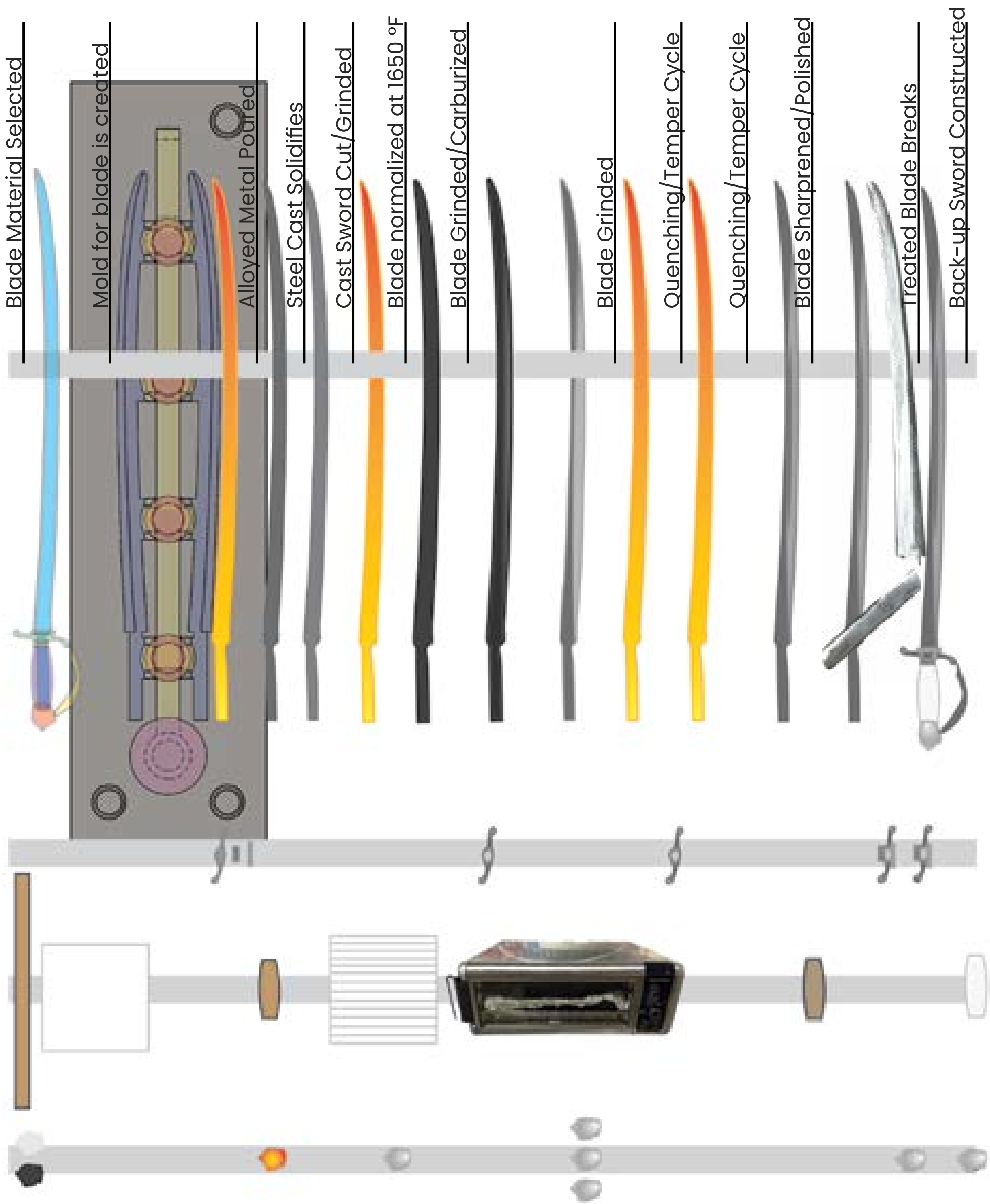
Above: The graph of the heat treatment processes thresholds for the 5160 Spring Steel Blade's tempering and quenching.

Sharpening

Final Dimensioning and Sharpening of the Blade Component

For the sharpening of the sword, the team used two grinding discs, and then a double-sided whetstone. The team had access to a coarse grinding disc, a fine grinding disc, and then a course, and fine side of the whetstone, both being consecutively finer grain as the process continues. The team were initially concerned about the possibility/difficulty of grinding our sword due to the high carbon steel, the tempering, and the carburization, which made the sword extremely rigid. However, the task was found to be very possible, yet still somewhat time consuming. The two main concerns while sharpening the blade were keeping the edge centered along the blade, and ensuring that the blade angle remained constant along the blade. These however, were easily achievable goals, seeing as it's possible to switch to a finer grit for more precise grinding, which also allowed less room for mistakes. Another issue encountered while grinding was ensuring that uneven amounts of material weren't being removed along different parts of the blade. Careful efforts were taken in order to ensure that the grinding was as even as possible. With the whetstone, water was used to provide a surface lubricant, which helps prevent the small metal particles from grinding back against the blade. The water was applied generously, and the stone was rinsed very often in order to ensure the best edge quality.

Component Construction



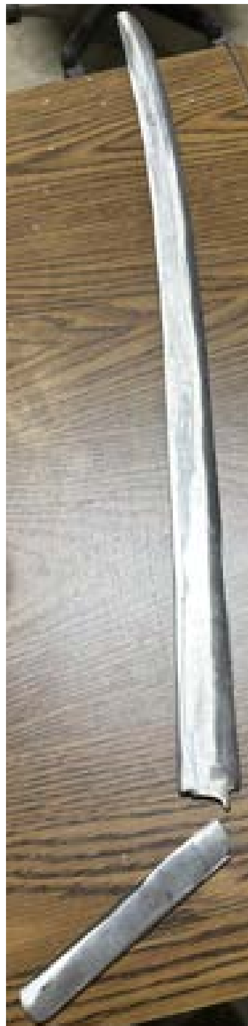
Primary Sword Fracture Event

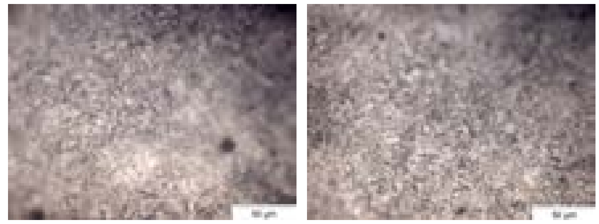
Above: Oak Dowel Rod Grip Core with Faux Bone formed grip, prior to application.

The break point indicates partial brittle fracture and partial ductile. Indicates moderate hardness and strength. The crack initiated on a 90 degree radius which is responsible for the break on a site where a cut was already present. The smaller width of the tang and geometry is more so responsible. It was a perfect storm not just one thing to blame.

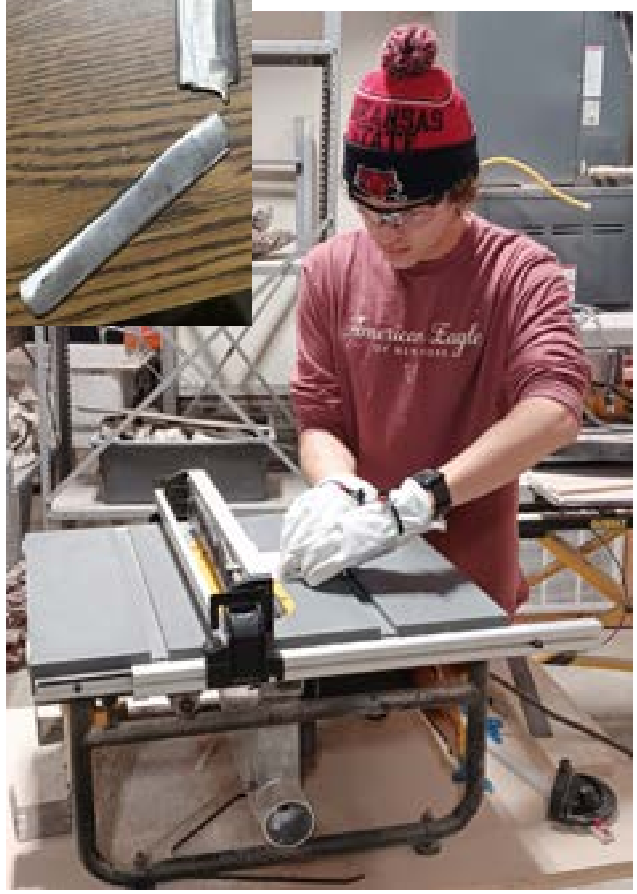
Failure analysis includes geometry stress concentrations, rapid impact on a cut and high hardness and strength from high carbon steel.

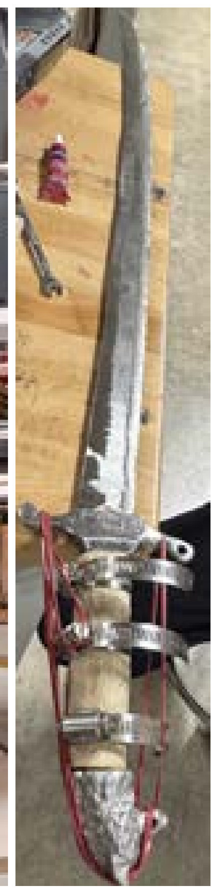
Above: The Fracture Point of the initial, carburized, and tempered blade, only a day before shipment.





Above: OES imaging from within the fracture point of the broken sword.

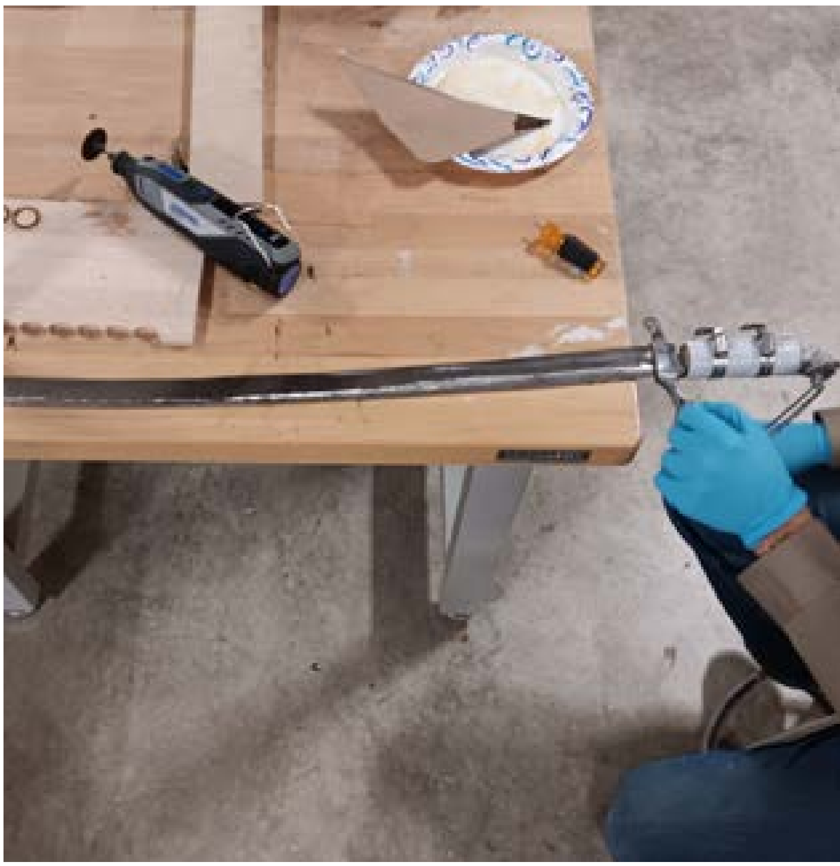




Above Left: Caden Grimmet prepares the exterior grip layer.
Above Right: Grip and Pommel curing with clamps.

Final Product

With the deadline looming, and the back-up sword behind in treatments, the team was forced to construct the back-up sword, and leave the tempered, and carburized sword behind. Juan Montoya, Caden Grimmet and Gibson Hance worked tirelessly to get the back-up sword to dimensions in time for shipment. When the sword is brought to dimensions, the team puts the guard on and welds it in place, and affixes the dowel rod grip core with adhesive. The new sword's grinding left no time for threading for the pommel, so a pommel was simply attached with JB weld. Using various clamps and elastic codes for tension, the grip assembly is held together tightly during the initial curing process as Caden Grimmet prepares the final exterior faux bone layer of the grip by dimensioning it, then heating it for forming. With a great deal less time than initially expected.



Above: Juan Montoya affixes the chain as the Faux Bone shell grip is curing, then prepares it for shipping in a segment of a pool noodle (pictured immediate right) The final connection for the pommel was solely JB Weld adhesive, and many things didn't go as expected, but we're still very proud and appreciative of the experiences and have an appreciation for the difficulty of this craft. Without having tested it's durability any further, the blade is shipped before it's too late to do so.

Final Sword's weight was 4 lbs.

Reference

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G/flex 650 spec reference page - https://www.westsystem.com/products/g-flex-650-toughened-epoxy/

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Shout out to Gotay's Jewlery for engraving our Guard component - https://gotaysgallery.com/

Carburization Illustration that I borrowed for now - https://www.mdpi.com/metals/metals-13-00335/article_deploy/html/images/metals-13-00335-g014.png

Faux Bone Material Website - https://cooltools.us/products/faux-bone%E2%84%A2-sheet

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