

Cast in Steel Bowie Knife

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Table of Contents

Students	2
Rationale of Design	2
History	2
Blade Design.....	2
Knife Design for Process and Performance.....	3
Gating Design	3
Alloy and Processing for Desired Properties.....	4
Manufacturing Processes.....	5
3D Printed Wax Patterns.....	5
Investment Casting & Shell Mold.....	6
Dewax in Autoclave & Burnout & Mold Cleaning	7
Preheat & Pouring.....	9
Knockout	10
Gating & Rough Blade Grinding	10
Hole Drilling at AWL-Tech	11
Heat Treatment at Pacific Heat Treat	11
Sharpening at Ridgeline Knife Works.....	11
Handle	12
Quality and Property Testing	13
Final Product	13
Acknowledgements.....	14
American Casting Company	14
AWL-Tech	14
Pacific Heat Treat.....	14
Ridgeline Knife Works	15
California Polytechnic State University.....	15

Students

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Rationale of Design

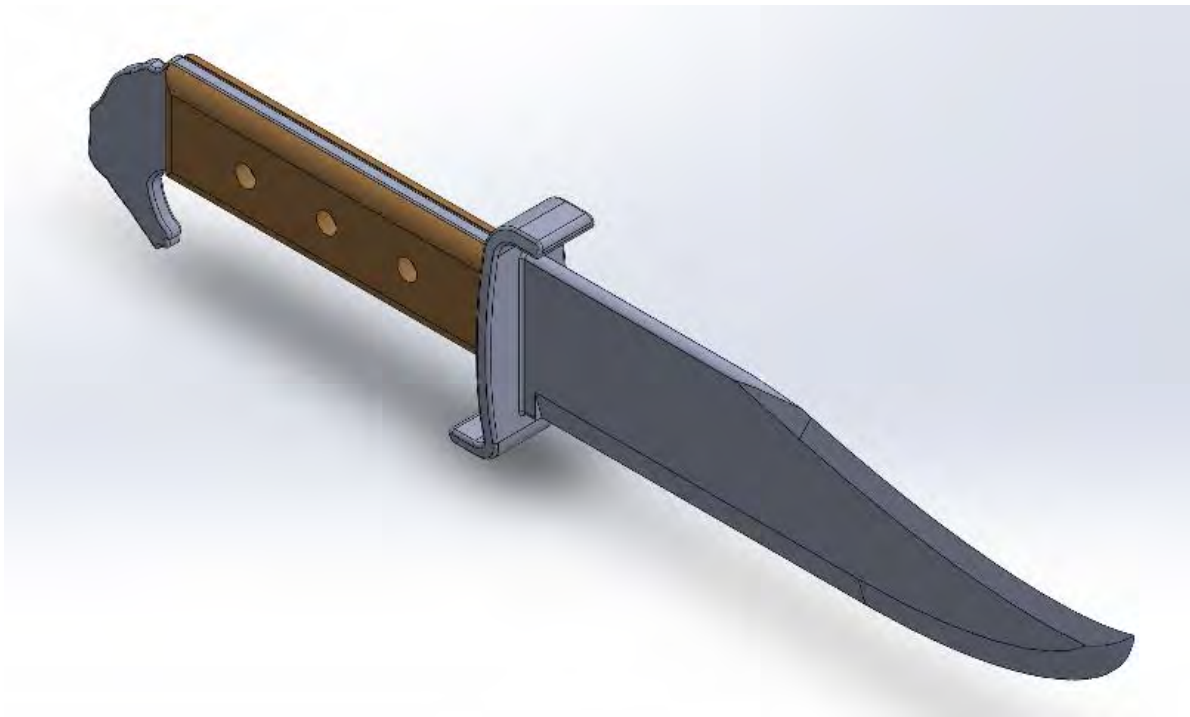
History

Although the origins of the first bowie knife are unsure, the name comes from James Bowie, who was a known as a knife fighter. James Bowie's Sandbar Fight was recorded and publicized, and afterwards he would be seen carrying a very large butcher knife. This is the style of knife that would get his namesake.

In following revisions of a bowie knife, the general design remained similar with a longer blade (generally $>9''$). The next big change was to add the Clip Point, the hook shape at the point of the blade, and to sharpen that part of the back of the blade.

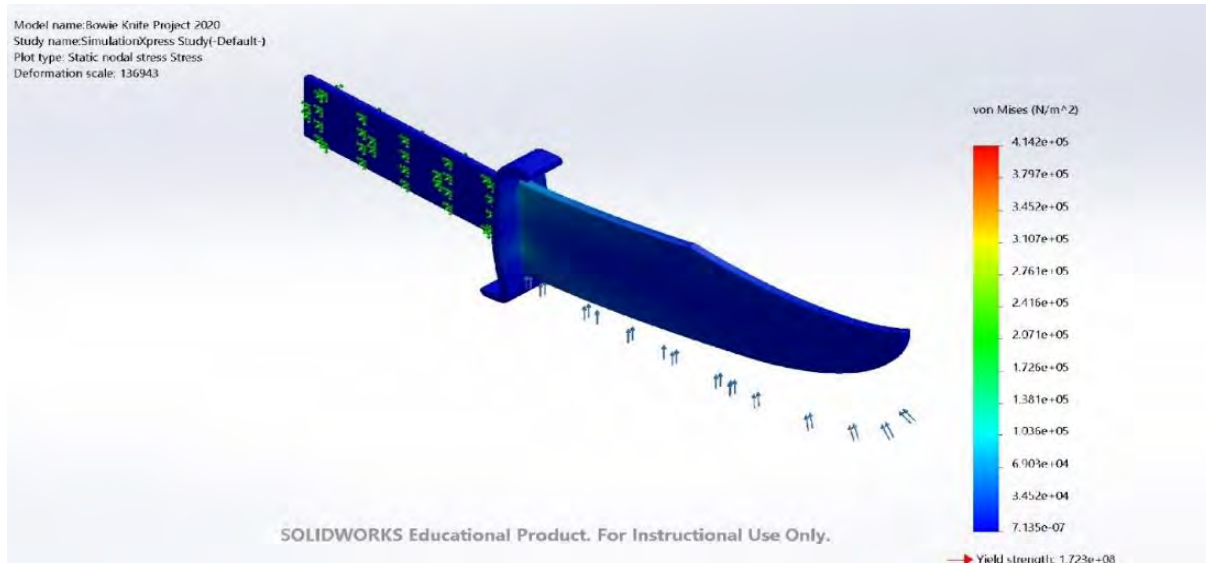
Blade Design

In the design of the bowie knife, there were multiple sources of inspiration. The hand guard was designed to look more like something that would normally be found on a sword. The pommel of the knife was modeled off Cal Poly's mascot, the Mustang. The blade design was based on the design of other bowie knives that we found in our research. In the implementation of these design ideas, the goal was to have a knife that would only be able to be made effectively with casting.



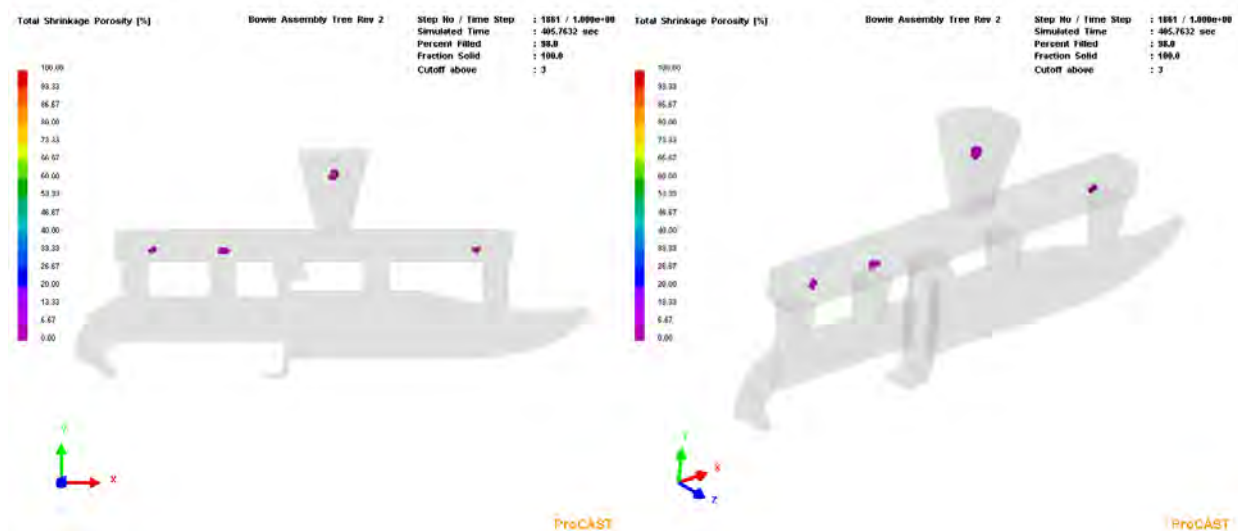
Knife Design for Process and Performance

After the knife was initially designed, to ensure that the blade would perform well, simulations were run to find weak points. The weak points according to the force simulation was between the blade and the hand guard. After finding this weak spot, we added larger fillets on this joint.



Gating Design

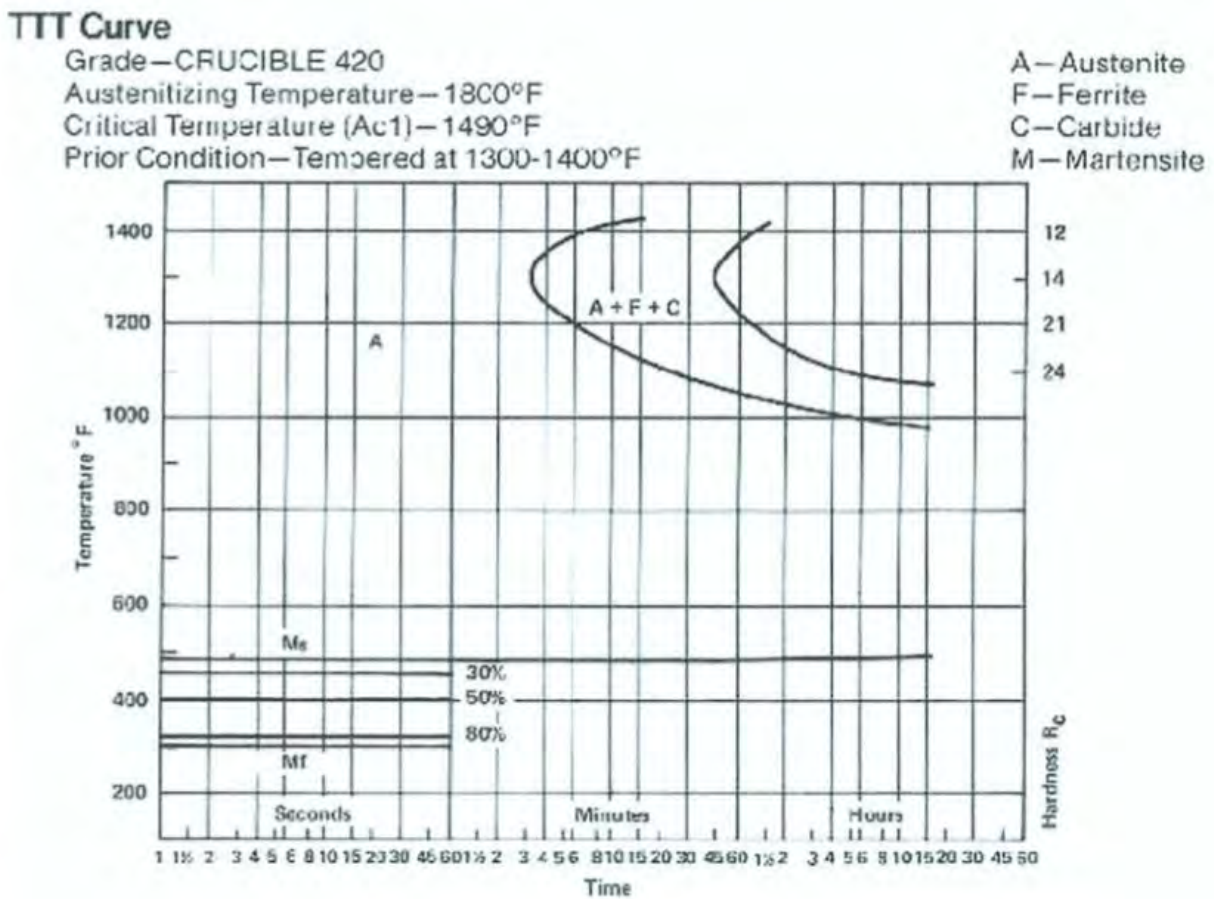
Once the designs of the knives were sent to American Casting Company, they put recommendations for a simple gating design. The gated model was then put through porosity simulations that found that this first version of gating would have some porosity in the hand guard. To fix this, the gate on the hand guard was made larger and sloped down to the tang. The final porosity simulation is below. The only porosity found in the final version of the simulated model were in the risers, so this will not be an issue.



Alloy and Processing for Desired Properties

As for the alloy chosen for the knife, 420HC steel was used to produce the bowie knife. 420 steel is commonly used in professional production of similar knives, and a high carbon content was chosen to create a harder and better cutting blade. Additionally, 420 steel was also an easier alloy to work with for our purposes.

Below is the "Time-Temperature-Transformation" curve that was followed for the hardening process of the 420HC steel knives. This helped outline the cooling speeds of our process to achieve a good internal structure that would create a strong, hard edge that would last. A nitrogen gas quench was used after heating up the knives to 1950 F in order to create the desired hardness.



The goal for the final hardness of the knife was RC59. This is slightly above the average of what is common with this type of steel.

Manufacturing Processes

3D Printed Wax Patterns

Using wax 3D printers, the handle and blade were printed in two parts due to the work area of the printers. These two parts have a joint near the hand guard that is used to locate the two halves. This process allows for the natural shapes that are desired to be made into a small-scale pattern for small production runs. This process also allows for the gating to be included in the printed pattern.



Once the two halves are joined with a wax glue, the riser is joined to the tops of the gates. The riser is then attached to the sprue.



Investment Casting & Shell Mold

In the investment process, multiple layers of investment and other materials are added on top of the pattern to build up the shell. This process starts with fine layers of the investment for accuracy.



As the layers build on the shell, coarser materials are added to increase the bulk of the shell and are cheaper in cost.



After a total of ten layers of investment and other materials, the shell has been built up and will be strong enough to withstand the heat and forces of the casting process.



Dewax in Autoclave & Burnout & Mold Cleaning

Once the shell is formed around the wax pattern, the wax is melted out first using an autoclave to get the majority of the wax out.



The shell is then burned out at 1800 degrees Fahrenheit to get any remaining wax that would be left in after the dewaxing process.



Lastly, the shells are insulated to make sure that they retain their heat during the preheat process.



Preheat & Pouring

The insulated investment shells were preheated to 1800 degrees Fahrenheit for 15 minutes to prevent the mold from cracking upon contact with the molten metal or for the casting to cool too quickly or unevenly. This was especially important due to the large surface area of the blade of the knife.



The 420HC Steel was melted in an induction furnace and heated to 2850 degrees Fahrenheit with a tolerance of +/- 20 degrees. There was only one pour spout per knife to fill.



Knockout

Once cast and cooled, the castings went into knockout and the investment shell was broken off the finished casting. It was important that this was done carefully to avoid damage to the blade or the hand guard.



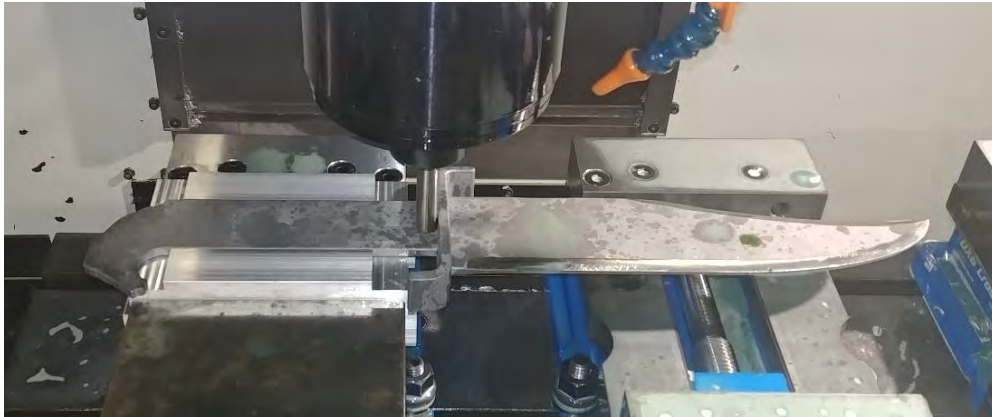
Gating & Rough Blade Grinding

The gating was ground off at American Casting Company. The larger gate that was added on the top and back of the hand guard ended up being harder to grind than the others due to the geometry of the hand guard. A rough first pass of the blade shape was ground into the blade. This would make it easier to sharpen later after the knife is hardened.



Hole Drilling at AWL-Tech

AWL-Tech drilled three 3/8" holes into the handle using a CNC mill to make the holes that would be used to secure the wooden handle pieces with brass pins.



Heat Treatment at Pacific Heat Treat

The heat treatment process discussed earlier was ordered at Pacific Heat Treat. The knives were heated to 1950 F (just above austenitizing temperature) and then cooled via nitrogen quenching. An oil quenching or cryogenic quenching were considered but it was found that nitrogen quenching would provide the best and most predictable results with little likelihood for warping. From this process, a Rockwell C hardness of 57 was achieved for the knife.

Sharpening at Ridgeline Knife Works

Ridgeline Knife Works volunteered to do the knife sharpening and asked for creative freedom in the design of the sharpening.



Handle

The goal of the handle was to include some of the manufacturing techniques that we had wanted to include in the design of the knife before access to campus became impossible. To accomplish this, the handle was milled out of wood on a homemade CNC machine to meet dimensional specifications and to add a texture to the handle to add grip.



The wood selected was bubinga, which is a hardwood which will hold up better for this application and when finished looks good against the steel of the blade. The handles were sanded and finished by hand until soft to the touch. To secure the wooden handles, a traditional technique of peening a brass pin was implemented. This added a strong method to hold on the handle that will be more weather-proof than an adhesive or other method.



Quality and Property Testing

While our initial goal was to reach a Rockwell C hardness of 59, we reached RC57 during our hardening process and decided it was sufficiently close to our goal such that the knife would not be as brittle and not shatter easily. There were no visual cues for where the testing was done on the knife itself.

Final Product

The final product exceeded expectations with its quality and accuracy to the model. There were other aspects of the final product that were not feasible at the time of production, such as grinding the pommel to add detail to the horse head.



Acknowledgements

American Casting Company

Chris St. John at American Casting Company helped us through the entire project process, was always excited to be helping, and got us in contact with the other companies to help get this project done. The American Casting Company is based in Hollister California that focuses high tolerance investment casting. Industries that rely on American Casting Company for castings include medical and aerospace, among others.



AWL-Tech

AWL-Tech is an engineering design and machining company based in Hollister California. AWL-Tech uses many different in-house manufacturing techniques to create high quality custom designs or modify existing products.



Pacific Heat Treat

Pacific Heat Treat is a family heat-treating company based in Sunnyvale California. Pacific Heat Treat has 20 different pieces of equipment and the capability to run many kinds of heat treat services with the goal of exceeding customer's requirements and expectations.



Ridgeline Knife Works

Ridgeline Knife Works is a small knife manufacturing company based in Auburn California. Ridgeline Knife Works has the mission to make high quality functional knives designed to be put to work.



California Polytechnic State University

Rob Carter was the professor on campus that helped get the San Luis Obispo campus to compete this year and helped along the way. Cal Poly's Industrial and Manufacturing Engineering department has a casting class taught by Rob Carter and Martin Koch that covers many different casting techniques and lets students get hands on experience casting themselves on campus.

CAL POLY

Manufacturing Engineering