

Cast in Steel 2021

Thor's Hammer Technical Report



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Acknowledgements

We in Texas State Team 2 would like to give a special thanks to Abel Ardis over at American Foundry Group Inc. for all of his help and guidance throughout the creation of our hammerhead. We are grateful for all of the knowledge, suggestions, and advice he has given to us. We would also like to thank him for all of the information he has given us on the aspects of his part in our project, even with all of the issues our team has faced here in Texas.

We also must give thanks to the Steel Founders Society of America and the American Foundry Society for another fun and challenging year of competition as well as SFSA's flexibility to allow our team to compete

Project History

Originating from Norse Mythology, the mighty hammer Mjölfnir was a powerful weapon wielded by the god Thor, son of Odin. Forged to fight the Jötunn (Giants) and Jörmungandr the World/Midgard Serpent, only the mightiest of the gods were able to wield such a hammer.

This hammer and its subsequent history and design was heavily prevalent in Scandinavia during the Viking Age, used as a sigil of protection and strength among Norsemen. Many who wore this type sigil prayed for the protection from the god Thor. Thor is known as the Bringer of lightning, thunder, and storms. Widely regarded as the strongest of the Norse Gods, many were proud to bear his symbol going about their daily life or into battle.

In today's day and age, Thor is still heavily present throughout the world, though not much for his religious aspects. The character Thor stays in the limelight from the incredibly successful Marvel adaptation of the much beloved god, depicted by Chris Hemsworth. In the Marvel cinematic universe, Thor's Mjölfnir is a massive hammer forged in the heart of a dying star, which only the most worthy can pick up, yet alone move.

Design

We went through many initial designs of our interpretation of Mjölfnir, all with various different focal points. However, it wasn't until we began to design out the AutoCad model that we scrapped all previous ideas and created an entirely new design that we felt envisioned all that

we were hoping to achieve. We spent much time deliberating on how we wished to achieve our goals while still being relatively realistic. It took us nearly an entire week, hours after school discussing over AutoCad in-person and online to finally achieve the best possible design that we could come with that everyone agreed upon.

We decided to bring aspects from both ancient history and the modern Marvel adaptation to create an interesting yet historically inspired combination. To give our hammer a unique flare we have added two designs onto the sides, the first side shows the Mjölfnir sigil seen commonly throughout Norse and Scandinavian history. The other side of the hammer depicts Yggdrasil, known as the World Tree, which connects all the Nine Realms together where the Gods could travel between them. The other aspect of Yggdrasil that influenced its inclusion was the prophecy of Ragnarök, where Jörmungandr would eat the roots of Yggdrasil and cause the death of the Norse Pantheon, amongst other cataclysmic events throughout the universe. The arch-enemy of the World Serpent is Thor, who is destined to fight the beast in order to prevent Ragnarök, so its inclusion seems fitting.

The other design aspect that we included was the awe inspiring, cool aesthetics given to Mjölfnir in the Marvel cinematic universe and other such depictions. Typically, historical depictions are very basic and we wished to avoid that, aiming to create a visually striking work of art that shows the design ability available thanks to casting that could not be achieved otherwise through the use of forging. We then set on blending these elements together to accomplish our final product.

Material Selection/ Technical Aspects

Material selection was not one of the larger concerns of our design aspects, as much as weight and general strength was. Our primary consideration was AISI 440C steel as a strong, trusted tool steel. Having a high carbon content and a heat-treated hardness reaching 58-60 HRC, we felt it would be a solid choice for our hammer as it would undergo vigorous impact testing and high amounts of stress from usage. However, from the recommendation of Abel Ardis, our foundry sponsor, we decided to go with AISI 4140 stainless steel. Both 440C and 4140 steel have extremely close densities, 7.80 g/cm^3 and 7.85 g/cm^3 respectively, so the weight factor was not much of a concern. The other aspect was the case hardening offered at American Foundry Group Inc. which we felt would give us a much more competitive edge compared to annealing or quenching. While both materials share many characteristics, the resilience and corrosion protection offered by 4140 stainless steel won out for our design and ended up being the material we decided to go with.

Moving on to the technical side of our hammerhead and its design was how to get the most out of our project while still maintaining its strength. We wanted to go with a sunken in portion to reduce weight and create a longer overall hammer to be more visually appealing. We also wanted to make use of casting instead of forging, coming up with the idea of having a Norse-inspired weaving pattern be casted into the final product. We wanted to put a level of detail hard to achieve through other processes.

To go with our desire to cast detailed, hard to achieve goals, that determined our casting process to be investment casting as any other would fall short. The level of detail provided by investment casting was exactly what we were looking for without going into a method much too extreme or costly for our one-time production. While time intensive, we feel that the results were well worth it when it came to the final product that we are proud of.

Challenges

The biggest challenge facing us is the design. How to make a world famous hammer/symbol with our own spin, while staying in the constraints provided. Making a battle hammer under six pounds with a handle. Our design was wax printed and ready to go when we found out that our combined weight of hammer and handle must be under six pounds. While we now see it as a very large and obvious oversight, no one within our team realized our issue until much too late. We managed to have some luck dealing with our extreme weight as the mold made of our hammerhead was not scaled to account for shrinkage, giving us a fairly lighter head all together, allowing us to keep working.

One additional problem we faced was, here in Texas we had a snowstorm from February 13th - 17th. Leaving our electric grid crippled in some areas and pipes bursting all over the state, which caused rolling blackouts and no water, making us unable to do any work to the project and sheltering at our homes. While much more fortunate than others who were affected, we still lost over a week of being able to work with what we felt was already a challenging time frame.

The last ongoing issue that we, and every other team faced, was the continuing Covid-19 pandemic. Our access to tools, equipment, and any other location has been affected in some capacity, making the production of our hammer be a tougher challenge than we ever anticipated. We have continued to work as hard as we can and have felt that the hammer we produced was done to the best of our ability given all the extenuating circumstances we have experienced.

Conclusion

Our team here at Texas State University feel that the Thor's Hammer we have created demonstrates the creative, technical, and determined attributes of all team members involved, and believe that our stands out as a great representation of what we can achieve. From its symbolism and iconography serving to show the background of the mythology, the strength, resilience, and durability behind our material, and the level of detail and benefits of the casting process, we wholeheartedly feel that our hammer is a strong contender for this year's Cast in Steel competition.

Photos







