Steel Castings

A Tool for Efficient Design and Cost Savings

By William C. Gibb

Pouring steel.

I often start a conversation with the simple statement that this is a steel casting. I can see eyebrows lift slightly and I know what they are about to ask. A casting…isn't it brittle? Can you weld it? The simple answer is this is cast steel not cast iron. To explain this further we need to explore how castings are made, their properties and where their application is most effective.

My father started North Star Casteel Products Inc. in 1972, where I am currently serving as president. In 2001, I became involved in a task committee formed by the American Institute of Steel Construction (AISC) and the Steel Founders Society of America (SFSA) that is actively promoting the use of steel castings in the construction industry. This is where I first heard about the Kaiser Bolted Bracket (KBB), a steel casting that is shop fillet welded to a beam to form a field bolted special moment frame connection. The retrofit version is drilled and bolted in place without any welding. After the parent company, ICF Kaiser Engineering, closed in 2000, I purchased the patent and Steel Cast Connections LLC was formed to develop and sell the KBB connection.

In January of 2004, we submitted the KBB for the review process by the AISC Connection Prequalification Review Panel (CPRP) for inclusion in the ANSI/AISC 358-05 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*. The interesting challenge came when we realized that AISC only had a very basic generic casting specification. So, with the direct help of SFSA, a specification that covers the material and all QA/QC requirements was developed as Appendix A to the code.

Cast Iron verses Cast Steel

Cast iron contains a carbon content above 2%, which crosses the point where the carbon can go into solution. The result is free carbon that moves very easily between the grains and precipitates out as carbon flakes or spheres. This is why it is difficult to weld, as this carbon pools up along grain boundaries and the heat affected zone (HAZ). These flakes tend to create a cushioning action, making it an excellent material for compression or vibration loads. On the other hand, it has very poor strength in tension, as the flakes tend to encourage cracking and breakage. Cast iron is also easier for the foundry to pour, as it remains fluid much longer which is why it is an excellent material for ornamental iron work. The March 2009 issue of *STRUCTURE magazine* contains an excellent article by Jon A. Schmidt, P.E. about iron.

In the mill the steel is rolled, which causes the grains to lie down and form an anisotropic structure where the steel has high strength in one direction and a low strength in the transverse direction. This structure is also common in a forging. In a steel casting, the dissipation of heat as it solidifies causes the dendrites (crystals) to form from the outside of the part toward the center creating an isotropic structure (equal in all directions). In addition, once the part is in its final shape, it is typically normalized, quenched and tempered to form a very fine-grained homogonous structure.

Structural elements that incorporate parts of differing thickness can work better as a casting than a built-up fabrication because the entire piece, including the varying thickness areas, can be cast as one element. The bracket is one example of a good application for a casting because

Finishing a KBB mold.

Kaiser bolted bracket casting.

of the varying thicknesses throughout the part, including a 2-inch thick base. To make such parts as a weldment would require costly complete penetration (CJP) welds to become one element. The end result would then likely have warping and HAZ issues, and would require special inspection of each weld. In the casting, there are no residual stresses or weld materials to cause these problems.

Foundry Process

In a typical steel casting, the sand is compressed around a pattern, then drawn apart to remove the pattern and leave a cavity. The molten steel is poured into the mold at around 3,000 degrees Fahrenheit. At North Star Casteel, we pour around 170 different types of steel. A typical material selection for construction castings is a grade of low alloy (grade 80/50), which closely matches steel beam material and can be easily welded. The addition of alloys and the heat treatment process provide a lot of tools with which the designer can balance toughness and ductility to the needs of the application. In short, the foundry has many options for finding the best material for a particular part.

Initially, it costs more to make a steel casting than a simple fabrication. As the shape becomes more complex, with varying wall thicknesses and CJP welds, the cost of the fabrication goes up considerably. The cost to make a complex design shape as a casting is still about the same, so the two cost curves cross and the casting will become the least expensive option for complicated shapes. In addition, the casting will not have HAZ issues or residual stresses that would be found in the weldment.

Conclusion

Steel castings can provide one more tool in the toolbox of the engineer who is trying to find an effective solution for special situations. The foundry industry is anxious and willing to help in the process of material selection and interactive design to help the engineer. Steel castings can provide considerable savings and a more efficient solution to certain engineering problems.▪

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Tapping the furnace.