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PROJECT TITLE: ***Quantifying the Effect of Filling Conditions on Low Alloy Steel Casting Quality***

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IMPACT: To quantitatively compare casting metal quality and filling simulation results for a variety of filling conditions utilizing a combination of optical metallography, automated nonmetallic inclusion analysis, and evaluation of mechanical properties.

Technical Need

Filling related defects are one of the leading causes for casting rework and rejection and represent a significant cost to steel foundries. In response to the demand for cleaner quality castings, new gating systems are being developed to prevent air entrainment and enable better filling conditions. Previous research has shown that a well-designed gating system can help decrease molten metal turbulence, air entrainment, and slag, as well as capture detrimental inclusions that might enter the casting cavity. Various types of flows that occur in gating systems can entrain air into molten metal leading to the formation of oxides entrapped in the liquid metal as reoxidation inclusions. The conditions that produce these defects are still not well understood or predicted by commercially available filling and solidification software packages.

Project Goals

To study the effects on steel casting quality of various gating systems developed utilizing commercially available simulation software and tested in laboratory and commercial trials.

Technical Approach

This study examines the comparison of quality and mechanical properties produced in laboratory and commercially cast low alloy medium carbon steel castings with three different gating systems: horizontal gating partially pressurized, horizontal gating non-pressurized and best practices bottom filling utilizing a vortex-style gating system. A novel mold was created to simultaneously compare the three different gating systems along with a control gating system.

Findings and Conclusions

Alumina inclusions were the main filling related inclusions and were found in clusters throughout the castings from all the four systems. The overall comparison of inclusion area fraction, size, and distribution obtained from the top layer of the castings showed that the horizontal non-pressurized systems and best practices bottom filling systems had the least filling related inclusions. The pressurized system exhibited a high area fraction of alumina inclusions. Sectioning of the vortex overflows revealed that the area fraction of inclusions in the overflows were higher than in the castings, proving that the overflows collected most of the damaged incoming metal and slag effectively. The bottom fill system with a top riser was shown to have the highest measured toughness among all the systems.