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Quantifying Casting Quality Through Filling Conditions

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IMPACT: Oxide-related damage within castings shows inconsistent findings when applying bi-film theories during filling of aluminum castings.

Technical Need

Focused concern and education related to filling damage and oxide inclusions has been widely promoted among the foundry industry in the past three decades, with special regards to aluminum. However, due to a lack of supporting data, predicting the quantifiable damage oxide film may cause to the quality of aluminum castings during the filling process remains largely theoretical.

Project Goals

To study and quantify the relationships of various filling conditions to a casting's quality. The attribute qualities related to filling will be gathered by noting the differences in mechanical properties, dye penetrant inspection, leak testing, radiographic inspection and metallography. With the help of simulation analysis, actual casting damage will be compared with the predicted filling results. This process will look to correlate actual filling-related damages with filling concerns related to oxide formation.

Technical Approach

The study is uniquely designed to measure the qualitative effects based on filling conditions. This was accomplished by comparing the quality of leg sections within a test casting. Samples were poured for four different aluminum alloys.

Findings and Conclusions

Inconsistent with bi-film theory predictions, the overall porosity and tensile quality of the bottom fill castings fared similarly and even slightly lower than the side-fill and top-fill castings. Directional solidification and cooling rates played a more significant role in controlling casting quality.

The turbulent top fill system demonstrated the ability to create repeatable filling damage in the forms of bubbles, seams and flow tubes. The bubbles associated with the top fill system were noted as being very buoyant, clinging to within a few mm of cope surfaces. The buoyant nature of the bubbles indicates that these defects could be removed by venting areas of concern, or by machining cope surfaces.

The semi-tranquil side fill system demonstrated the ability to create filling damage in the forms of flow lines and flow tubes. Despite the metal falls that occurred, little evidence of bubble formation was noted.

The tranquil filling conditions of the bottom fill system demonstrated the ability to avoid bubble formations, seams and flow tubes. However, it did so at the cost of establishing adverse thermal gradients by bringing heat through the bottom of the casting. These thermal conditions increased porosity and decreased tensile properties.

