Industrial Technologies Program

Characterization of Surface Anomalies from Magnetic Particle and Liquid Penetrant Indications

Steel castings utilize the superior properties of steel to produce lighter weight and more energy efficient components for transportation systems (cars and trucks). In order to use the geometric flexibility of castings, accurate numerical simulations are essential. Accurate simulations require an understanding of surface and near surface anomalies. The most common mode of failure for ground-based vehicles is fatigue, which causes about 60 percent of construction equipment failures. Fatigue failures almost always initiate at or near the surface, so surface quality also has an important effect on the number of stress cycles that occur before failure. In addition, the current surface acceptance standard (ASTM A-903) may be excessively restrictive, resulting in scrapped or reworked parts due to surface indications that do not affect part performance.

Researchers from the University of Alabama at Birmingham have found that accurate simulations increase the net melting energy efficiency by improving casting yield and reducing rework and scrap. Quantitative data on the shape, size, and source of surface discontinuities indicated by ASTM A-903 would be extremely valuable for estimating anomaly effects on dynamic properties. This project will produce castings at steel foundries and collect a variety of surface discontinuities. With input from the Steel Foundry's Society of America's Carbon and Low Alloy steering committee, molding sands, alloys and pouring conditions will be selected to produce anomalies that will provide a range of magnetic particle and liquid penetrant indications.

A low alloy steel casting containing surface crack indications (MPI)

Benefits for Our Industry and Our Nation

- *An estimated energy savings of 1.33 x 10^{12} BTU/year.*
- *An increase in net melting energy efficiency.*
- *Improvements in casting yield and reductions in rework and scrap.*

Applications in Our Nation's Industry

This research will develop accurate simulations to improve casting yield and reduce rework and scrap rate in steel castings. This will enable the utilization of the superior properties of steel to produce lighter weight and more energy efficient components for the transportation industry.

Project Description

The goal of this project is to characterize surface/near surface indications and develop an inspection and analysis protocol to evaluate the effectiveness of current surface quality standards.

The objectives of this research are:

- Collect a variety of surface/near surface indications from participating foundries with the appropriate ASTM rating as measured by the foundry.
- Metallurgically characterize each anomaly to determine source, size, shape, depth, and sharpness.
- Evaluate the effectiveness of current surface quality standards in predicting the actual size and shape of the indication and their effect on casting performance.

Milestones

The tasks for this project are:

1. Review Literature on Surface/ Near Surface Anomalies: Review literature on the effects of surface anomalies on steel castings, qualifying and quantifying methods and potential new identification methods.
2. Select test plate pouring conditions: Select molding sands, alloys and pouring conditions to produce a wide range of anomalies.
3. Pour test plates and collect donated castings: Produce castings at steel foundries that provide a variety of surface indication types and severities.
4. Metallurgically examine selected indications: Examine a statistically valid population of each defect type to determine causes, shapes and sizes and potential effects of the indications.
5. Conduct Gage R&R on current surface anomaly standards: Conduct a round robin study to determine the repeatability and reproducibility of current surface anomaly standards.
6. Explore Unconventional NDT techniques: Evaluate unconventional NDT techniques to determine their ability to distinguish between cosmetic defects and defects that degrade casting performance.

Project Partners

University of Alabama-Birmingham
Birmingham, AL
Steel Founders Society of America
Crystal Lake, IL
Cast Metals Coalition Partnership
Charleston, SC
A.G. Anderson, London, Ontario
Atlas Foundry & Machine Company, Tacoma WA
American Cast Iron Pipe
Birmingham, AL
Harrison Steel Castings, Attica, IN
Monett Steel Castings, Monett, MO
Matrix Metals, Richmond, TX
Sawbrook Steel LLC, Cincinnati, OH
Sivyer Steel Foundry, Bettendorf, IA
Southern Alloy Corp., Sylacauga, AL
Southern Cast Products, Meridian, MS
Southwest Steel Casting Company
Longview, TX
Spokane Steel Foundry, Spokane, WA
Vancouver Iron & Steel, Portland, OR
Wollaston Alloys, Braintree, MA

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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