

METAL CASTING

Project Fact Sheet



ADVANCED STEEL CASTING TECHNOLOGY

METHODS IDENTIFIED TO PRODUCE CLEANER STEEL CASTINGS

BENEFITS

- Reduces macroinclusion saving the industry \$38 million.
- Reduces energy usage by 5% due to the production of cleaner, lower weight castings that require less heat treatment.
- Reduces greenhouse gas emissions due to the reduction in energy usage.

APPLICATIONS

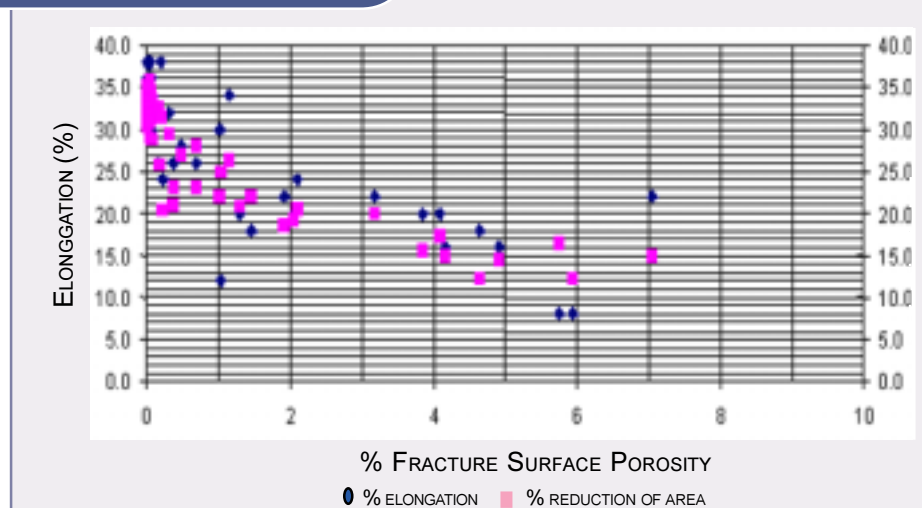
These findings are being applied in the steel foundry industry and will improve quality in virtually all steel castings. Participating foundries are already seeing dramatic results. In one foundry, for example, the number of welds requiring repair dropped 82%. This information will be used by designers to expand the use of castings in existing markets and improve opportunities for sales in new markets through the development of new alloys for the steel industry.

One of the barriers to steel casting productivity is the formation of macroinclusions as the molten metal is processed and poured. Research has shown that a large share of casting defects consist of re-oxidation products. Therefore, any method of reducing the exposure of molten steel to atmospheric oxygen during mold fill should reduce macroinclusions and casting repairs. This research performed at the University of Alabama- Birmingham is identifying causes of macroinclusions and devising methods to eliminate their occurrence. It will result in cleaner, lower weight castings.

Research to date has resulted in a number of significant benefits. The use of ceramic shrouds has resulted in improved casting consistency. The key to reducing oxygen exposure has been a submerged nozzle. Test results have shown that shroud defects are near zero on shroud systems versus gating systems. Demonstrations have shown cost reduction of 14% with a 4% increase in yield. Participating foundries have also seen measurable improvements in reducing dirt and the number of welds requiring repairs.

The current phase of research will analyze the effects of micro-porosity on mechanical properties of cast steel. Guidelines and models will be developed to design a ladle and gating system that reduces re-oxidation and the formation of inclusions. Finally, dilatometry and heat treatment techniques will be used to determine the decomposition kinetics of ferrite into austenite and other phases in duplex stainless alloys.

ELONGATION AND REDUCTION OF AREA
VS. FRACTURE SURFACE POROSITY



Effect of fracture surface porosity on elongation and reduction of area for medium carbon steel.



Project Description

Goals: This R&D project's goals are as follows:

- To develop a database for micro-porosity, material properties, nondestructive response, and a mathematical micro-porosity predictor of four commercial cast steels.
- To provide the steel foundry industry with a set of guidelines on how to gate a steel casting.
- To develop an improved understanding of the transformation behaviors in these duplex stainless steels and the interrelationship between heat-treatment conditions (i.e. temperature, time-at-temperature, and cooling rate) and resulting phase constitution.
- To provide a knowledge database that may be used to optimize alloy composition for a particular casting.

Progress and Milestones

Phase I is complete:

- Testing was conducted on the gating system and pouring tests were performed. Initial procedures for improving machinability and for obtaining cleaner castings have been identified. A shroud that will seal against the bottom of the ladle was developed -- significantly reducing defects. Participating foundries have poured more than 2000 tons of castings using this technique. This is reclaiming work that had gone to forgings. Additional foundries have begun trials with ladle shrouds.

Phase II is complete:

- A final report on the machinability of clean cast steel was submitted in 1999. An instructional video on clean cast steel was produced and made available to industry in December 1999. Thermodynamic relationships between metal quality and basic refractory furnace practice were developed. Computer models of metal flow and fill have been generated for a number of steel gating systems. Gating systems have been rated using numerical values of turbulence and surface area calculated from the computer model. Guidelines were developed from foundry trials and computer modeling for gating steel castings.

Phase III is underway:

- A test plate will be developed and poured at participating foundries using various gating systems and the cleanliness of the castings correlated with the gating system. Nondestructive evaluation (NDE) will be performed on blanks removed from selected areas of the test plates. Tensile specimens will be machined from the inspected blanks and mechanically tested. Fractography will be performed on the fracture surfaces, and the relationship between micro-porosity, mechanical properties, computer simulation, and NDE response will be developed. Transformation diagrams will be determined utilizing dilatometry and heat treatment techniques, supplemented with metallographic examinations, to determine the decomposition kinetics of ferrite into austenite and other phases in two duplex stainless alloys: 4A (22Cr-5Ni-Mo-N) and 6A (25Cr-7Ni-Mo-N). Transformation kinetics will be determined for both isothermal and continuously cooling conditions to produce TTT and CCT diagrams, respectively. The results will be compared with those predicted by Thermo-Calc.



PROJECT PARTNERS

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