METAL CASTING

Project Fact Sheet

Die Life Extension: Design Factors

Benefits

An average 20% extension in die life is anticipated as a result of the better design procedures generated by this research. Improved die life of this magnitude could result in a savings of $200 million per year in die replacement costs. Energy savings will occur as a result of reduced die manufacturing requirements as well as reduced downtime in die casting operations.

Applications

The results of this research can be applied throughout the die casting industry. These and other measures for extending die life will greatly improve productivity in die casting operations. It is anticipated that once perfected, these tools will also promote more effective use of advanced materials and cooling methods in extending die life.

Design factors causing thermal fatigue to be identified, will extend die life

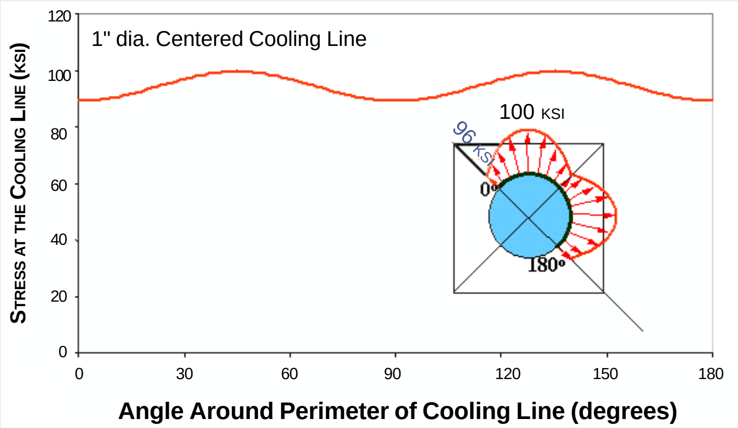
In die casting, parts can be manufactured in large quantity with desired mechanical properties and near net shapes at relatively low cost. A significant cost center in die casting, however, is cost to design and develop machined dies. Even when optimum die steels are used, these dies are subject to thermal fatigue cracking -- the main cause of failure for die casting dies.

Case Western Reserve University has been conducting a program of research to extend the life of die casting dies. As part of that program, this project is using computer simulation to identify the design factors which cause thermal fatigue cracking. These factors include size and location of cooling lines, sudden changes in cross-section and sharp radii, and dimensional factors that cause concentrated thermal stresses.

Researchers will use thermal fatigue immersion tests to quantify the relationship between temperature, stress, and heat checking. Finite Element Analysis will be used to develop a quantitative prediction of heat checking damage in production dies. The results will be used to create an "H13 Steel Thermal Stress Damage Map". In addition a final report on design criteria for die life extension will be developed. It will include guidelines for eliminating or minimizing thermal stress related failures.

These tools will enable die designers to address the factors which cause premature die failure. They will also allow die designers to make an intelligent compromise between fast production rates and long die life.

Stress at the Cooling Line



Maximum stress at the cooling line of a 2" x 2" x 7" thermal fatigue specimen.

Project Description

Goal: The goal of this research is to identify and evaluate the effect of design factors on the life of die casting dies. The study will provide die designers with computer tools that allow them to predict the thermal stresses in dies, and a method to relate these stresses with thermal fatigue cracking. These tools can be applied towards mitigating or eliminating design related problems and their adverse effect on die life.

The basic thrust of this project is to show how changes in the dimensions of the die and the location of the water-cooling lines in the die will affect die life. It has been shown that the thermal fatigue life of the surface is considerably improved by moving the cooling lines closer to the surface but the tensile stresses on the inner surface of the cooling lines is increased.

Progress and Milestones

This three-year project began in January 2000. Specific activities include:

- Finite Element Simulation - Finite Element Simulation of thermal fatigue samples will be conducted using both Procast simulation software and ANSYS code. The main thrust of the modeling will be to map the thermal stresses in the thermal fatigue samples. The reason for duplicate testing with both Procast and ANSYS is to identify any software-related issues and to define the best simulation procedures for thermal stress.

  Finite element simulation of production inserts will also be conducted using Procast and ANSYS.

- Thermal Fatigue Testing - The modeled geometries will be fabricated and tested for thermal fatigue cracking. The softening of the sample also will be monitored.

- Shot Block Experiments - A 350-ton squeeze casting machine will be used to test the predictions of the model on an annealed H13 shot block.

- In-Plant Testing and Evaluation - In-plant evaluation of inserts and cores will be conducted along with thermal fatigue testing. Emphasis will be placed upon demanding die casting applications that have traditionally required frequent die component replacements as a result of premature die failure.

- Analysis and Reporting - The results will be used to create an "H13 Steel Thermal Stress Damage Map". In addition a final report on design criteria for die life extension will be developed. It will include guidelines for eliminating or minimizing thermal stress related failures.

Project Partners

Case Western Reserve University
Cleveland, OH

North American Die Casting Association
Rosemont, IL

A. Finkle & Sons, Chicago, IL
Alloy Tool Steel, Santa Fe Springs, CA
Badger Metal Technologies, Menomonee Falls, WI
Brush Wellman, Cleveland, OH
Chem-Trend, Howell, MI
CSM Industries, Cleveland, OH
DCD Technologies, Cleveland, OH
FPM Heat Treatment, Chicago, IL
General Die Casters, Peninsula, OH
Hayes Tech Center, Ferndale, MI
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