METAL CASTING

Project Fact Sheet

Predicting Pattern Tooling and Casting Dimensions for Investment Casting

Benefits

- Improves design guidelines
- Improves casting quality
- Reduces scrap and associated reduction in remelting requirements, energy consumption and emissions

Applications

The results of this project will be disseminated, and can be applied, throughout the investment casting industry. They will be made available to casting engineers in simple spreadsheet models as well as detailed computer models.

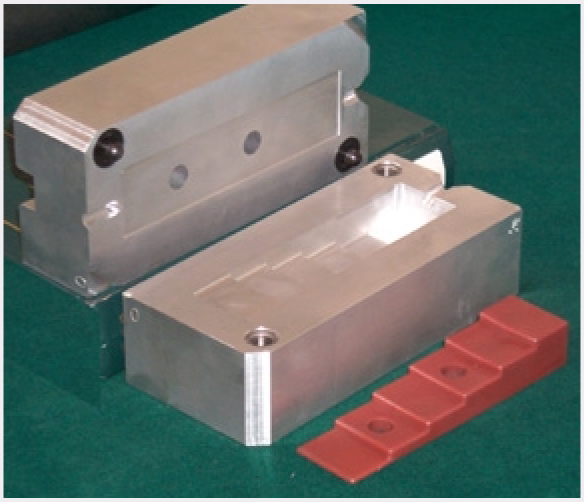
Factors affecting casting dimension, and tools to reduce their impact, are being identified

In this project tools are being developed to predict pattern tooling and casting dimensions for investment castings. Currently, the investment casting process involves the creation of a disposable wax pattern by injection into a metal mold. A ceramic shell mold is created around the wax pattern by the application of a series of ceramic coatings to the wax pattern. The ceramic shell mold is dewaxed and the alloy is cast into the dewaxed shell mold. The final linear dimension of the casting depends on the accumulated effects of the linear expansion or contraction in each step of the investment casting process, including the solidification and thermal contraction of the casting itself.

Prediction tools being developed in this project will take into account the thermal expansion, the mold restraint on the wax and alloy, and the resulting plastic, creep, and elastic deformation of wax, shell, and mold materials during solidification and subsequent cooling. The molds also will take into account the solidification characteristics of the wax and alloy, and consider solidification shrinkage. Results will be provided to the investment casting industry in two formats:

- a simple spreadsheet-based calculation for determining pattern dimensions controlled only by linear shrinkage or expansion of wax, casting, or mold materials; and
- a detailed computer model that will take into account the total effect of linear dimensional change, solidification, and mold restraint.

Validating Model Predictions



Stepped pattern and pattern die that are being used to generate experimental data and validate model predictions.

Project Description

Goal: The goal of this project is to determine and develop tools for predicting pattern tooling and casting dimensions for investment castings, taking into account the thermal expansions, the mold restraint on the wax and alloy, and the resulting plastic, creep, and elastic deformation of wax, shell, and mold materials during solidification and subsequent cooling. The models also will take into account the solidification characteristics of the wax and alloy, and consider solidification shrinkage.

Progress and Milestones

This two year project began in April 1998. A number of findings have been made.

- Literature review found that technical literature is limited to experimental, phenomenological studies that do not necessarily provide information on material constitutive behavior.

- Dimensional changes between the pattern tooling and its corresponding cast part occur as a result of thermal expansion, shrinkage, hot deformation, and creep of the wax, shell, and alloy during solidification and subsequent cooling. Relevant properties of wax, shell, and alloy materials include both thermophysical and mechanical properties.

- Data on waxes commonly used by the investment casting industry provide information on wax flowability, and guidelines for pattern handling. However, they cannot readily be used to predict wax deformation. However, test methods used to characterize polymeric materials may be used to determine properties needed to quantify wax deformation.

- Waxes are primarily viscoelastic materials, while the shell and alloy are elastic and viscoplastic materials at investment casting temperatures.

- Models that seek to predict investment casting and tooling dimensions must include heat transfer, solidification, stress build-up due to the restraint of wax and alloy geometrical features, and elastic, plastic, viscoelastic, and viscoplastic (creep) deformation.

Commercialization Plan

Following validation tasks, tutorials will be developed for casting engineers for using models for production castings. Workshops will be conducted providing tutorials for industry members. The results also will be disseminated through trade press and industry conferences.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

American Foundry Society
Des Plaines, IL

Accu-Cast, Inc., Chattanooga, TN

Howmet Corp., Whitehall, MI

Johnson & Johnson, Inc.
Raynham, MA

M. Argueso & Co.
Mamaroneck, NY

MINCO, Inc., Midway, TN

PED Manufacturing Ltd.
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Precision Metalsmiths, Inc.
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