Industrial Technologies Program

Predicting Pattern Tooling and Casting Dimension for Investment Casting

Determining the pattern tooling dimensions is crucial to the dimensional control of the investment casting processes. Pattern dies are used to create wax patterns by injecting wax into dies. The wax patterns are used to create a ceramic shell by the application of a series of ceramic coatings, and the alloy is cast into the dewaxed shell mold. The final linear dimension of the casting depends on the accumulative effects of the linear expansions or contractions in each step of the investment casting process. The program will consider *filled* waxes, thermo-mechanical behavior of shell molds based on fused silica, and a high-temperature alloy (17-4PH steel).

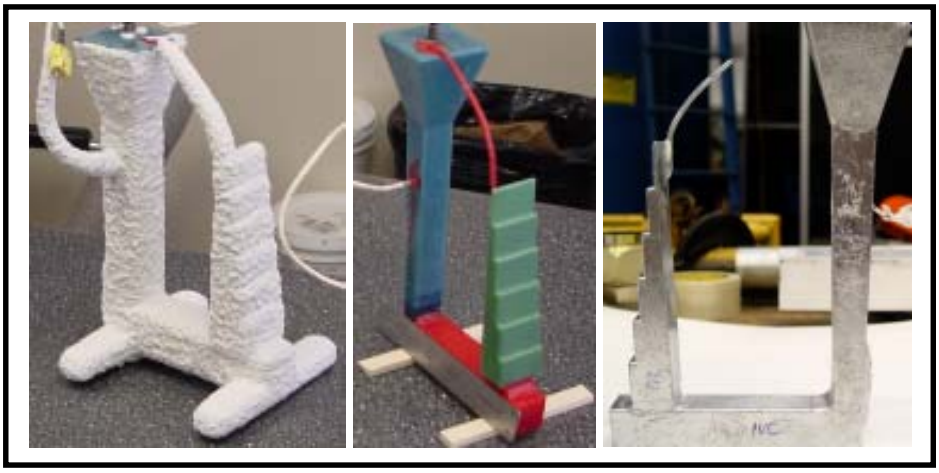
Researchers at the Edison Materials Technology Center will be working closely with those at the Oak Ridge National Laboratory in predicting pattern tooling and casting dimension for investment castings.

Project Description

This project has two primary objectives.

The first is to develop computational tools and methodologies for predicting pattern tooling and casting dimensions for investment castings.

The second objective is to enable the production of investment castings to meet blue print nominal during the first casting run.



Benefits for Our Industry and Our Nation

- *Improved predictability in pattern tooling and casting dimensions*
- *Enabling investment castings to meet blue print nominal, the first casting run*
- *Acquisition and documentation of data based on the thermo-mechanical behavior of the wax molds*

Applications in Our Nation's Industry

This research will improve the predictability of pattern tooling and casting dimension for investment castings. This will enable the production of investment castings to meet blue print nominal during the first casting run.

Milestones

The milestones for this project are:

1. Design Die Molds for Wax Patterns – Following the design activities, the die mold for wax injection will be manufactured, wax patterns will be injected, and pattern dimensions will be measured. A die mold will be made by adjusting its dimensions based on computed shrinkage factors.
2. Determine Wax Shrinkage Allowance Using Enhanced and Simplified Viscoelastic Models for Unfilled Waxes – The development of simplified constitutive models for the viscoelastic behavior will be beneficial for further implementation in the commercial casting software such as ProCAST™ and EKK™. Possible model simplifications will be considered to the traditional viscoelastic models for waxes. The simplified formulation could be based on a non-Newtonian fluid flow.
3. Obtain Properties Of Filled Waxes and Determine Wax Shrinkage Allowance – Constitutive equations for filled waxes will be developed. If the fillers are plastic materials, the filled waxes may behave more like plastic materials, depending on filler content. Industry members will provide property data and specimens for measurement, and conduct tests.
4. Determine Shrinkage Allowance Due to Shell Molds – This task will consist of obtaining property data from industrial partners, conducting experiments needed to determine the thermomechanical behavior of the shell mold materials, and determining shell dimensions. ORNL will develop additional data and constitutive models.
5. Determine Alloy Shrinking Allowance – In this task, the precipitation-hardening stainless steel 17-4PH will be considered. The thermo-physical and thermomechanical properties of 17-4PH alloy will be determined. Numerical simulations to determine casting dimensions will be performed by taking into account geometrical feature constraints, thermal effects, elastic and inelastic deformation of shell and alloy.
6. Documentation and Technology Transfer – Reports will be written for shell and alloy materials. Short reports will be made available as tutorials for prospective industry users. A simplified PC version of the proposed models will also be developed for use by foundries that do not have access to FEM computational software and engineering workstations. EMTEC and AFS members will play an important part in this task, and ORNL personnel will develop documentation, tools, and training manuals.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

American Foundry Society
Schaumburg, IL

Cast Metals Coalition Partnership
Charleston, SC

BuyCastings
Dayton, OH

J&J, A Depuy Company
Raynham, MA

JEM Manufacturing
Oregon City, OR

Precision Metalsmiths
Cleveland, OH

S&A Consulting
Beechwood, OH

Schrey & Sons
Valencia, CA

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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