ADVANCED LOST FOAM CASTING QUARTERLY REPORT
FOR THE PERIOD OCTOBER 1, 1995 - DECEMBER 31, 1995

OBJECTIVE

The objective of this project is to advance the state of the art in Lost Foam Casting technology in order to improve the competitiveness of the U.S. metals casting industries. Activities to accomplish this objective will be conducted through a Lost Foam Technology Center located at the University of Alabama at Birmingham (UAB). This Lost Foam Technology Center shall focus on developing and demonstrating advanced casting technology and transferring the knowledge to program participants. Participants include casting designers, foundry suppliers, equipment producers, producing foundries and casting users. This project shall provide a means for designers, manufacturers, and purchasers/users of cast metal parts to understand the benefits of the lost foam casting process, and shall furnish project participants the best available technology and contact with leaders in lost foam casting. The report covers the period from January 21, 1995 to February 20, 1996.

ACCOMPLISHMENTS

Task 1 - Pyrolysis Defects and Sand Distortion

An L8 test matrix was performed to determine the effects of sand type, coating type, coating viscosity, and vacuum level on the critical dimensions of a Caterpillar oil cooler pattern. Sixteen patterns were selected from a group of patterns having a density of 1.3 lbs/ft³. Critical pattern dimensions, including internal and external pattern diameters, wall thicknesses, and overall pattern lengths were measured with an air gaging system. The patterns were then poured with gray iron. The experimental variables were different from casting to casting, and were selected to quantify the effects of effects of these variables on the dimensional changes from pattern to

final casting.

The critical dimensions of the final castings were measured using the air gaging system, and the changes from the initial dimension were recorded. In this experiment, it was determined that only the sand type used to pour the casting had a significant impact on the casting dimension. The silica sand produces erratic dimensions due to the fact that it goes through a significant phase change around 600° C, whereas Olivine sand expands only slightly.

Another thirty oil intercooler patterns were selected, measured, and shipped to three different foundries. Two of these foundries poured the castings in silica sand while one used olivine. Dimensions were recorded on the final castings, and the following changes resulted: Foundry #1 produced castings with larger inner diameters and smaller outer diameters. Foundry #2 produced castings with larger inner and outer diameters on one end, and smaller inner and outer diameters on the other end. Foundry #3 produced oval-shaped castings. This suggested that compaction and pouring procedures at different plants affected final dimensions of the casting.

Experiments are currently being performed on the pilot line at UAB to correlate pattern pyrolysis related casting defects with metal front shape and velocity. These tests involve four different coatings with known permeabilities and dried thicknesses with known dimensions and foam densities. Metal front profiles and velocities such as porosity, surface carbon, and sand burn-on in the finished castings.

This task is on schedule.

Task 2 - Bronze Casting Technology

Several sponsors have expressed in interest in developing the lost foam process to casting of bronze alloys. Designed experiments will be performed to determine the process variables important in making successful lost foam bronze castings. These experiments will include such variables as coating type and permeability, sand type, pattern type and density, and vacuum level.

Task 3 - Steel Casting Technology

As with bronze casting using the lost foam process, steel casting requires special attention to casting parameters. Designed experiments will be performed to determine which process variables are important to successfully producing lost foam steel castings.

Task 4 - Sand Filling and Compaction

Compaction experiments were conducted in conjunction with the L8 casting matrix on oil cooler patterns to determine the effects of compaction on the distortion of these oil cooler patterns. Two oil cooler patterns were mounted on a casting tree identical to the ones used in the L8 dimensional study. One of the patterns was instrumented with two distortion strips consisting of a piece of stainless steel shim stock with a number of strain gages attached. The other pattern was instrumented with potentiometric linear sensors arranged at key locations to measure changes in the part diameter at the right, center, and left positions on the oil cooler pattern.

The results of the strain gage tests indicated that distortions similar to those recorded in final castings occurred during the fill and compaction cycle.

A series of experiments was performed evaluating the distortion behavior of an industrial truck spring hanger pattern. The pattern was compacted in a flask in eight separate trials utilizing variations of position of the pattern and acceleration levels of the compaction table. In all of the recent experiments, significant pattern distortion occurred in the pattern during the compaction cycle. The key dimension of the pattern (arm spacing) has been shown to decrease .4" or more. Analysis of the results of the tests indicate that pattern orientation and acceleration level are the most critical factors in determining the degree of pattern distortion.

Two extensive sets of plant trials were conducted over the past quarter. In one set of trials, a sponsor was having difficulty accurately casting a two cylinder engine block casting. The pattern was instrumented with linear potentiometric sensors, and in-situ pattern distortions were measured on the pattern. These sensors revealed several sections of the compaction cycle which were causing significant distortions in the compaction cycle, and the compaction cycle was adjusted to reduce pattern distortions.

In the other compaction trial, a project sponsor was having difficulty with compaction operations at their plant which could be described as inconsistent compaction from flask to flask. Some flasks produced consistently good castings, while others produced castings with a high degree of variability in a critical dimension. Extensive vibrational diagnostics tests were conducted at the sponsor's plant to identify possible causes for the high degree of variability. The tests concluded that improper seating of the flask on the compaction

table was to blame for the compaction difficulties.

This task is on schedule.

Task 5 - Coating Technology

A gage R&R test was performed on the coating air permeability and liquid absorption tests. A previously performed gage R&R using one standard test specimen was used to show the effects of the test procedure (reproducibility) and the operator (repeatability) on the coating test results. The new gage R&R made use of actual coating specimens. This test was performed to separate the variability due to the specimen from that due to the test procedure and the operator. The test has been completed, and the results are currently being analyzed.

An error was discovered in the coating permeability measurement procedures. Permeability procedures used up until this point did not take the compressibility of air into account. Because of this, all previously calculated data had to be reanalyzed to take this into account.

This task is three months behind schedule.

Task 6 - Precision Pattern Production

A set of flange patterns was produced using two densities of foam for use in casting trials at the University of Missouri - Rolla using 356 Aluminum. Flanges were produced using average foam densities of 1.35 and 1.85 lbs/ft³ and two steaming processes using both Autoclave and Cross-steaming processes. Unexpectedly, little difference in foam density and density gradient was found between patterns produced using Autoclave processes and those produced using a cross steam process. Casting trials will investigate the effects of different pattern densities and density gradients on Lost Foam mold filling.

Earlier sets of experiments with flange patterns were designed to investigate the causes of foam density gradients in patterns. A pattern was instrumented with thermocouples in key locations, and trials were conducted using several variables, including autoclaving, cross-steaming, vacuum, cooling water impingement locations, fill gun pressure, fill gun vacuum, and fill gun type. Results indicate that factors other than the controlled variables are controlling the foam density gradients within the flange pattern. These other factors may be the molecular weight and pentane content of the foam beads.

Further testing and analysis is required to determine the controlling parameters in quality foam pattern production.

This task is on schedule.

Task 7 - Computational Modeling

The designed experiment to study fill of the EPS flange experiment was completed. This experiment was designed to investigate the effects of the following variables on the fill characteristics of the pattern:

- 1) Average foam density
- 2) Pattern steaming process (Autoclaved vs. Cross-Steamer)
- 3) Metal pouring temperature (750°C and 800°C)
- 4) Coating permeability
- 5) Gating locations (gates placed at high and low density sections of the foam)

The results of these trials will be combined and verified for use in a computational model of the lost foam casting process.

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DISCLAIMER

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Approval

A handwritten signature in black ink, appearing to read "Charles E. Bates". The signature is fluid and cursive, with a long horizontal stroke at the end.

Charles E. Bates
Research Professor

File Name: epcq4sum.fav

U.S. DEPARTMENT OF ENERGY
FEDERAL ASSISTANCE PROGRAM/PROJECT STATUS REPORTFORM EIA 459F
(10/80)FORM APPROVED
OMB No. 1900 0127

1. Program/Project Identification No. DE FC07 93ID1230	2. Program/Project Title Advanced Expendable Pattern Castings	3. Reporting Period _____ through _____
4. Name and Address University of Alabama at Birmingham, AL 34294-4552		5. Program/Project Start Date October 1, 1995
1016 15th Street South, Birmingham, AL 35294-4552		6. Completion Date September 30, 1997

7. Approach Changes

☒ None

8. Performance Variances, Accomplishments, or Problems

Revisions of Casting Permeability measurements required that all previous Permeability Data be updated to include the effects of Air Compressibility. These Data Revisions have slowed progress in task 5.

☐ None

9. Open Items

☒ None

10. Status Assessment and Forecast

☒ No Deviation from Plan is Expected

11. Description of Attachments

☐ None Accomplishments and Project Status is attached.

12. Signature of Recipient and Date	13. Signature of DOE Reviewing Representative and Date
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MASTER