Microwave Drying of Foundry Investment Casting Shells

Prototype Testing Confirms Substantial Potential to Improve Productivity

Background

The investment casting process is capable of producing castings with extremely accurate dimensional tolerances and is very popular for production of both steel and nonferrous near-net-shape castings. The process utilizes a wax pattern to form a mold cavity. The wax pattern is encased (invested) with a ceramic slurry/stucco consisting of 7 or 8 layers to form a ceramic mold or shell, see Figure 1.

After the shell is dried at room temperature the wax is melted from the shell using direct gas-firing or a steam autoclave. The shell is then fired at high temperature to cure the ceramic. Finally the shell is filled with molten metal to form the casting.

During the production of shells it is necessary to dry the ceramic slurry after each layer is applied. This is usually accomplished by conventional convection air drying at ambient temperature to prevent cracking of the shell. As a result, drying is the most time consuming step in the process and can take days to produce a shell.

Heating the shell by direct gas-firing to rapidly dry the ceramic coating will cause the wax core to melt. Because thermal expansion of the wax is appreciably greater than that of the ceramic coating, rapid expansion of the wax may lead to cracking of the shell. Development of a suitable method for enhancing the drying process without cracking the shells could dramatically increase productivity.

Materials Production (CMP) and New York State Electric and Gas Company funded a project with Cober to evaluate the application of microwaves to enhance the drying of investment casting shells.

For this study, a special microwave oven was designed and constructed to accommodate a vacuum system. Vacuum was created in a glass bell jar, which was contained within the micro-

**Figure 1.** Schematic showing production of investment casting shell and microwave drying operation.

The CMP Project

Cober Electronics, Inc. a manufacturer of microwave equipment proposed a method for drying investment casting shells using microwaves, see Figure 1. During the drying cycle, water is evaporated from the shell surface which causes cooling to take place. Cober theorized that if heat (microwave energy) could be carefully added to overcome the cooling, the drying process could be accelerated without cracking the shell. The EPRI Center for wave cavity, with a vacuum pump. This system is capable of producing a vacuum down to about 40 millibar (mbar). Microwave power was adjustable from 0 to 1200 W at a frequency of 2450 MHz. Also, arrangements were made for measuring specimen surface temperature, specimen weight, and process duration. A rectangular bar shape, measuring 2.40 inches wide by 1.34 inches thick by 4.33 inches long, was used for the wax core specimens.
The drying process variables studied during the research were as follows:

- Air Drying at Room Temperature
- Vacuum Drying at 40 mbar
- Microwave + Air Drying at 100 W and Room Temperature
- Microwave + Vacuum at 100 W at 40 mbar

The specimen surface temperature was limited to 80°F to prevent excess expansion of the wax and shell cracking.

Summary of Results

A total of 20 specimens were tested, 5 at each of the four conditions evaluated. The test results showed that the following times to achieve 80% moisture loss were typical for drying one layer:

- Air Drying 180 min.
- Vacuum Drying >180 min.
- Microwave + Air Drying 60-80 min.
- Microwave + Vacuum 45-50 min.

Following the drying step all 20 samples were dewaxed in a steam autoclave and examined for cracks. None of the specimens exhibited cracking. The shells were then fired in an oven to cure the ceramic coating.

About 40% of the specimens exhibited no cracks. The remaining shells had some very small surface cracks but were considered suitable for casting. Fourteen of the shells were then filled with molten steel. All of the shells held the molten metal... indicating that they were satisfactory. It can be concluded from the study that microwave drying of investment casting shells offers a significant reduction in drying time without any deleterious effects to the casting shell.

Benefits

Based on the results of the experimental study the application of microwaves to dry investment casting shells should provide a reduction in drying time of 50 to 60%. This should result in a significant increase in productivity. The amount of energy required to dry the test shell was 6 kWh. In a typical investment casting foundry shells are processed in clusters, 25 to 50 shells at a time on a rack. It is estimated that energy usage could range from 150 to 300 kWh per cluster with a microwave process.

Key Words: Foundry, Investment Casting, Microwave

Applicable SIC Codes: 3324, 3325

To Implement this Technology

Additional pilot tests should be undertaken prior to a commercial installation. Interested foundries or their electric companies should contact CMP.

For technical information, call CMP's Bob Schmitt 412-268-6442, or John Svoboda 708-427-9060.

A research report on the R&D work is also available (94-4RR), and can be obtained from CMP Publications 412-268-3404.

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For ordering information, call the EPRIAMP Program 1-800-4320-AMP.