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R.J. Collins Incorporated White Paper

Accu-Set™ Mass Flow Mold Calibration For Air-Casting Systems

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Mass Flow

To understand the mass flow concept, it is essential to begin with the relationship between mass, temperature and pressure. Real gases roughly follow the ideal gas law, which states that the pressure, temperature and volume of a gas are all interrelated PV = nRT, where: P = pressure of the gas V = volume that the gas occupies n = number of molecules (i.e., mass) R = ideal gas constant T = temperature of the gas. The ideal gas law defines the volume a certain mass of gas will occupy under specific conditions. For example, say a fixed mass of gas occupies a one liter container at 70°F under 1 atmosphere pressure.

When the pressure of the system is increased (with the temperature held constant), the volume will decrease. If the temperature is increased, (with the volume held constant), the pressure will increase. The only constant variable is the mass of the gas; it does not change. *Mass flow is the molecular measurement of the gas flow rate*. This is usually measured in units of mass per unit of time, as liters per minute.

Introduction

The heart of the air-casting mold is the graphite casting ring which distributes a combination of oil and casting gas. This gas and oil combines to suspend the molten metal to achieve a frictionless casting surface within the mold. The permeability of a casting ring changes over the life of the ring due primarily to oil contaminants and polymerization. As the permeability decreases, higher gas pressure is required to achieve the required air flow to overcome the resistance in the fouled casting ring.

Variable area flow meters (rotometers), traditionally supplied with new casting mold tables, does not compensate for changing pressure conditions; therefore, do not show actual gas flow rates. Figure 2 shows the difference in gas flow measurements between a mass flow meter and a rotometer for 11 molds tested. This demonstrates the need for casting gas flow measurement to have pressure and temperature compensation.

Figure 1 Rotometer

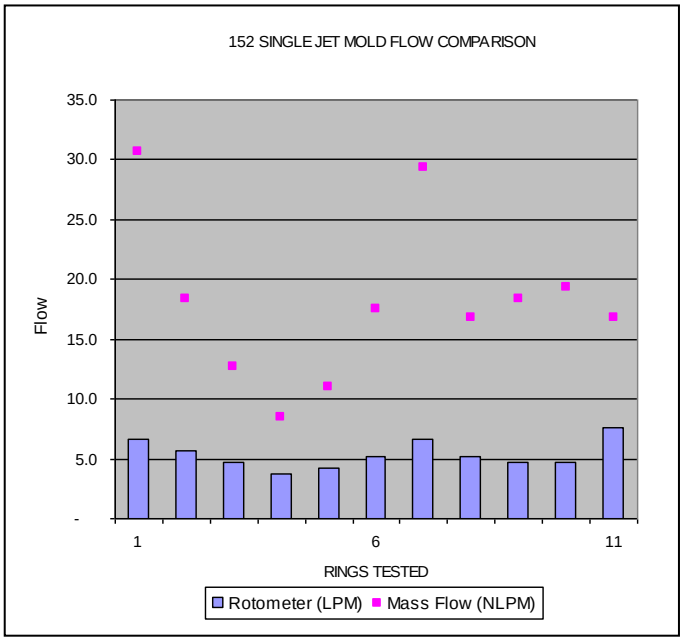

Figure 2 Rotometer and mass flow comparison

Inaccurate flow rates can lead to casting defects such as out of air-cast, especially during the critical cast start-up phase.

R. J. Collins pioneered the use of mass flow meters to accurately measure the actual flow rate to each mold. The implementation of these meters, plus testing to insure the casting characteristics of each casting ring, has made dramatic improvements in many casthouses. Some users have reported the investment as the single best investment they have made because of the fast payback.

R. J. Collins pioneered *mass flow* implementation

Problem Statement

It is critical to have a dependable and accurate casting gas flow to each mold at the start of cast. Not enough gas will prevent going into air-casting mode. Too much gas can cause excess bubbling, surface defects and bleedouts, increasing safety risks, impacting production and making after-cast cleanup more difficult.

The required casting gas flow rate is the amount of gas required to develop a desired gas bearing inside the mold to enable the air-casting process. The upstream gas flow to the air bearing depends on pressure losses in the system. The most significant pressure loss occurs across the casting ring because it changes over the life of the ring.

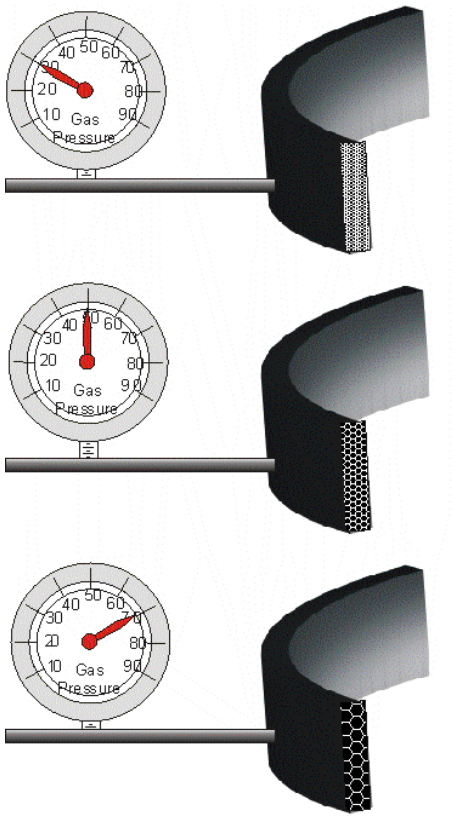

Figure 3 Greater pressures required for constant actual flow rate as casting ring plugs

Rotometers have been used to measure gas flow to each air-casting mold. Rotometers depend on fixed downstream pressure; however, with air-casting the downstream resistance changes due to graphite plugging. As the graphite resistance increases, higher pressure is required to maintain the required casting gas flow (Figure 2). The calibration of a rotometer changes if the downstream pressure or temperature changes making the measurement inaccurate.

Previous Options

As the requirement for higher billet casting recoveries goes up so does the need to more closely control the casting process. One key casting process variable that needs tighter control is casting gas flow rate.

For many years, rotometers have been used to measure casting gas flow rates. Though they are relatively inexpensive devices, they are limited in their capabilities.

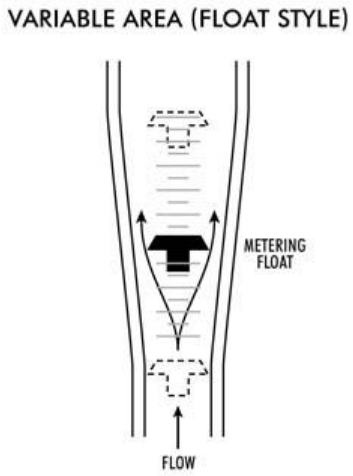

Figure 4 Rotometer operating principles

Rotometers

Rotometers do not compensate for variations in pressure and temperature of the fluid being measured. Since pressure conditions change as graphite ring conditions change, the indicated flow rate of a rotometer becomes inaccurate over the life cycle of a casting ring. Additionally, since the flow characteristics of all molds are different, the indicated flow rates cannot be compared unless pressure and temperature compensation is considered.

Pressure Compensation Needed

Since pressure can vary significantly in the air-casting process, pressure compensation is necessary. As an example, if the pressure drops across a casting ring changes from 30 psi to 60 psi, the actual gas flow would decrease by 23% even though the indicated flow rate would be the same for both conditions as shown in Figure 4.

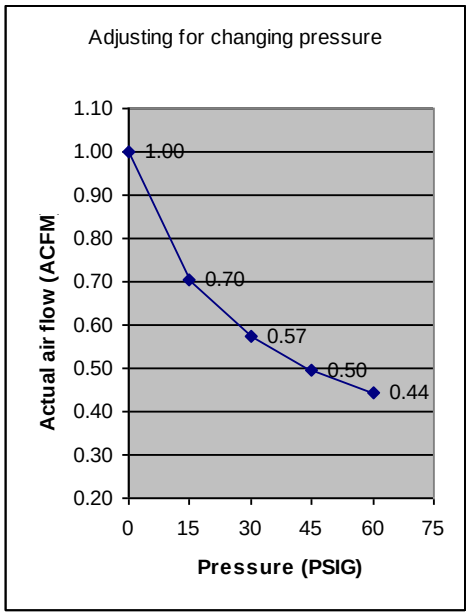

Figure 5 Impact of Pressure on Rotometers

R. J. Collins Solution

Accu-Set™ Mold Calibration System

Since 1998, R.J. Collins has recognized the importance of accurate gas flow settings in the air-casting process. This has led to the development the ***Accu-Set™*** Mold Calibration System. This system uses mass flow meters to accurately set gas flows to each mold that result in better billet surface quality with less surface scrap.

Figure 6 Typical Accu-Set™ Mass Flow Mold Calibration Installation

Electronic mass flow meters use thermodynamic principles to measure true mass flow rate without the need for temperature or pressure compensation. A detailed description of the devices is beyond the scope of this white paper. Detailed descriptions are available from many flow meter manufacturers. Many flow meter manufactures offer mass flow meters in various configurations and multiple technology types.

Figure 7 Mass Flow Meter

An electronic mass flow meter requires a power source and is typically configured with analog voltage output. The output value is true mass flow and is not influenced by system pressure or temperature. The analog output is connected to a digital display (Figure 7) that shows the actual gas flow going to a mold.

Figure 8 Digital Mass Flow Display

Mass flow meters are more expensive than rotometers. Ideally it would be best to have an individual mass flow controller for every mold. This option is very expensive and difficult to justify because it requires a flow controller with feedback control loop to every mold. The flow to each mold would then need to be controlled by the PLC.

R. J. Collins has found over the years that the simplest design is usually the best design. The R. J. Collins approach minimizes the number of flow meters to provide casthouses the best overall value but still achieve success. Since flow measurement and adjustment is done intermittently, a mass flow meter can be shared by several molds. Simply turn on a selector valve to the mold in question and the airflow is displayed on the meter. The operator can adjust the flow rate using a precision control valve that is located above the selector valve.

R. J. Collins has converted over 40 tables to the **Accu-Set™** Mold Calibration System.

Implementation

All equipment is configured for a specific billet system. R. J. Collins performs a project review upon receipt of order. Connections fittings and mounting information are confirmed. All equipment is shipped ready for easy installation. The R. J. Collins team is on site to supervise installation, start-up, training and parameter optimization.

R. J. Collins Enhancement

Accu-Set™ Air Pressure Control Panel

In most cases dry air can be used as the casting gas instead of the originally supplied gas mixing panels that relies on the operators to set, is costly to operate and is a safety concern. In addition, the components inside the gas mixing panel and airlines to the table are typically undersized which causes large pressure drops to occur during a cast start or when calibrating molds at high pressure. The Accu-Set™ Air Pressure Control Panel solves this problem by having the correctly sized internal components and airlines to the table. It also includes a pressure transducer if one is not already sensing the air pressure on the mold table. With this panel the air pressure is proportionally controlled by the PLC casting recipe using a PID loop control similar to the way that cast speed and water flow is controlled. Optional equipment to aid in process troubleshooting is also available such a totalizing mass flow meter and dew point meter if they do not already exist in the casting pit air supply system. Start-up assistance is included when combined with Accu-Set Mass Flow Mold Calibration retrofit.

Figure 9 Air Pressure Control Panel

Accu-Set™ Pressure Control Box

If no PID loop control system is available in the casting pit PLC, then the Accu-Set™ Air Pressure Control Box is used to manually control the air pressure from the Accu-Set™ Dry Air Pressure Control Panel to the mold table. To adjust the air pressure simply turn the control knob on the panel until the correct air pressure is shown on the display. These adjustments are controlled by the operator during a cast or when calibrating molds. This insures the correct amount of air pressure is supplied to the mold table during the table fill, cast start, and during the rest of the cast as per the casting recipe. Start-up assistance is included when combined with Accu-Set Mass Flow Mold Calibration retrofit.

Figure 10 Air Pressure Control Box

Summary

Accurate casting gas flow rates are critical to high performance air-casting. R. J. Collins originated the mass flow approach to measuring and controlling casting gas flow rates and offers a cost effective solution with mass flow meters that are shared with several molds. Dramatic improvements to casting recoveries can be achieved with mass flow measurement.