ЛИТЕЙНОЕ ПРОИЗВОДСТВО

ABP INDUCTION

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AUTOMATIC POURING WITH STOPPER–CONTROLLED POURING MECHANISMS

The principal challenge is to pour, at a defined moment in time, a melt of suitable quality and specific temperature into a mold to achieve an expected result. The various parameters that have to be controlled creates high demands on the casting process (see fig. 1). In the industrial manufacture of castings it is no longer the art of the craftsman that is critical, but rather the absolute reproducibility of the pouring parameters.

The following will demonstrate the mechanized and automatic pouring systems guarantee reproducibility and also fulfill the stringent demands expected of the pouring process.

1. History of Automated Pouring

ABB developed the automated pouring activities with the introduction of the “Teapot” type furnace in 1961 for holding and pouring of molten metal via siphons.

During 1967, the first open heated pouring system was developed to support a DISA-Molding line continuously with molten metal.

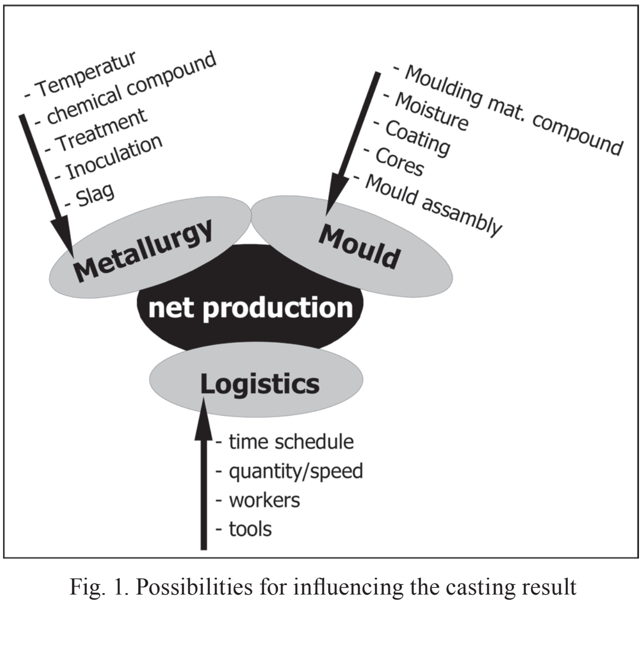
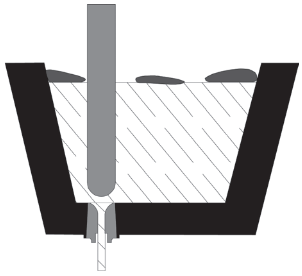
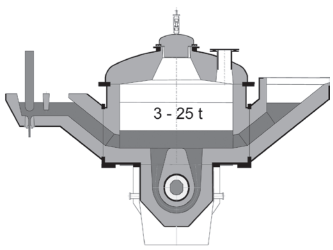


Fig. 1. Possibilities for influencing the casting result



The first pressurized heated pouring furnace PRESSPOUR was developed in 1969 and was installed in the Volvo-Foundry located in Skövde/Sweden. Production commenced in 1970.

The high reliable stopper rod system – used for pouring of grey iron and magnesium treated iron – were developed in the early 60’s to support the pouring systems.



The next milestone in the development of automated pouring solutions was the direction to go to the controlled stopper rod system. In the early 60’s the “teach-in” pouring process, a pre-programmed time based system, was introduced. Furthermore, an optical (1986) and laser-based (1987) automated stopper controlled pouring systems were introduced into the foundry industry to support the complex process. This development directly enhanced the overall pouring process including consistent pouring streams, over-pouring prevention, and increased yields.

Within the last few years developments within visualization and specific design improvements focus on maintenance and high reliability/flexibility to pour various metals.

2. Demands of Automated Pouring

The common position within the overall production process of the foundry with an automatic molding line is shown in fig. 2. Accordingly, the pouring facility has two principal functions, namely to hold the melt ready for pouring at the respective mold line and

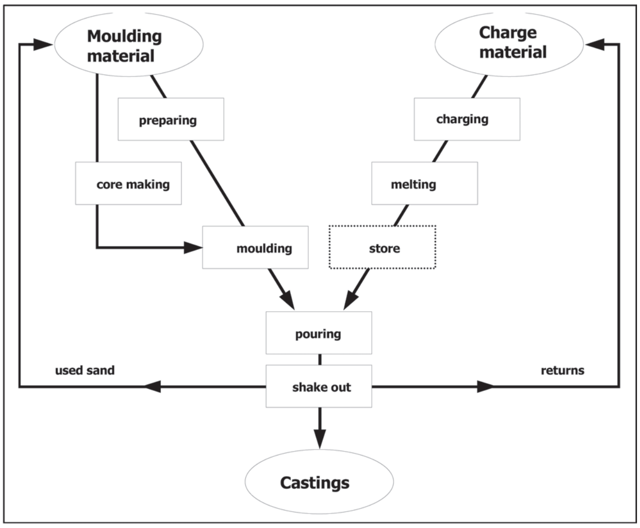


Fig. 2: Simplified Diagram: Principal Material Flow Circuit

to pour the material into molds in conformity with defined requirements.

The demands for automatic pouring are:

• provision for an adequate quantity of melt within the defined temperatures;

• dosing the required melt quantity with the defined accuracy and the characteristic melt flow in the mold;

• pouring in short cycle times with high yield and low personnel expense;

• low-turbulence movement of the melt;

• ability to obtain each pouring position;

• high availability rate with low maintenance of the pouring device.

3. Possibilities for Automatic Pouring

Fig. 3 depicts typical solutions used in automatic pouring.

The tilting ladle assembly represents a pouring process that can be completed manually. The ladle movement is motorized and integrated into a control system. The problem of material movement (sloshing effect) when pouring is uncontrollable and a migrating pouring stream remains virtually unchanged with an automated pouring system. The amount that can be supplied to the ladle is very limited. The ladle has to be constantly changed very rapidly to maintain a continuous pouring process without any production interruptions. In regards to the batch mode operation, this process results in the fluctuation of the alloy composition and temperature of the melt, and has a direct influence on the divergence of the quality of the castings produced.

The similar result applies to the stopper ladle. The advantages of this pouring system over the tilting ladle is the bottom-pouring principle. The pouring stream does not migrate and it can be directed into the sprue cup without sloshing, and all pouring points can be obtained. Rapid pouring is not a problem. The slag floating on the surface of the melt cannot enter the pouring stream as long as the melt level is constantly maintained above the nozzle.

The pressurized pouring system combines these advantages, with compensating the level of the fluctuations in the alloy composition and temperature. It is characterized by the following features:

• a sufficiently large holding capacity is always available at the pouring line to ensure continuous mold filling;

• effective insulation and the capability to heat; ensuring the temperature can be kept within defined limits during standstills of the molding line;

• quantity portioning is reproducible as the unchanging static pressure does not cause any variation in the flow speed;

• the pouring stream to the mold is short and without severe turbulence;

• decreased maintenance and a high availability rate reduces costs;

• the syphon in-gate and discharge gate ensure slag separation and provide a closed atmosphere over the melt. This permits the use of an inert gas which is particularly advantageous when pouring Mg-treated melts.

Heated and Unheated pouring systems

The tilting ladle system is an unheated pouring system. Stopper ladle systems can be unheated or heated as well.

A more detailed distinction will be made between unheated and heated pressurized pouring systems (fig. 4).

The unheated Pouromat® system (Fig. 5) is designed for smaller quantities and rapid alloy changing.

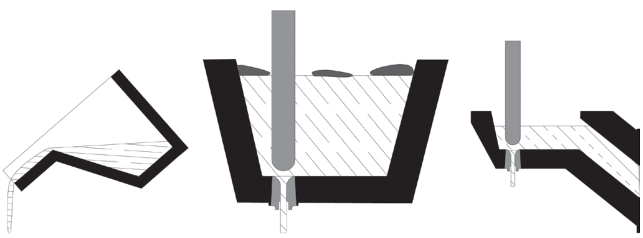


Fig. 3. Tilting ladle, Stopper ladle, Pressurized pouring system

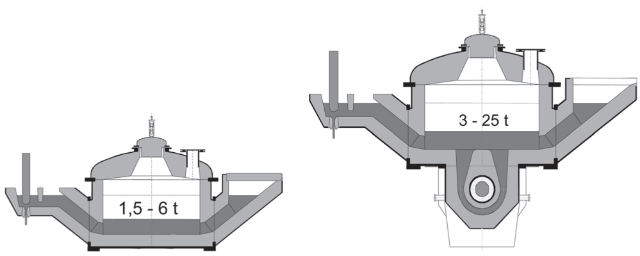


Fig. 4. The unheated Pouromat® System and the Heated Presspour® System

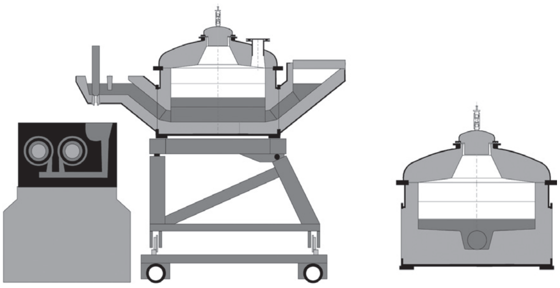


Fig. 5. The Unheated Pouromat® pouring system

A designed basin in the bottom of the vessel ensures that the residual amount, which has to be drained, is minimal and the heel is minimized within in the vessel.

The low profile design provides the capability of the system to be installed on a foundry floor without a pit. The frame construction ensures rapid changing of the pressure vessel. The stopper rod mechanism, pouring level control, and inoculating system, etc., are connected to the furnace frame. The time for vessel changing is approx. 1–2 hrs.

The temperature drop of the melt in the unheated Pouromat® system is limited to max. 1.5 K/min. Temperature uniformity is enhanced by the shape of the pouring basin with a very small surface and the pneumatically actuated lid covering the filling siphon.

The heated system PRESSPOUR® is deeper in design as an inductor is incorporated at the bottom of the vessel. A channel inductor is standard in this configuration, but it is also possible to attach a crucible inductor. Filled pouring furnaces with a channel inductor are maintained hot during standstills on account of the susceptibility of the inductor refractory lining to cracking. Pouring furnaces fitted with a crucible inductor can stand without melt over the weekend, and they only require a gas burner for preheating.

The advantage of pouring furnaces over unheated systems lies in the fact that, after an unexpected delay of the molding line, production can be resumed as the pouring furnace is ready for pouring without any hesitation.

Both heated and unheated systems feature the same practice-proven substructure with longitudinal and transverse axis so that they can be readily adapted to different pouring positions.

The stopper rod design is common for both systems. Figure 6 shows the design of a pneumatically actuated stopper mechanism consisting of a pneumatic drive with a torsionally rigid arm, a rapid-change stopper rod holder, a stopper rotating device and a patented cleaning device for the nozzle assembly. The latter has proved to be particularly valuable in connection with automatic pouring of Mg-treated pouring applications.

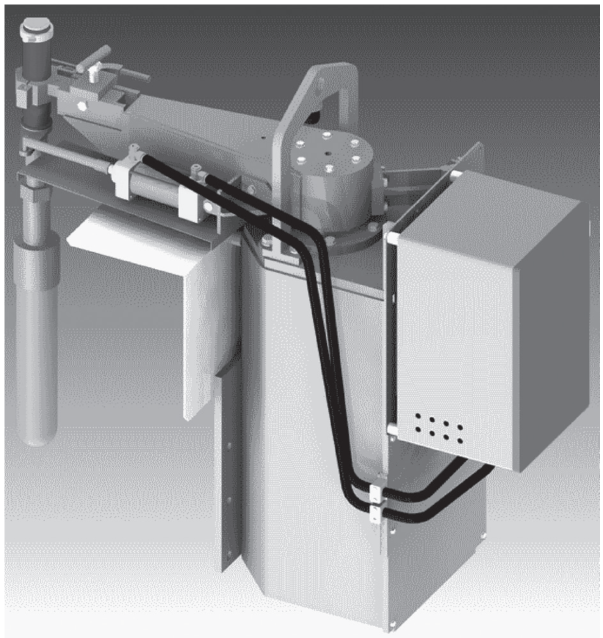


Fig. 6. Design of the ABP stopper system for automatic pouring

The operating force of the drive has been purposely limited to 750 N to minimize stopper wear. This pressure still produces a tight closing seal, yet the surface pressure exerted on the edge of the nozzle still remains well within the limits of the materials. A pneumatic cylinder adequately dimensioned for this purpose and fitted with a proportional valve operates faster (by the factor 2.5) than a hydraulic cylinder designed for the same limit values. Moreover, the pneumatic system eliminates the use of hydraulic fluid within the hot zone of a pouring installation.

The stopper rod rotating device prevents leakage. The stopper is rotated by approx. 60° during the closing operation before the maximum closing pressure is applied. The number of pouring cycles between the individual turning operations can be adjusted in the control system for adaptation to individual requirements.

The outlet cleaning rod operating through the hollow stopper can be used whenever required. At the end of a selected pouring cycle the cleaning rod passes through the nozzle and cleans the incrustation which falls onto the mold. The resulting clean cross-section of the nozzle guarantees a reproducible pouring stream.

4. Pouring-Level Control and Regulation

There are Two (2) control configurations to ensure demand-conform mold filling.

- “Teach-In” pre-programmed control.
- Automated control including closed loop level control.

The “Teach-In” programming is defined as the control configuration following a pre-determined pour-

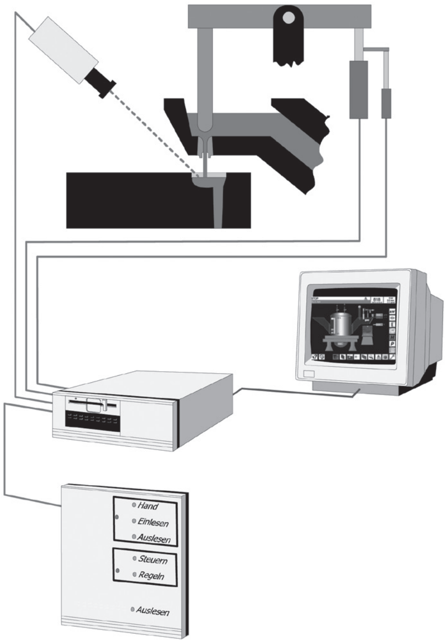


Fig. 7. Diagram of a Laser-Controlled Pouring Stream

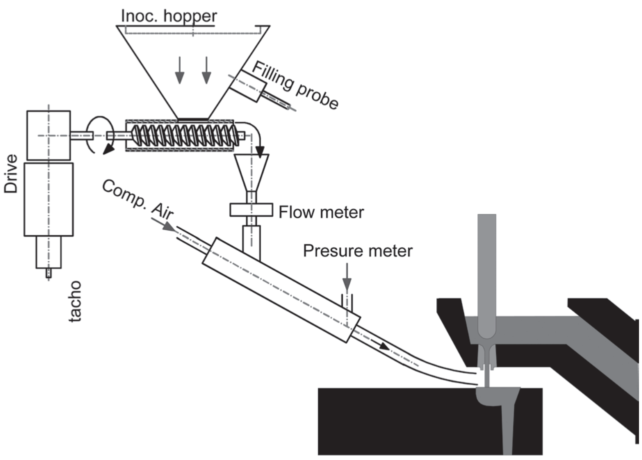


Fig. 8. Pouring Stream Inoculation Monitoring System

ing curve associated with the mold geometry without reactions to operating tolerances or changes to the stopper rod and nozzle.

In the case of the automatic control configuration, the filling level of the sprue cup is continuously measured by a laser (fig. 7) or a camera, within a closed loop control circuit. Molten iron dosing is adapted to the filling characteristic of the mold by way of feedback from the stopper rod drive, i.e. the pouring level in the sprue cup always remains constant. At the end of mold filling the bath level in the sprue cup is lowered to minimize the returns.

The control systems offered are the Optipour® and LaserPour® systems, which are different in regards to the cup level measuring method. The distinction is between utilizing the camera optical system, or by laser technology. The implementation depends on mold geometries specifically the overall size of the sprue cup diameter.

These systems prevent sprue cup overflow because the stopper is closed with sufficient speed. Pouring is stopped within a specified time in the event of mold breakage, even if the bath level has not been obtained. This prevents excessive iron spillage pertaining to a mold run-out.

An additional module is available specifically for rapid indexing molding machines with vertical mold partitions according to the Disamatic principle. As a result of advance control commands, the off-time between the pouring cycles is minimized, so that a cycle time of <8 sec. per mold can be achieved.

5. Integrated Inoculation

Another advantage of the pouring system is providing reliable inoculation prior to filling the mold. The method described here ensures that the timed sequence between inoculation and solidification is reproducible for each casting, while the fluctuations caused by fading and segregation can be ignored. The inoculation control is integrated in the control system of the pouring device.

The most common form of inoculation in conjunction with an automatic pouring system is pouring stream inoculation. The powdery inoculant is blown into the pouring stream during mold filling. It is important for the foundry process that the complete inoculation can be entirely documented. Figure 8 shows an example of a complete monitoring system.

Wire inoculation can be used as an alternative or in addition to stream inoculation. The wire is fed into the pouring basin by a spooling device just during pouring (see figure 9). The variable parameters (speed, length, moment in time) and the type of filler wire (diameter, composition) can be influenced in the control.

Lastly, higher standards of accuracy are achieved by the Isopour® process (fig. 10). The inoculator is added in a closed chamber so that only the defined

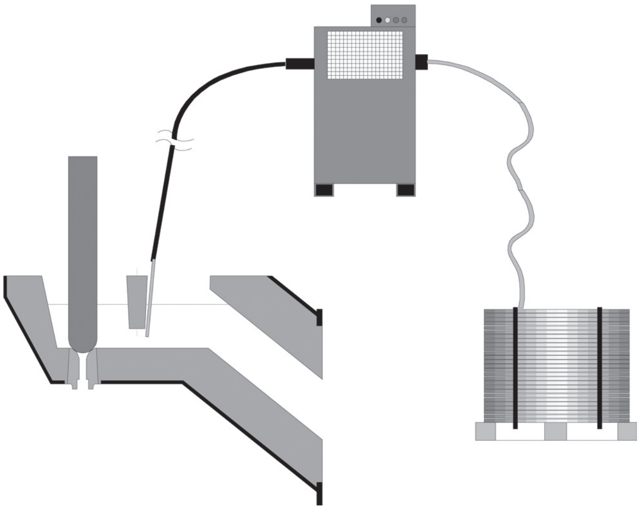


Fig. 9. Wire Inoculation Configuration

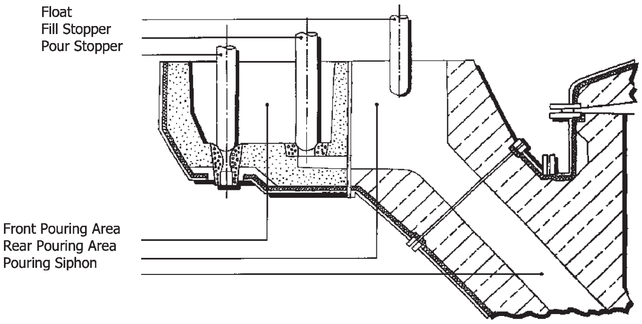


Fig. 10. Isopour® Process

quantity that is to be poured is treated. However, this system requires more mechanical maintenance which is to be evaluated in comparison to the metallurgical advantages.

Summary

The reproducibility of the many parameters influencing the pouring process is the main condition to reach the quality required in industrial casting manufacturing. This requirement can be fulfilled by automatic pouring pressurized systems with stopper dosage characterized by the following features:

- material buffer at the pouring line with melt temperature in the required tolerance;
- conformance of the Requirements for mold filling;
- regulated pouring speed;
- pouring in short cycle times with minimized returns;
- application of inert gas for oxygen-sensitive melts;
- integrated inoculation;
- high availability and low maintenance;
- low personnel expense.

By continuous improvements the pressurized automatic pouring systems are proven and are accepted worldwide in the foundry industry.