Fully automated liquid metal weight measurement

The industrial casthouse performance of the BatchPilot furnace liquid metal weight measuring system, and its new automation features, are discussed in this review by Michael Bryant of a forthcoming TMS 2012 paper to be presented by John Courtenay of MQP Ltd, UK.

The BatchPilot system, which operates on the principle of detecting changes in the furnace cylinder hydraulic pressure and tilting angle, is well established as a reliable means of measuring accurately liquid metal heel and full furnace weight in tilting furnaces. To date forty seven systems are in operation in twenty casthouses worldwide. The benefits of accurate measurement of furnace heel and full furnace weights are well accepted in the casthouse industry in terms of increasing the percentage of “right first time” batching, increasing productivity and eliminating short casts.

The BatchPilot system has the capability to measure furnace heel and transfer weights to an accuracy of between 0.5 - 1.0 %, which in practice means measuring the weight of a 50 t full furnace to +/- 500 kg. A unique feature is its ability to recognise build-ups on furnace hearth and walls, thus eliminating potential errors in the heel weight measurement. This paper outlines the development of the BatchPilot system, its performance in an industrial casthouse and the recent innovation of a fully automated weighing capability and down line integration of the output data into the customer management data network.

Development

A schematic view of a typical tilting furnace is shown in fig 1. In operation, the furnace is supported by its pivots and up to two hydraulic cylinders, which means that the furnace mass is distributed between the furnace pivots and the cylinder(s). The proportion obviously depends on the location of the centre of gravity of the whole system and can be obtained by straightforward calculations. Due to the geometry of the system, a large furnace angle corresponds to a larger pressure in the cylinder.

Figure 1 Schematic diagram of a tilting furnace

Weighing the liquid metal inside the furnace using the hydraulic pressure in the cylinder seems, at first glance a straightforward procedure. Knowing the pressure when the furnace is empty, a correspondence can easily be established between the pressure variations caused by various amounts of liquid metal to determine the actual metal mass inside the furnace. Importantly, however, several other parameters must be taken into account in order to obtain an accurate measurement.

First, friction plays a significant role in such a system. Indeed, the overall weight of a tilting furnace can be as high as 300 tonnes, imposing a friction force in the various pivots as well as in the cylinder seals. Secondly, leaks, which are always present in hydraulic systems, can make the furnace move slightly over a period of time. Since pressure in the cylinder depends on the furnace position, this can prevent accurate measurements being obtained. Furthermore, deposits of dross accumulate on the furnace walls, and build-ups of significant weight can occur. This creates a “dead” mass adhering to the furnace walls, that does not move when the furnace is tilting, as opposed to the molten metal, and influences the pressure accordingly.

A series of fundamental experiments (1) were carried out to establish the relationships, under dynamic conditions, between pressure and furnace tilt angle, pressure versus time and furnace position versus time. This allowed a comprehensive model to be developed to determine accurately the weight of molten metal in the furnace.

In practice the BatchPilot system software is able to characterise any furnace by means of conducting a series of calibration measurements with the furnace completely empty and full. Once characterised, the system can be used to determine both heel weights and the weight of metal transferred into the furnace. BatchPilot has the facility to detect build-up of dross on the furnace lining and to compensate for this in determining an accurate heel weight.

Industrial performance

An extensive programme of assessment and evaluation work on the BatchPilot system was carried out at the Alunorf casthouse in Neuss. (2) The aim was to examine the potential for using the BatchPilot system as a means of achieving better control of metal transfer weight and metal weight in the furnace and thereby optimise the number and sizes of slabs being produced per cast as a means of increasing production capacity. The work at Neuss was carried out in two phases, measurement and analysis.

Phase one - measurement:

- Heel weight measurements were made to establish the inherent BatchPilot system accuracy and variation between measurements.
- To achieve this three different furnace casts were used, and the same heel weights measured five times each on each of the three casts as shown in Table 1.

<table>
<thead>
<tr>
<th>FURNACE No.</th>
<th>SGA06</th>
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<tr>
<td>CHARGE No.</td>
<td>112714</td>
<td>112570</td>
<td>112674</td>
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<tr>
<td>1. Heel measurement</td>
<td>16.0 tonne</td>
<td>0.5 tonne</td>
<td>2.7 tonne</td>
</tr>
<tr>
<td>2. Heel measurement</td>
<td>16.2 tonne</td>
<td>0.8 tonne</td>
<td>2.7 tonne</td>
</tr>
<tr>
<td>3. Heel measurement</td>
<td>16.3 tonne</td>
<td>1.1 tonne</td>
<td>2.8 tonne</td>
</tr>
<tr>
<td>4. Heel measurement</td>
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<td>1.2 tonne</td>
<td>3.0 tonne</td>
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<tr>
<td>5. Heel measurement</td>
<td>16.5 tonne</td>
<td>1.2 tonne</td>
<td>3.2 tonne</td>
</tr>
<tr>
<td></td>
<td>DeltaG</td>
<td>DeltaG</td>
<td>DeltaG</td>
</tr>
<tr>
<td>1. Heel</td>
<td>= 0.3t</td>
<td>= 0.7t</td>
<td>= 0.5t</td>
</tr>
</tbody>
</table>

The BatchPilot furnace liquid metal weight measuring system control panel
Table 1. Heel weight measurements with BatchPilot (t denotes tonnes)

<table>
<thead>
<tr>
<th>Measurement Type</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heel weight</td>
<td>0.5 t - 0.7 t</td>
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These results showed:

- Delta G ranged from 0.5 t to 0.7 t
- (a) To maintain the integrity and stability of the BatchPilot system. This was not possible before.
- (b) The secure bridge connection is achieved by using an Ethernet/IP to DF1 Gateway communication module. This module creates a function to share a data exchange table without the risk of destabilising BatchPilot or client systems. A program has also been designed to transfer and store the data and this has been installed on the clients IT server. This program reads the time stamp of the last heel measurement and when there is a date change an ASCII file is created that sends the last heel measurement to the client batching system. When the next batch is being created the operator has the option to accept or decline the measurement.
- At the time it was developed and introduced the BatchPilot system was seen as a means of providing a more accurate estimate of furnace heel or transfer weight than had hitherto been available. This is still true but it has also become apparent that unless data from the system could be automatically introduced into the batching calculations, and measurements made without exception on every cast, the system was not achieving its full potential. Therefore the logical next step was to achieve full automation of the measuring cycle and integration of the data from BatchPilot into the batching calculation.

In conclusion:

1. BatchPilot is a system capable of measuring furnace heel and transfer weights to an accuracy of between 0.5 - 1.0 %, which means measuring the weight of a 50 tonne full furnace to +/- 500 kg.
2. A key feature of the system is its ability to recognise build-ups on furnace hearth and walls, thus eliminating potential errors in the heel weight measurement.
3. The recent development of a capability to achieve full automation of both the measuring cycle and the transfer of data on heel weight into the batching calculation is of significant benefit in improving key performance indicators such as percentage “right first time” batching.

Acknowledgements

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Bibliography

2. C. Buening et al, BatchPilot System Evaluation at Alunorf lead to increased Production Capacity, Norcast 2009.

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