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(54) Title: SYSTEM AND METHOD FOR MONITORING MOLD FLUX CONSUMPTION

(57) Abstract: A system for monitoring the consumption of mold flux in a continuous casting apparatus including a transfer apparatus for transferring mold flux from a bulk source to an intermediate hopper; a feed control apparatus for controlling the transfer of mold flux from the transfer apparatus to the intermediate hopper, the feed control apparatus including at least one load cell for weighing the intermediate hopper and the mold flux within the intermediate hopper over a period of time, the feed control apparatus further including a controller receiving input from the at least one load cell and for controlling the operation of the transfer apparatus based on the input; and a delivery apparatus for receiving mold flux from the intermediate hopper and delivering the mold flux to a mold, the delivery apparatus pneumatically feeding the mold flux to the mold.

FIG. 1
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with international search report (Art. 21(3))
SYSTEM AND METHOD FOR MONITORING MOLD FLUX CONSUMPTION

CROSS-REFERENCE TO RELATED APPLICATION


FIELD OF THE INVENTION

[2] This application discloses an invention which is related, generally and in various embodiments, to the metal casting field wherein mold flux consumption is monitored.

BACKGROUND OF THE INVENTION

[3] It is customary to apply a mold flux, which may be a powder or granular material, onto the top of a shapes mold during the continuous casting of a molten metal, typically steel, as shown in US Patent No. 6,474,398, the disclosure of which is incorporated by reference. The mold flux turns into slag when sufficiently heated by the molten steel. Typically, the mold flux being fed is in the form of a granulated powder from a bulk source such as a bag. The mold flux is fed by way of a vacuum from the bulk source to an intermediate feeder hopper. In prior arrangements such as that shown in US Patent No. 6,474,398, a constant level is maintained within the intermediate hopper with a proximity sensor which measures the level of mold flux within the hopper. The operator adjusts the set point level on a feed controller to deliver a steady feed of mold flux from a feed box.
BRIEF DESCRIPTION OF THE DRAWINGS

[4] Various embodiments of the invention are described herein in by way of example in conjunction with the following figures, wherein like reference characters designate the same or similar elements.

[5] FIG. 1 illustrates a front view of various embodiments of a system for measuring mold flux consumption in a continuous casting operation.

[6] FIG. 2 illustrates a back perspective view of the system of Fig. 1.

DETAILED DESCRIPTION

[7] It is to be understood that at least some of the figures and descriptions of the invention have been simplified to illustrate elements that are relevant for a clear understanding of the invention, while eliminating, for purposes of clarity, other elements that those of ordinary skill in the art will appreciate may also comprise a portion of the invention. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the invention, a description of such elements is not provided herein.

[8] FIG. 1 illustrates various embodiments of a system 10 for measuring mold flux consumption in a continuous casting operation; common parts will be represented by the same reference numeral. As shown, the continuous casting operation is for the continuous casting of any shape, from molten metal 15, which in the illustrated embodiment is molten steel. Mold flux 11 in granular or powder form is fed onto the top of the shapes mold 13. The shapes mold can be, by way of example, a slab mold. The mold flux 11 becomes a slag when sufficiently heated by the molten steel.
The system of various embodiments is indicated generally by reference number 10. The system generally includes four major components: a transfer apparatus 12; an intermediate hopper 14, a feed control apparatus 16, and a delivery apparatus 18. The transfer apparatus 12 transfers powder mold flux from a bulk source 20 to the intermediate hopper 14. The bulk source of powder mold flux 20 may be, for example, a large bag or barrel. After the delivery apparatus 18 feeds powder mold flux 11 from the intermediate hopper to the top of the mold.

The transfer apparatus includes a vacuum 22 having an inlet port 24 to which one end 26 of a flexible suction tube 28 is connected. The other end 30 of flexible suction tube 28 extends into the bulk source 20. Vacuum 22 has an outlet at the bottom for transferring mold flux to the intermediate hopper 14. On the bottom of the vacuum hopper 22, there is a valve such as a flapper 43 with a counter weight attached. While the vacuum 22 is energized this creates a seal between the flapper 43 and the bottom of the vacuum bin 22. When the vacuum 22 stops, the weight of the material that was picked up allows the flapper 43 to open and the material drops into the intermediate hopper 14. The intermediate hopper 14 has a fitting on the bottom that extends into the top of the feed hopper 31. The delivery apparatus 18 includes a feed hopper 31 and feeds mold flux from a pair (could be up to six outlets) of outlet ports 32, 34 of the feed hopper 31 to the top of a mold. There is no contact between the intermediate hopper 14 and feed hopper 31 as this would give a false weight.

The delivery apparatus 18 includes a pair (could be up to six delivery tubes) of delivery tubes 36, 40 each having one end connectable to an outlet port 32, 34, and the other end having anywhere from one to six feed heads 46 (two shown in the illustrated embodiment) disposed above a mold or series of molds. The mold flux
is pneumatically fed from the feed hopper 31 with 1 inch venturi pumps 41 which are operatively connected to the outlet ports 32, 34. The number of ports or 1 inch venturi pumps could vary depending on the type of continuous casting machine or shapes cast. For example: If the continuous caster is a small 6-strand billet machine, there would be a total of six molds, each mold being the size of the cast product. This would require six 1 inch venturi pumps and feed lines.

[12] The control apparatus 16 includes at least one load cell 42 supporting the intermediate hopper 14 for weighing the intermediate hopper 14 and its contents of mold flux over a period of time for measuring the real time consumption of mold flux. The at least one load cell 42 preferably includes a plurality of load cells 42, each supporting a side of the intermediate hopper 14. There are three load cells 42 in this embodiment. Only two load cells 42, however, can be seen in Fig. 1. The control apparatus further includes a programmable logic controller (PLC) 44 (Fig. 2) receiving input from the load cells for controlling the operation of the vacuum 22. The PLC 44 causes the vacuum 22 to turn on, thus causing mold flux to feed into the intermediate hopper 14, based on a predetermined weight of the feed bin as compared to the consumption or loss of weight of mold flux calculated using the output of the at least one load cell 42. The use of PLC 44 allows the ability to record daily mold flux consumption files. Alternative to a PLC 44, any suitable processor having the appropriate software such as FACTORY TALK software may be used. Also, alternative to measuring mold flux consumption by weight, it may be desirable to measure mold flux consumption volumetrically. The rate of which the mold flux is delivered onto the mold can be adjusted by the operator using an operator control screen 48 on the PLC 44 that can be used for adjusting the feed rate. The operator control screen 48 is a touch screen display that gives the operator a scale of 0 - 100.
This scale represents the mA voltage sent from the PLC 44 to the current to pressure transducers that are located in the feed hopper. Alternatively, the rate of which the mold flux is delivered onto the mold can be adjusted by the operator by a handheld wireless controller 50 in communication with a receiver 52 on PLC 44. The wireless controller 50 can be used to control the feed rate instead of the operator control screen 48 on the PLC display.

[13] Nothing in the above description is meant to limit the invention to any specific materials, geometry, or orientation of elements. Many part/orientation substitutions are contemplated within the scope of the invention and will be apparent to those skilled in the art. The embodiments described herein were presented by way of example only and should not be used to limit the scope of the invention.

[14] Although the invention has been described in terms of particular embodiments in this application, one of ordinary skill in the art, in light of the teachings herein, can generate additional embodiments and modifications without departing from the spirit of, or exceeding the scope of, the claimed invention. Accordingly, it is understood that the drawings and the descriptions herein are proffered only to facilitate comprehension of the invention and should not be construed to limit the scope thereof.
CLAIMS

What is claimed is:

1. A continuous casting apparatus comprising;
   a transfer apparatus for transferring mold flux from a bulk source to an intermediate hopper;
   a feed control apparatus for controlling the transfer of mold flux from the transfer apparatus to the intermediate hopper, the feed control apparatus including at least one load cell for weighing the intermediate hopper and the mold flux within the intermediate hopper over a period of time, the feed control apparatus further including a controller receiving input from the at least one load cell and for controlling the operation of the transfer apparatus based on the input from the at least one load cell; and
   a delivery apparatus for receiving mold flux from the intermediate hopper and delivering the mold flux to a mold, the delivery apparatus including a feed hopper configured to receive mold flux from the intermediate hopper, at least one outlet, and a delivery tube connected to each outlet for pneumatically feeding the mold flux to the mold.

2. The apparatus of claim 1, wherein the transfer apparatus includes a vacuum for transferring mold flux from the bulk source to the intermediate hopper, and wherein the feed control apparatus controls the operation of the vacuum.

3. The apparatus of claim 2, wherein the transfer apparatus further comprises a valve which is operable between a first closed position which prevents mold flux from transferring to the intermediate hopper when the vacuum is on, and a second open position which allows mold flux to transfer to the intermediate hopper when the vacuum is off.
4. The apparatus of claim 3, wherein the valve is a flapper valve having a counter weight.

5. The apparatus of claim 1, wherein the controller is a programmable logic controller.

6. The apparatus of claim 5, wherein the programmable logic controller is operable to turn on the transfer apparatus to transfer mold flux from the bulk source and to turn off the transfer apparatus to transfer mold flux from the transfer apparatus to the intermediate hopper.

7. The apparatus of claim 6, wherein the transfer apparatus includes a vacuum for transferring mold flux from the bulk source to the intermediate hopper, and wherein the programmable logic controller is operable to turn the vacuum on and off.

8. The apparatus of claim 5, wherein the programmable logic controller includes an operator touch screen adaptable for receiving input from an operator for controlling mold flux feed rate.

9. The apparatus of claim 5, wherein the programmable logic controller includes a receiver and a wireless remote in communication with the receiver adaptable for receiving input from an operator for controlling mold flux feed rate.

10. The apparatus of claim 1, wherein each outlet includes a venturi pump.

11. A method for monitoring the consumption of mold flux in a continuous casting apparatus comprising:

   transferring mold flux from a bulk source to an intermediate hopper using a transfer apparatus;

   weighing the intermediate hopper and the mold flux within the intermediate hopper over a period of time;

   controlling the operation of the transfer apparatus based on the weight of the intermediate hopper and the mold flux within the intermediate hopper;
transferring mold flux from the intermediate hopper to a feed hopper; and

pneumatically feeding the mold flux from the feed hopper to a mold.
### INTERNATIONAL SEARCH REPORT

**International application No.**
PCT/US2012/058285

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(8) - B22D 11/16 (2012.01)
USPC - 164/268

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - B05B 7/00; B22D 11/16 (2012.01)
USPC - 118/398; 164/267, 268, 412, 470, 472, 474; 222/64, 529, 531, 536, 537; 239/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Orbit, Google Patents

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>Y</td>
<td>EP 0139060 A1 (WAHL et al) 02 May 1985 (02.05.1985) entire document</td>
<td>1-10</td>
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<tr>
<td>Y</td>
<td>US 5,598,647 A (MARAZZO et al) 04 February 1997 (04.02.1997) entire document</td>
<td>3, 4</td>
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Further documents are listed in the continuation of Box C.

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**Date of the actual completion of the international search**

11 December 2012

**Date of mailing of the international search report**

17 JAN 2013

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