CONTAINERS FOR MOLTEN METAL

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ABSTRACT

Means for controlling the flow of molten metal through an orifice in a container comprises a sleeve insertable into the orifice from outside the container and located within the orifice, and means adapted to move the sleeve axially with respect to the orifice, the sleeve being closed at its end towards the inside of the container and having one or more inlet holes in the wall of the sleeve at a point approaching the closed end of the sleeve communicating with an axial bore through the sleeve, the sleeve being movable from a first position in which the closed end of the sleeve is co-planar with the inside face of the part of the container containing the orifice, with the inlet holes lying within and being closed by the orifice, to a second position where the inlet holes are exposed to the inside face of the container.

15 Claims, 5 Drawing Figures
CONTAINERS FOR MOLTEN METAL

This invention relates to containers for molten metal, e.g., ladles, and is particularly concerned with means for controlling the flow of molten metal from such containers.

Hitherto the control of the flow of molten metal from, e.g., a ladle or tundish has for many years been effected by a so-called stopper-rod system involving the introduction in the ladle of a stopper secured to a rod, the stopper normally seating on a correspondingly shaped nozzle secured in the opening from the ladle. Such systems, however, have several fundamental disadvantages such as the improper alignment that frequently occurs between the stopper and nozzle caused by distortion of the rod due to the heating effect caused by the molten metal through which the rod must pass. Therefore, not only are such systems disadvantageous because of the need for an operative to enter a ladle to ensure correct initial seating of the stopper on the nozzle, improper shut-off during the course of teeming frequently occurs by virtue of the distortion of the rod and by the wear that takes place on the stopper and the nozzle caused particularly by the erosion effect of the flowing molten metal.

In an attempt to avoid certain disadvantages of stopper-rod constructions, attempts have been made to eliminate the need to have a stopper-rod by providing mechanism capable of activating a stopper from outside the ladle. Such systems, however, retain the disadvantages caused by wear on the nozzle and the stopper leading to imperfect shut-off and still call for the replacement of the stopper from inside the ladle for otherwise the whole bottom assembly requires to be replaced. In addition to the above the very nature of the seating between the nozzle and the stopper is such as to provide a well in the bottom of the ladle in which molten metal can freeze thereby causing sticking on the nozzle of the stopper.

In an attempt to obviate all the above disadvantages there has been recent development of so-called sliding gate valves which are capable of application to a ladle and operation from outside a ladle. However, because the shut-off point is outside the ladle, the orifice through the ladle bottom lining provides an area where molten metal can freeze and it has frequently been found necessary to melt molten metal frozen in the orifice after opening of the valve, e.g., by the application of an oxygen lance.

According to the present invention, means for controlling the flow of molten metal from a container comprises a sleeve located within an orifice in the container and means adapted to move the sleeve relative to the orifice, the sleeve being closed at its end towards the inside of the container and open at its opposite end and there being one or more inlet holes in the wall of the sleeve at a point approaching the closed end of the sleeve communicating with an axial bore through the sleeve, the sleeve being such as to be capable of insertion into the orifice from outside the container, and the relative movement between the sleeve and the orifice being such as to move the sleeve from a first position in which the closed end of the sleeve is co-planar with the inside face of the part of the container containing the orifice with the inlet holes lying within and being closed by the orifice to a second position where the inlet holes are exposed to the inside of the container.

Thus, from closed position, i.e. the position in which molten metal cannot flow from the container by virtue of the inlet holes lying within and being closed by the wall of the orifice, the sleeve can simply be urged inwardly of the container until the inlet holes have cleared the orifice when molten metal flows through the inlet holes into the sleeve and along the axial bore of the sleeve.

The invention therefore avoids the use of a stopper and therefore does not embody the known disadvantages of stopper constructions, and by avoiding the provision of a well in the ladle bottom, eliminates the possibility of freezing taking place in the vicinity of the sleeve and consequently there is no possibility of the sleeve sticking. Also, because the orifice closes the inlet holes any molten metal lying within the inlet holes and the axial bore drains out of the sleeve and accordingly there is no part of the means of the invention where molten metal can freeze, the invention therefore avoiding that disadvantage in known slide valve arrangements.

To prevent flow of metal through the gap between the outside of the sleeve and the inside of the orifice that gap must be as small as possible, i.e., the sleeve must be a close sliding fit in the orifice. To this end it is preferred that the sleeve and the part of the lining containing the orifice be of the same or different high quality refractory material, or ceramic material, such as silicon nitride or fused silica which have a very low and predictable expansion, and therefore capable of providing and maintaining an accurate smooth surface finish to both the orifice and the sleeve.

Preferably, the orifice through the container is in an orifice block set in either the lower part or the container bottom, and the orifice block may be located within a support block that may be integral with or separate from the container lining. In either case the closed end of the sleeve in its "closed" position is co-planar with the top or inner face of the orifice block and the top or inner face of the support block. Preferably, the orifice block is held in place by a mounting plate suitably secured to the container casing or shell, which plate may also serve to hold the support block in place. It is further preferred that the outer surface(s) of the orifice block tapers, and is set with its end of lesser diameter towards the inner face of the lining, the orifice block locating in a correspondingly shaped bore in the lining or support block.

Movement of the sleeve may be effected by any suitable pneumatic, hydraulic, mechanical or electromechanical means, and may be a simple push/pull action or the sleeve may be rotated as it is moved, the means causing movement being suitably secured to the container shell and the sleeve such that no excess stressing of the shell and sleeve, and particularly bending moments applied to the sleeve, is caused. Thus, for example, mechanical means may be provided in the form of a cradle pivotally secured on the mounting collar and with the ends of the arms of the cradle suitably secured to the exposed end of the sleeve whereby pivoting of the cradle causes the sleeve to be lifted and lowered, the connection between the arms of the cradle and the sleeve being such that no transverse loading is applied to the sleeve. Alternatively, two or more hydraulic cylinders may be secured to the mounting collar and to a plate suitably secured to the exposed end of the sleeve.
Activation of the cylinders by the admission of pressure fluid causes the sleeve to be moved inwardly and outwardly with respect to the vessel lining to "open" and "close" the means of the invention.

The invention therefore provides an extremely simple and efficient means for controlling the flow of molten metal from a container free from the problems of metal freezing with the consequent impairing of the performance of the device. More than that it may be simply arranged to provide a high degree of control of the rate of flow of molten metal. Thus, the inlet holes through the wall of the sleeve may be elongate when the degree to which they are exposed beyond the inner face of the container lining dictates the rate of flow. Alternatively the inlet holes may be circular and spaced along the sleeve such that progressive movement inwardly of the sleeve first exposes one hole and then a second and so on, again to determine the rate of the flow up to the maximum permitted by the axial bore through the sleeve. It is preferred that the holes, whether elongate or plain cylindrical, should be inclined with respect to the plain closed face of the sleeve.

The exposed end of the sleeve may be formed such that the axial bore extends directly to the end of the sleeve. Alternatively, the bore may be caused to diverge towards that end of the sleeve, and branched to provide a number of outlets.

It will also be recognised that a number of axial bores may be provided in the sleeve, each fed by a number of inlet holes, or that a number of sleeves may be provided in a corresponding number of orifices in the orifice block.

One embodiment of the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of control means according to the invention with its mounting plate removed;
FIG. 2 is an underneath plan of FIG. 1 but shows the mounting plate;
FIG. 3 is a side elevation of FIG. 2 with the control means shown secured to a ladle bottom;
FIG. 4 is a sectional side elevation of the device of FIG. 3; and
FIG. 5 corresponds to FIG. 4 but shows the control means in the "open" position.

Means for controlling the flow of molten metal from a container such as a ladle 1 is formed by a sleeve 2 having an axial bore 3 open at its lower end and extending to two generally transverse, but downwardly inclined, bores 4 emerging at the outside face of the sleeve 2 as inlet holes 5 at points below the upper closed end of the sleeve. The diameter of each bore 4 is preferably equal to the diameter of the bore through the sleeve. The sleeve is mounted in a housing block 6 of high alumina set in the bottom of the ladle and surrounding outlet hole from the ladle, there being an orifice block or liner 7 set in the housing block and in which the sleeve is a close sliding fit. Preferably, the orifice block has an external downwardly divergent frustoconical shape to fit in a correspondingly shaped hole through the housing block. To prevent any movement of the orifice block, the orifice block at its lower end is provided with a collar 7A engaged by a correspondingly shaped locking ring 7B. Therefore, any upward loading on the orifice block is taken by the locking ring which, by being suitably secured to the lining, transmits such load to the lining and not to the housing block 6.

The locking ring also serves to ensure that there is no transverse movement of the orifice block which might otherwise affect the movement of the sleeve.

The outside diameter of the sleeve is less than the inside diameter of the bore through the orifice block by an amount which, by virtue of the surface tension of the molten metal, is less than that which would allow molten metal to flow through the small gap between the two, but the gap being great enough to allow any expansion of both the sleeve and the orifice block without the sleeve jamming in the bore through the orifice block. Thus, it is preferred to utilise silicon nitride as the material for both the sleeve and the orifice block which, by having a low and predictable expansion allows a close machine fit between the two, or they may be of fused silica which has a very low but predictable coefficient of expansion. When utilising fused silica it is preferred to have an overall tolerance between the diameters of the bore and the sleeve of between 0.002 and 0.003 inch.

The sleeve towards its lower end has a collar 8 secured between two clamping rings 9 themselves held together by bolts 10. Secured to opposite sides of one (upper) clamping ring 9 is a locating lug 11, the locating lugs being a sliding fit in a slot 12 in side support members 13 secured to a valve mounting plate 14, the valve mounting plate being suitably secured to the ladle casing by welding or by bolts to serve additionally to hold the orifice block in place. Also secured to the valve mounting plate are two supports 15 for pivots 16 for a cradle 17, the outer ends of the arms of which lie alongside and outside the locating lugs 11. The arms of the cradle are provided with slots 18 towards their outer ends to receive clamp pivots 19 secured to the locating lugs 11. The cradle 17 extends to an operating arm 20.

Thus, with the sleeve secured to the arms of the cradle, it is capable of movement between two positions, that shown in FIG. 4 when the top (closed) end of the sleeve is co-planar with the top or inner face of the orifice block, the support block and the ladle lining and the position shown in FIG. 5 where the holes 5 are exposed to the inside of the ladle. With molten metal applied to the ladle with the closure device in the position shown in FIG. 4, molten metal is held within the ladle and the ladle and the ladle can be transported from a point alongside a furnace to a position above a suitable receptacle (a mould) for the molten metal. During this time, the metal in the ladle forms no more than a skull adjacent the face of the lining, there being no well in protuberance which would increase the cooling effect on the metal with the consequent danger of freezing. With the cradle in that position the operating arm 20 is swung to cause the cradle to pivot about the pivots 16, the engagement between the clamp pivots 19 and the slots 18 being such as to cause the clamping rings 9 and thus the sleeve 2 to be lifted. The engagement of the locating lugs 11 and the slots 12 in the side support members 13 ensures that the sleeve is maintained in a vertical position during its movement. The slots 18 in the arms of the cradle 17 allow relative movement between the arms of the clamp pivots 19 thereby preventing any transverse loading on the clamping rings 9. Thus, the sleeve 2 is lifted vertically until such time as the openings to the inclined bores 4 lie above the top of the ori-
office block 7 when molten metal in the ladle is allowed to flow through the bores 4 and 3 and into a suitable receptacle such as a mould. When teeming is to be discontinued the arm 20 is operated to cause opposite pivotal movement of the cradle 17 to lower the sleeve 2 until such time as the openings to the bores 4 lie within the orifice block 7. Obviously, if teeming is not required to cease but is required to be reduced or throttled, the cradle can be pivoted by an amount such that the sleeve 2 will be positioned with the openings to the bores 4 lying partially within the orifice block 7, the degree to which they lie below the top of the orifice block determining the rate at which metal will flow through the bores.

To ensure that the top of the sleeve is co-planar with the top of the orifice block, in the closed position, set screws 21 are provided passing through the bottom of the support members 13 and emerging in the slots 12 to be abutted by the locating lugs 11 in the lower (closed) position of the closure device. On closure of the device, any molten metal already in the bores 4 and 3 will continue to flow out of the bores and accordingly, the device is self-draining. Due to the cooling effect of the ladle lining, the so-called skull frequently forms above the closure device before teeming commences. Hence, the device is well capable of being lifted through the layer of viscous cooling metal forming the skull and the subsequent flow of hot metal is well capable of melting the skull.

Apart from the simplicity of the construction, one of the primary advantages of the device of the invention is that it gives a position shut-off without the need for a stopper and without providing an area where molten metal can freeze, and the molten stream from the device is compact and steady due to the effect of the relatively long bore 3 and is not subject to divergence from the outlet of the bore thereby giving better ingot quality on direct teeming. Also, because the sleeve can be inserted into the orifice from below, the sleeve itself can readily be replaced should it be damaged during use without the need to disassemble the other refractory components.

In addition to its applicability to direct teeming from a ladle, the device may also be used to pour molten metal from tundishes in continuous and sequential casting, and with the sleeve extended it can be used for the submerged pouring of molten metals directly into continuos casting moulds. The device can also be fitted in the bottom of metal refining furnaces, e.g., electric arc and basic oxygen process furnaces and used to teem molten metal from the furnace. It could also be fitted such that the sleeve is horizontally disposed and with the device mounted in the wall of a furnace at a predetermined level to provide an outlet for slag or metal.

What we claim is:

1. Means for controlling the flow of molten metal from a container, comprising a sleeve located within an orifice in the container and means adapted to move the sleeve relative to the orifice, the sleeve being closed at its end towards the inside of the container and open at its opposite end and there being one or more inlet holes in the wall of the sleeve at a point approaching the closed end of the sleeve communicating with an axial bore through the sleeve, the sleeve being such as to be capable of insertion into the orifice from outside the container, and the relative movement between the sleeve and the orifice being such as to move the sleeve from a first position in which the closed end of the sleeve is co-planar with the inside face of the part of the container containing the orifice, with the inlet holes lying within and being closed by the orifice, to a second position where the inlet holes are exposed to the inside of the container.

2. Means for controlling the flow of molten metal as in claim 1, wherein the orifice through the container is in an orifice block set in either the lower part of the container wall or the container bottom, the closed end of the sleeve in its first position being coplanar with the inner face of the orifice block.

3. Means for controlling the flow of molten metal as in claim 2, wherein the orifice block is located within a support block, the inner face of the orifice and support blocks being co-planar.

4. Means for controlling the flow of molten metal as in claim 3, wherein the orifice block is of frusto-conical form with its end of lesser diameter towards the inner face of the lining of the container, the orifice block locating in a correspondingly shaped bore in the support block.

5. Means for controlling the flow of molten metal as in claim 2, wherein the sleeve and the orifice block are formed from the same or different high quality refractory material or ceramic material.

6. Means for controlling the flow of molten metal as in claim 5, wherein the refractory material is silicon nitride.

7. Means for controlling the flow of molten metal as in claim 5, wherein the refractory material is fused silica.

8. Means for controlling the flow of molten metal as in claim 2, wherein a mounting plate is secured to the ladle below the orifice block.

9. Means for controlling the flow of molten metal as in claim 1, wherein the sleeve is moved relative to the orifice by a simple push/pull action means.

10. Means for controlling the flow of molten metal as in claim 2, wherein mechanical means for moving the sleeve relative to the orifice comprise a cradle pivoted and secured on the mounting plate and with the ends of the arms of the cradle suitably secured to the exposed end of the sleeve whereby pivoting of the cradle causes the sleeve to be lifted and lowered, the connection between the arms of the cradle and the sleeve being such that no transverse loading is applied to the sleeve.

11. Means for controlling the flow of molten metal as in claim 10, wherein the lower end of the sleeve is secured in a clamping ring provided with locating lugs to engage in slots in side support members secured on the mounting plate, there being clamp pivots extending from the locating lugs which pivot in slots in the ends of the arms of the cradle.

12. Means for controlling the flow of molten metal as in claim 1, wherein the inlet holes through the wall of the sleeve are elongate and the degree to which they are exposed between the inner face of the container lining dictates the rate of flow of molten metal through the axial bore of the sleeve.

13. Means for controlling the flow of molten metal as in claim 1, wherein the inlet holes through the wall of the sleeve are circular and spaced along the sleeve such that progressive movement inwardly of the sleeve first exposes one hole and then subsequent holes to determine the rate of flow of molten metal through the axial bore through the sleeve.

14. Means for controlling the flow of molten metal as in claim 1, wherein the inlet holes are inclined with respect to the plain closed face of the sleeve.

15. Means for controlling the flow of molten metal as in claim 1, wherein the axial bore through the sleeve extends directly to the end of the sleeve.