

STOPPER ROD

This invention relates to a stopper rod for controlling the flow of molten metal, for example from a vessel, such as a tundish, to a mould, and more preferably, to a stopper rod for supplying an inert gas to the melt in the vessel.

Such a stopper rod is well known, it being moved in the direction of its longitudinal axis by a lifting device external to the vessel in which the stopper rod is disposed, so that an outlet opening in the base of the vessel, into which the stopper rod fits at its lowest position, shutting it off completely, is opened either more or less. The flow of metal through the opening is thus controllable.

However extreme conditions prevailing in the processing of steel place severe demands on the materials and the engineering of the stopper rod, which has to withstand the effects of molten metal over the course of many hours. It must also be able to withstand the wide variations in temperature acting on the stopper rod during a pouring process. Moreover where the stopper rod serves to introduce an inert gas to the metal melt, it is important that no air reaches the interior of the stopper rod and thus the metal melt through the connection between the stopper rod body and the part of the lifting device which extends into said body, since this would lead to increased oxidation and thus a deterioration in steel quality. This connection is particularly problematical owing to the high thermal and mechanical loads acting on the connection. The difference in respective thermal expansion

- 2 -

coefficients between different materials involved in the connection, in particular, needs to be compensated or allowed for.

An object of the invention is to provide a stopper rod in an improved form.

According to the invention there is provided a stopper rod comprising a refractory material stopper rod body having an internal passageway extending from a first end of the body towards a second end thereof, a metal carrier element having one of its ends received in said passageway, the carrier element having a laterally enlarged portion received in a laterally enlarged portion of the passageway, which passageway portion defines a seating surface, and sealing means between said seating surface and an underside of the laterally enlarged portion of the carrier element, wherein an insert is threadedly engaged with one of the carrier element and the stopper rod body at a position above said laterally enlarged portion of the carrier element, with further sealing means being disposed between said insert and the carrier element.

Preferably the carrier element, which serves, in use, to connect the stopper rod to a lifting device, has a gas supply passage extending therethrough.

Desirably the sealing means is a graphoil seal. In one embodiment the insert is threadedly engaged with the carrier element. In that embodiment the further sealing means is a packing gland seal. In another embodiment the insert is threadedly engaged with the stopper rod body. In that embodiment

- 3 -

the further sealing means is a graphoil seal, which is preferably thicker than the graphoil seal forming said sealing means. In a still further embodiment the insert is threadedly engaged with a ceramic insert which is preferably pressed into the stopper rod to form part thereof.

Conveniently the sealing means is disposed between complementary frustoconical surfaces respectively of the enlarged portion of the carrier element and said seating surface. Until the stopper rod heats up, the sealing means is compressed between the carrier element and the stopper rod body and provides a gas-tight seal therebetween. As the stopper rod heats up, gas tightness is maintained by the further sealing means, even if the seal provided by the sealing means starts to leak due to the expansion of the metal carrier element.

Advantageously in said one embodiment the insert is engaged with a complementary thread on the carrier element. The insert is screwed down tightly on the further sealing means to effect radial sealing to the inner annular wall of the passageway of the stopper rod body. On expansion of the metal carrier element, the whole assembly simply slides up fractionally, but the force on the further sealing means, and hence the gas-tightness, is maintained.

In said another embodiment the insert is a collar, which can be metallic or ceramic, threadedly engaged with a corresponding thread at an upper inner surface of the internal passageway in the stopper rod body. The thread can be pressed in the stopper rod body passageway, or provided by a pressed-in ceramic insert forming part of the stopper rod body. Initially the

- 4 -

collar is tightened to compress the further sealing means. On expansion of the metal carrier element, the further sealing means will be subject to additional compressive forces between the expanding carrier element and the restrained collar to provide an effective gas-tight seal.

In a preferred embodiment according to the present invention the insert is in the form of a nut screw-threadedly engaged on the carrier element, which nut, when tightened, effects axial compression of said further sealing means, resulting in sealing between the stopper rod body and the carrier element.

The nut preferably effects axial compression of said further sealing means through the intermediary of a washer. Desirably the washer is located around the carrier element at one end of the stopper rod body. Conveniently the washer is larger than the further sealing means, and particularly of larger diameter than the diameter of the upper end of the internal passageway in the stopper rod body, in which upper end the further sealing means is received. The further sealing means is preferably two graphoil seals which stand proud of said upper end of the stopper rod body when the nut is untightened, and are axially compressed into said upper end of the passageway when the nut is tightened onto the washer to cause the washer axially to compress the graphoil seals.

The invention will now be described, by way of an example, with reference to the accompanying drawings, in which:

- 5 -

Figure 1 is a schematic side view of the interior of the upper end of a prior art stopper rod,

Figure 2 is a view like Figure 1, for a stopper rod of the invention, and

Figure 3 is a similar view to Figure 2, for a stopper rod according to a further embodiment of the invention,

Figure 4 is a view like Figure 3 of a stopper rod according to a still further embodiment of the invention, and

Figure 5 is a split schematic cross-sectional view of the upper end of a stopper rod of the invention, the left half showing sealing means uncompressed, and the right half showing the sealing means compressed.

Figure 1 schematically shows the upper end of a prior art stopper rod 10 having a conventional stopper rod body 11 of refractory/ceramic material. Extending centrally, axially within the stopper rod body 11 from the upper end thereof is a circular cross-section longitudinal bore 12. A short way down from the upper open end of the bore, it is stepped inwardly to form a frustoconical shoulder defining a seating surface 13. Extending downwards from this surface 13 is a constant diameter circular cross-section part, which leads to a radially enlarged portion of the bore in which is secured a ceramic insert 14, the insert being secured to the stopper rod body 11. Below this insert 14, the remainder of the bore 12 has the same diameter as the part between the surface 13 and the insert 14. Accordingly the uppermost part of the bore 12 down to and including the surface 13 is a laterally (radially) enlarged portion of the bore 12. Instead of being ceramic, the insert could be of metal or of cermet material.

- 6 -

Extending into this upper part of the bore 12 is, as shown in Figure 1, a metallic carrier rod 15, which at its upper end outside of the bore 12 is fixed in any convenient manner to a lifting device for raising and lowering the stopper rod, in use, in a vessel such as a tundish, in the normal manner. The carrier rod 15 is of circular cross-section, but is provided with a laterally (radially) enlarged portion in the form of an annular collar 16, the external shape of which substantially matches the lower end of the bore 12 above the surface 13 together with the surface 13 itself. In other words the upper part of the collar is cylindrical, as at 17, whilst the lower part is in the form of a frustoconical surface 18 matching the frustoconical seating surface 13. Below the collar 16, the carrier rod 15 is of its normal circular diameter, but this is provided with an external thread at the position of the insert 14, so that the engagement of the rod 15 with the insert 14 enables a lifting of the carrier rod 15 to be transmitted to the stopper rod body 11 so as to lift or lower the stopper rod 10 in use in the normal manner. As shown in Figure 1, there is disposed between the corresponding frustoconical surfaces 13 and 19 a graphoil seal 19. Although not shown, it would normally be the case that there is a gas flow passageway through the centre of the carrier rod 15 for transmitting inert gas, in the normal way, into the lower part of the bore 12 in the stopper rod body 11, this inert gas generally being supplied through an opening in the lower nose part of the stopper rod into the molten metal in the vessel in which the stopper rod is received.

A problem with the prior art system shown in Figure 1 is that when the stopper rod becomes heated, in use, the thermal expansion of the carrier rod 15 leads to reduced pressure being applied to the graphoil seal 19, resulting in leakage.

- 7 -

The embodiment of the present invention shown in Figure 2 is designed to solve that problem. As can be seen from the drawing, all the features of the stopper rod shown in Figure 1 are present in Figure 2 and have accordingly been numbered identically, but with the suffix a. To overcome the sealing problem identified with the Figure 1 arrangement, it can be seen that in Figure 2 an insert in the form of a nut 20 is threadedly engaged on the carrier rod 15a at a position somewhat above the upwardly facing surface of the cylindrical part 17 of the collar 16 so that, as shown, the upper face of the nut 20 is substantially flush with the upper face of the stopper rod body 11. Between the lower end of the nut 20 and the upper surface of the cylindrical part 17 of the collar 16 is sealing means in the form, for example, of a packing gland seal 21. Generally this seal 21 would be compressed by the screwing down of the nut 20, even when the stopper rod is not heated, so that there is some radial sealing as shown by the arrows at the seal 21 in Figure 2. Accordingly instead of the bore 12 being open at above the collar 16 as in Figure 1, this part of the bore 12 now receives the nut 20 and seal 21 as shown.

Accordingly with the arrangement shown in Figure 2 radial sealing by means of the seal 21 is maintained even when there is thermal expansion of the carrier rod 15a (and nut 20), given that the nut is connected to the carrier rod 15a. Although, as the metalwork expands, the whole assembly simply slides up fractionally, the force on the seal 21, and hence the gas-tightness, is maintained, even though there may be leakage at the graphoil seal 19a. Instead of being metallic, the nut 20 could be ceramic, of cermet or potentially of any other heat resisting, shape maintaining material, and both

- 8 -

the seal 19a and the seal 21 could be of materials different from those described. Although not shown with either Figure 1 or Figure 2, it will be understood that, as is well known with stopper rods, some means of restraint at the top of the stopper rod body could be provided around the part of the carrier rod which extends out of this end of the stopper rod body. Such means will be described in relation to Figure 3, and it will be understood that these could be applied equally to the arrangement of Figure 2.

The embodiment of the invention shown in Figure 3 is similar in many respects to that shown in Figure 2 and again like components will be similarly numbered, but with the prefix b. Accordingly it can be seen that the stopper rod shown in Figure 3 comprises a refractory/ceramic stopper rod body 11b with a longitudinal bore 12b extending therethrough from its open upper end. This upper laterally (radially) enlarged part of the bore 12b is formed with a seating surface 13b of frustoconical form, and spaced below this surface 13b there is pressed into the material of the body 11 a fixing insert 14b with which an externally threaded end of the metallic carrier rod 15b is engaged so that a lifting or lowering of the carrier rod will result in a corresponding lifting or lowering of the stopper rod in its vessel.

The carrier rod 15b, which is preferably metallic, has a central gas passage 22 extending therethrough. It is provided externally with a collar 16b made up of an upper cylindrical part 17b and a lower part which has a frustoconical undersurface 18b. As with the Figure 2 arrangement, a seal 19b, preferably a graphoil seal, is trapped between the frustoconical surface 18b and the seating surface 13b to provide a gas tight seal when the stopper rod is unheated.

- 9 -

A screw thread 23 is provided, for example by pressing, into the inner surface of the upper part of the bore 12b and an insert in the form of an annular collar 24 or equivalent is screw-threadedly engaged with the thread 23, there being, as shown, radial clearance between the inner cylindrical surface of the collar and the outer cylindrical surface of the carrier rod 15b. This is in contrast to the Figure 2 arrangement, where this radial clearance can be provided between the external surface of the nut 20 and the inner cylindrical surface of the bore in which the nut is received.

It can be seen from Figure 3 that trapped between the lower surface of the collar 24 and the upwardly facing top surface of the collar 16b is a thick graphoil seal 25, which radially seals against the inner surface of the bore 12b below the upper internally threaded part thereof.

The collar 24 is screwed down onto the seal 25 which is compressed thereby. Accordingly when the stopper rod is unheated, there is sealing both by way of the seal 19b and also by way of the seal 25, both of which seals are under compression. However as the stopper rod is heated, and the carrier rod 15b expands, the seal 19b is likely to start to leak in the normal manner as the compression thereof decreases due to the expansion of the carrier rod 15b. However the upper seal 19b, which is restrained by the fixed screwed-in collar 24, will be subject to additional compressive forces between the expanding carrier rod 15b and the retained collar 24 to provide an effective gas-tight seal. Figure 3 shows a conventional washer 26 on the carrier rod 15b at the top of the stopper rod body 11b, this washer being held down onto the top of the stopper rod body by a nut 27 which is screw

- 10 -

threaded onto the carrier rod 15b, the washer and nut providing a conventional lock at the top of the stopper rod body.

It is believed that the arrangement shown in Figure 3 is advantageous in that the force on the seal 25 will increase as the metalwork expands. In some instances it may be necessary for the stopper to be banded externally to overcome any problems as a result of the need to thread the refractory material of the stopper rod body.

Any such problems with threading the refractory material of the stopper rod body are overcome by the Figure 4 embodiment, where the thread 23a for the engagement of the collar 24 is provided by a ceramic insert 28 co-pressed into the stopper rod body to form part thereof. As shown, the upper part of the seal 25 is received in a lower non-threaded part of the insert 28.

Accordingly with each of the embodiments shown in Figures 2, 3 and 4 the thermal expansion/sealing problem identified with the prior art stopper rods is overcome in a simple, yet effective manner.

The stopper rod of the invention shown in Figure 5 is similar in several respects to that shown in Figure 3, having a stopper rod body 11c of refractory/ceramic material with a central, longitudinally extending circular cross-section bore 12c, which is open at the end of the stopper rod which is uppermost in use. This upper laterally (radially) enlarged part of the bore 12c is formed with a seating surface 13c of frustoconical form, and spaced below this surface there is pressed into the material of the body 11c a

- 11 -

(ceramic) fixing insert 14c with which an externally threaded end of the preferably metallic carrier element in the form of a rod 15c is engaged, so that a lifting or lowering of the carrier rod will result in a corresponding lifting or lowering of the stopper rod in its vessel.

The carrier rod 15c has a central gas passageway through it. It has an external collar 16c made up of an upper cylindrical part 17c and a lower part with a frustoconical undersurface 18c. A seal 19c, preferably a graphoil seal, is trapped between the surface 18c and the seating surface 13c to provide a gas tight seal when the stopper rod is unheated.

Above the collar 16c, at least part of the carrier element outside of the bore 12c is externally screw-threaded as shown at 28. A conventional washer 26c is received on the carrier element, as with the Figure 3 embodiment, with a conventional insert in the form of a nut 27c, also as in the Figure 3 embodiment, being engaged on the screw thread 28, to force the washer downwardly when the nut is tightened. The washer is of a diameter much greater than that of the bore 12c at the top of the stopper rod body.

Disposed around the carrier rod 15c and supported by the upwardly facing top annular surface of the collar 16c is further sealing means in the form of two graphoil seals 25a and 25b. When these seals are axially uncompressed the upper seal stands proud of the upper end of the stopper rod body. This is shown at the left hand side of the drawing. Here the nut 27c is in a loosened state, such that there is no force exerted by the nut on the washer 26c. The weight of the washer along acts on the seals, but does not axially compress them. Thus as they are not radially compressed there is no

- 12 -

effective seal produced by them between the carrier rod and the stopper rod body.

However if the nut 21c is now tightened, as shown at the right hand side of the drawing, it moves down the screw-thread 28 of the carrier rod and forces the washer 26c axially downwardly axially to compress the seals 25a, 25b to the position shown at the right hand side, with the washer engaging the top of the stopper rod body. The axial compression of the seals causes them to expand radially and form a gas-tight seal (as shown) between the carrier rod and the stopper rod body.

It will be understood that in an alternative embodiment, the washer could be sized to be received in the upper end of bore 12c and thus at least partly received therein when it axially compresses the seals 25a, 25b. In a still further embodiment, the insert screw-threaded on the carrier rod, such as nut 27c, could also at least partly be received in the bore 12c pressing down on the washer. In other words the arrangement could be similar to that of Figure 2, but with the addition of the washer between the insert and the further sealing means. The further sealing means could, in any embodiment, be a single seal or any suitable number of seals. With these alternative embodiments it is not of course necessary for the seal or one or more of the seals to stand proud when uncompressed.

Claims

1. A stopper rod comprising a refractory material stopper rod body having an internal passageway extending from a first end of the body towards a second end thereof, a metal carrier element having one of its ends received in said passageway, the carrier element having a laterally enlarged portion received in a laterally enlarged portion of the passageway, which passageway portion defines a seating surface, and sealing means between said seating surface and an underside of the laterally enlarged portion of the carrier element, wherein an insert is threadedly engaged with one of the carrier element and the stopper rod body at a position above said laterally enlarged portion of the carrier element, with further sealing means being disposed between said insert and the carrier element.
2. A stopper rod as claimed in Claim 1, wherein the insert is in the form of a nut screw-threadedly engaged on the carrier element, which nut, when tightened, effects axial compression of said further sealing means, resulting in sealing between the stopper rod body and the carrier element.
3. A stopper rod as claimed in Claim 2, wherein the nut effects axial compression of said further sealing means through the intermediary of a washer.
4. A stopper rod as claimed in Claim 3, wherein the washer is located around the carrier element at one end of the stopper rod body.

- 14 -

5. A stopper rod as claimed in Claim 3 or Claim 4, wherein the washer is larger than the further sealing means.
6. A stopper rod as claimed in Claim 5, wherein the washer is of larger diameter than the diameter of the upper end of the internal passageway in the stopper rod body, in which upper end the further sealing means is received.
7. A stopper rod as claimed in any one of Claims 3 to 6, wherein the further sealing means is two graphoil seals which stand proud of said upper end of the stopper rod body when the nut is untightened, and are axially compressed into said upper end of the passageway when the nut is tightened onto the washer to cause the washer axially to compress the graphoil seals.
8. A stopper rod as claimed in any one of Claims 1 to 7, wherein the further sealing means comprise three separate graphoil seals.
9. A stopper rod as claimed in any one of Claims 1 to 8, wherein the carrier element, which serves, in use, to connect the stopper rod to a lifting device, has a gas supply extending therethrough.
10. A stopper rod as claimed in any one of Claims 1 to 9, wherein the sealing means is a graphoil seal.
11. A stopper rod as claimed in Claim 1, wherein the insert is threadedly engaged with the carrier element.

- 15 -

12. A stopper rod as claimed in Claim 11, wherein the further sealing means is a packing gland seal.
13. A stopper rod as claimed in Claim 1, wherein the insert is threadedly engaged with the stopper rod body.
14. A stopper rod as claimed in Claim 13, wherein the further sealing means is a graphoil seal.
15. A stopper rod as claimed in Claim 14, wherein the graphoil seal is thicker than the seal forming the sealing means.
16. A stopper rod as claimed in Claim 1, wherein the insert is threadedly engaged with a ceramic insert.
17. A stopper rod as claimed in Claim 16, wherein the ceramic insert is pressed into the stopper rod to form part thereof.
18. A stopper rod as claimed in any one of Claims 1 to 17, wherein the sealing means is disposed between complementary frustoconical surfaces respectively of the enlarged portion of the carrier element and said seating surface.
19. A stopper rod as claimed in Claim 18, wherein until the stopper rod heats up, the sealing means is compressed between the carrier element and the stopper rod body and provides a gas-tight seal therebetween.

- 16 -

20. A stopper rod as claimed in Claim 11, wherein the insert is engaged with a complementary thread on the carrier element.
21. A stopper rod as claimed in Claim 20, wherein the insert is screwed down tightly on the further sealing means to effect radial sealing to the inner annular wall of the passageway of the stopper rod body.
22. A stopper rod as claimed in Claim 13, wherein the insert is a collar.
23. A stopper rod as claimed in Claim 22, wherein the collar is metallic or ceramic, threadedly engaged with a corresponding thread at an upper inner surface of the internal passageway in the stopper rod body.
24. A stopper rod as claimed in Claim 23, wherein the thread is pressed in the stopper rod body passageway.
25. A stopper rod as claimed in Claim 24, wherein the thread is provided by a pressed-in insert forming part of the stopper rod body.