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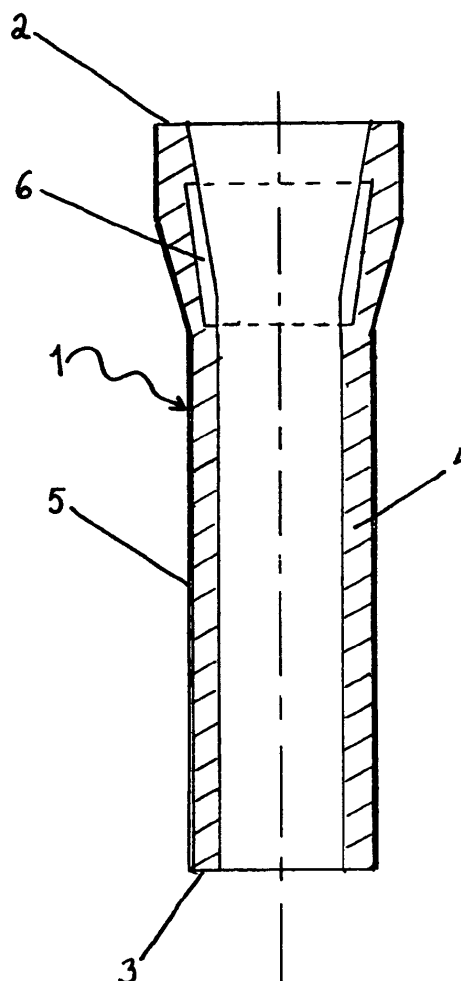
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(54) **Submerged entry nozzle for molten metal**

(57) The invention relates to a submerged entry nozzle (1) for molten metal, such as molten steel, comprising an upper attaching head (2) and a lower immersion head (3). The nozzle is reinforced by manufacturing the wall from cured refractory casting mass (4). The mass (4) is surrounded by reinforcing sheet steel (5), which is installed when casting. The mass can also be reinforced with reinforcing fibres and a reinforcement bushing (6) can be installed inside the mass before casting.



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Description

[0001] The invention relates to a submerged entry nozzle for molten metal, such as molten steel, comprising an upper attaching head and a lower immersion head. The invention also relates to a method of manufacturing the submerged entry nozzle of the type mentioned above.

[0002] The invention further relates to a pouring system of molten metal, such as molten steel, consisting of an upper container comprising a pouring hole, a lower container comprising an upwardly open space, and a submerged entry nozzle between the containers. The submerged entry nozzle comprises an upper attaching head that is attached to the pouring hole and a lower immersion head that is immersed in the open space.

[0003] When the molten metal is poured from the upper container, such as a pouring ladle, to the lower container, such as a casting box, the molten metal is protected against oxidation, among others, by directing it through the submerged entry nozzle (SEN). Generally, the attaching head of the entry nozzle is attached to the pouring hole of the upper container or to the valve that closes the pouring hole, and the lower head is immersed in the molten metal lying in the open space of the lower container. Typically, the metal to be melted is steel.

[0004] Generally, the conventional submerged entry nozzles for molten metal are manufactured by isostatically pressing refractory powder that typically contains aluminium oxide, silicon dioxide, and carbon (Deltek). As the nozzle gets in touch with the molten steel and the layer of slag floating on top of the same, the pouring times are then often restricted by the attaching part of the nozzle breaking and the immersion part wearing.

[0005] Isostatically pressed submerged entry nozzles for molten steel are well-known in the field, having the upper attaching head thereof strengthened with a metal jacket (Foseko, Vesuvius). Nozzles are also known, which have a sintered zirconium oxide sleeve (Didier) surrounding the immersion part, decreasing wearing.

[0006] Regardless of the above-mentioned improvements, the prior art submerged entry nozzles for molten metal still suffer from the problem that they do not withstand mechanical stress in use. Thus, the object of the invention is to provide as strong and wear-resistant nozzles as possible by using a casting method, wherein the curing at the manufacturing stage is based on hydration. This object has now essentially been achieved so that the wall of the nozzle consists of cured refractory casting mass, which is surrounded by a metal jacket that extends essentially from the attaching head to the immersion head. By using the casting mass, a more homogeneous material is obtained, which is also lighter and easier to handle. The metal jacket reinforces the nozzle and works as a mould in casting, see in detail hereinafter.

[0007] Typically, the length of the submerged entry nozzle according to the invention is from 500 to 2000mm. The diameters of the attaching head are mostly larger than those of the immersion head. The outer diameter of

the attaching head is typically from 150 to 400mm and that of the immersion head is typically from 100 to 300mm. Because of the torsional forces exerted on the attaching head, its wall is often also thicker than the wall of the immersion head. The total thickness of the attaching head wall is preferably from 100 to 300mm and the thickness of the immersion head is preferably from 50 to 150mm.

[0008] According to an embodiment, the attaching head of the nozzle consists of a part, which expands conically from the cylindrical surface of the immersion head, and a subsequent cylindrical part, which has a diameter and a wall thicker than those of the immersion part.

[0009] It is preferable that the casting mass of the nozzle is cast directly inside the metal jacket. The casting mass preferably has the following composition: the main components are $\text{Al}_2\text{O}_3 + \text{TiO}_2$ (3 to 50%), SiO_2 (35 to 50%), C (1 to 15%) and calcium aluminate cement, which provides the strength at the manufacturing stage by means of a hydration reaction. Reinforcing material, such as fibres, can be incorporated into the casting mass. Typical reinforcement fibres comprise steel fibres. The metal jacket preferably surrounds the casting mass so that the jacket extends throughout the nozzle. A suitable material for the jacket comprises steel and a suitable thickness is from 1 to 5mm, preferably from 1 to 3mm.

[0010] According to an embodiment of the submerged entry nozzle according to the invention, a reinforcement bushing is arranged on the inner wall of its attaching head, preventing the attaching head from wearing. Typically, it expands conically and is installed in a place, where the narrower and thinner immersion part turns into the wider and thicker attaching part. The reinforcement bushing is preferably made of a material stronger than that of the casting mass of the nozzle. It is preferably prefabricated by casting.

[0011] As stated above, the invention also relates to a method of manufacturing the submerged entry nozzle for molten metal that comprises an upper attaching head and a lower immersion head. The attaching head is typically intended to be attached to the pouring hole of the upper pouring container, such as the ladle, or to its closing mechanism, and the immersion head is typically intended to be immersed in the upwardly open space of the lower casting container, such as the casting box, which is intended for the molten metal.

[0012] Typically, the submerged entry nozzle that is manufactured according to the invention has a shape where the diameters of the attaching head are larger than those of the immersion head. Its wall is often also thicker and, thus, stronger than the wall of the immersion head. See the nozzle dimensions presented above. According to an embodiment, the attaching head consists of a conically expanding part and a cylindrical part, its diameter and wall being thicker than those of the immersion part.

[0013] The method according to the invention for manufacturing the submerged entry nozzle is characterized in that refractory material is cast, its strength at the man-

ufacturing stage being provided by means of a hydration, between the core that limits the inner surface of the nozzle wall and the metal jacket that limits its outer surface; the material is cured into cured refractory casting mass and the cured refractory casting mass that is closely surrounded by the metal jacket is recovered.

[0014] When manufacturing the nozzle, the refractory material or its raw material is cast in a metal mould, which in curing is left to surround the cured casting mass as a metal jacket, essentially strengthening the nozzle. This enables the use of the casting mass, as distinguished from prior art, wherein the nozzle has to be manufactured by sintering a powder. Typically, sheet steel is selected as the metal jacket. A suitable thickness is from 1 to 5mm, preferably from 1 to 3mm.

[0015] To strengthen the submerged entry nozzle against wearing, one or more reinforcement bushings are pre-installed in the mould according to an embodiment. For example, it can be installed in the part of the mould, which corresponds to the inner surface of the attaching head of the nozzle. Typically, it is conically expanding and installed in a place, where the narrower and thinner immersion part turns into the wider and thicker attaching part. Typically, the material of the reinforcement bushing is selected from a refractory material stronger than the casting mass, such as $\text{Al}_2\text{O}_3 + \text{TiO}_2$ (80 to 90%), SiO_2 (5 to 10%), Fe_2O_3 (0.5 to 1.5%). The reinforcement bushing is preferably pre-fabricated by casting.

[0016] In addition to the submerged entry nozzle and the manufacture thereof, the invention relates to the pouring system of molten metal, consisting of an upper container having a pouring hole, a lower container having an upwardly open space, and a submerged entry nozzle between the containers. The nozzle has an upper attaching head attached to the pouring hole of the upper container or to its closing valve, and a lower immersion head of the lower container that is immersed in the open space intended for the melt. The upper container of the pouring system is typically a pouring ladle and the lower container is a casting box. The pouring system is characterized in that the wall of the nozzle consists of cured refractory casting mass, which is closely surrounded by the metal jacket that extends essentially from the attaching head to the immersion head.

[0017] Typically, the submerged entry nozzle of the system according to the invention has a shape where the diameters of the attaching head are larger than those of the immersion head. Its wall is also often thicker than the wall of the immersion head. See the preferable dimensions of the nozzle presented above. Then the attachment of the nozzle to the upper container is stronger. According to an embodiment, the attaching head consists of a conically expanding part and a cylindrical part, its diameter and wall being thicker than those of the immersion part.

[0018] According to an embodiment, a reinforcement bushing is arranged on the inner wall and/or at the lower

end of the attaching head of the nozzle of the pouring system. Typically, it expands conically and is installed in a place, where the narrower and thinner immersion part turns (conically) into the wider and thicker attaching part. To withstand wearing, the reinforcement bushing is preferably manufactured of a material stronger than the casting mass of the nozzle and pre-fabricated, for example, pre-cast.

[0019] The invention is especially well-suited for casting steel and it is preferably part of the control system of the steel flow from a converter into the mould.

[0020] In the following, the invention is illustrated by means of examples with reference to the appended drawing.

[0021] In the figure, a submerged entry nozzle 1 according to the invention is shown, comprising an upper attaching head 2 and a lower immersion head 3. Such a nozzle is used when transferring molten metal, such as molten steel, from an upper container into a lower container (not shown in the figure). A typical upper container is a steel pouring ladle. The attaching head 2 of the nozzle is typically attached to the closing mechanism of the pouring hole of the upper container, the mechanism engaging the attaching head from both the outside and the inside. The immersion head 3 is submerged into the space of the lower container that is typically upwardly open. Typically, the lower container is a steel casting box, from where the steel is fed forward through orifices to make profiles or into moulds. As it gets in contact with the molten metal, wearing and transversal torsional forces are exerted on the immersion head.

[0022] The submerged entry nozzle 1 according to the invention has a shape where the attaching head 2 consists of a conically expanding part and a cylindrical part, its diameter and wall being thicker than those of the immersion part 3.

[0023] It is obvious that great wearing and torsional forces are exerted on the conventional hot-pressed submerged entry nozzle. In the solution now presented, the nozzle 1 is cast from casting mass 4, which in the figure is marked with transverse lines. Typically, the casting mass consists of a refractory mass having a strength that is generated at the manufacturing stage of the hydration reaction, its main components being $\text{Al}_2\text{O}_3 + \text{TiO}_2$ (30 to 45%), SiO_2 (35 to 50%), C (1 to 15%) and calcium aluminate cement, which by means of the hydration reaction provides the strength at the manufacturing stage.

[0024] Such a casting mass constitutes a more porous material, which, thus, insulates heat better than the conventional hot-pressed mass. However, its strength as such is not sufficient against the wearing and torsional forces that are generated in use. Therefore, both the attaching head 2 and the immersion head 3 of the nozzle 1 are reinforced with a metal jacket 5 that works as the casting mould and surrounds the nozzle 1, extending from the one end thereof to the other. The metal jacket 5 is sheet steel. When casting the nozzle 1, first, the mould or the inner surface of the mould is formed from

the sheet steel and, then, the casting mass 4 is cast in the mould to manufacture the refractory nozzle 1. After the casting, the sheet steel is left in place as the jacket 5 mentioned above so as to surround the cured casting mass 4 of the nozzle 1.

[0025] The nozzle 1 can further be reinforced by mixing, with the soft casting mass, reinforcing fibres, such as steel fibres, before casting and curing.

[0026] As mentioned above, wearing forces are exerted on the nozzle 1 during use. They are generated, when the (steel) melt in the lower container moves the immersion head 3 of the nozzle 1 during casting. In that case, wearing forces are exerted on the attaching head 2 of the nozzle 1, trying to break the head 2 and detach the nozzle 1 from the upper container. To prevent this, a reinforcement bushing 6 is embedded in the attaching head 2 of the nozzle 1 in the embodiment according to the figure. When needed, one is also added to the lower end.

[0027] The reinforcement bushing 6 is installed so as to constitute the inner surface of the attaching head 3 of the nozzle 1. When casting, it is installed in the part of the mould that corresponds to the inner surface of the attaching head 2 of the nozzle 1. The reinforcement bushing 6 is pre-fabricated either by sintering or preferably casting, and its material is selected from a refractory material stronger than the casting mass. According to the figure, the reinforcement bushing 6 expands conically and is installed in a place, where the narrower and thinner immersion part 3 turns conically into the wider and thicker attaching part 2, its main components being $\text{Al}_2\text{O}_3+\text{TiO}_2$ (80 to 90%), SiO_2 (5 to 10%), Fe_2O_3 (0.5 to 1.5%).

Claims

1. A submerged entry nozzle (1) of molten metal, such as molten steel, comprising an upper attaching head (2) and a lower immersion head (3), **characterized in that** the wall of the nozzle (1) consists of cured refractory casting mass (4) that is based on a hydration at the manufacturing stage and surrounded by a metal jacket (5) that extends essentially from the attaching head (2) to the immersion head (3).
2. A submerged entry nozzle according to Claim 1, **characterized in that** the casting mass (4) is cast inside the metal jacket (5) that also works as a casting mould.
3. A submerged entry nozzle according to Claim 1 or 2, **characterized in that** the casting mass (4) is essentially $\text{Al}_2\text{O}_3+\text{TiO}_2$ (3 to 50%), SiO_2 (35 to 50%), C (1 to 15%) and calcium aluminate cement that provides the strength at the manufacturing stage by means of a hydration reaction.
4. A submerged entry nozzle according to any of the preceding claims, **characterized in that** the metal

jacket (5) extends throughout the nozzle (1).

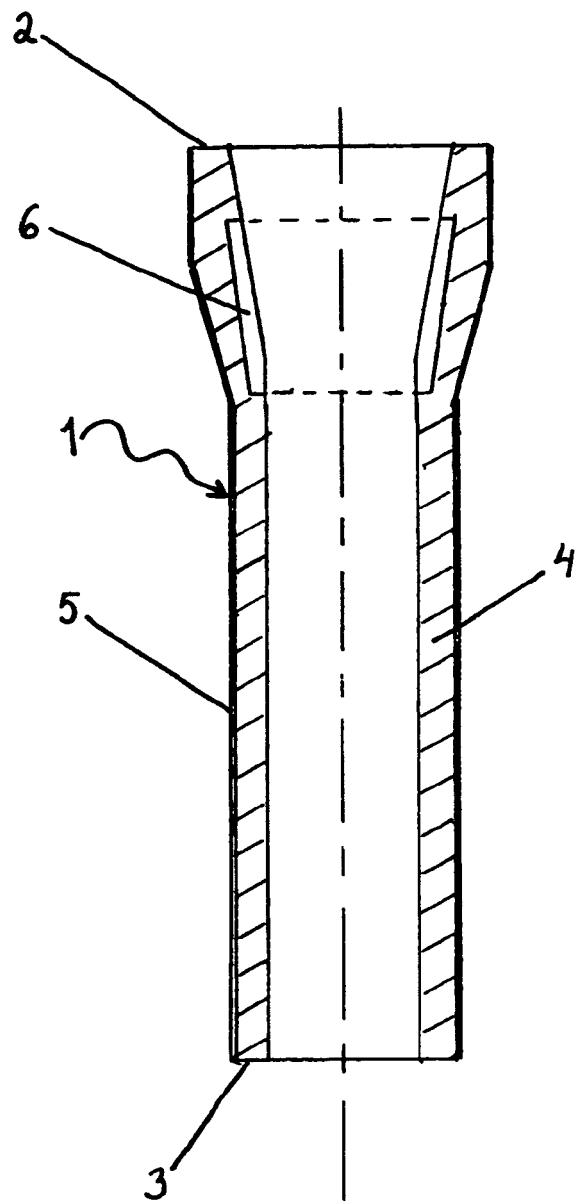
5. A submerged entry nozzle according to any of the preceding claims, **characterized in that** the metal jacket (5) is sheet steel.
6. A submerged entry nozzle according to Claim 5, **characterized in that** the thickness of the sheet steel is from 1 to 5mm, preferably from 1 to 3mm.
7. A submerged entry nozzle according to any of the preceding claims, **characterized in that** a reinforcement bushing is arranged on the inner wall of the attaching head and/or the lower end (2) of the nozzle (1).
8. A submerged entry nozzle according to Claim 7, **characterized in that** the reinforcement bushing (6) is pre-fabricated.
9. A method of manufacturing the submerged entry nozzle (1) according to any of the preceding claims comprising an upper attaching head (2) and a lower immersion head (3), **characterized in that** refractory material is cast, becoming strong at the manufacturing stage by means of a hydration reaction, between a core limiting the inner surface of the wall of the nozzle (1) and the metal jacket (5) limiting its outer surface; the material is cured into cured refractory casting mass (4), and the cured refractory casting mass (4) that is closely surrounded by the metal jacket (5) is recovered.
10. A method according to Claim 9, **characterized in that** the casting mass (4) is essentially $\text{Al}_2\text{O}_3+\text{TiO}_2$ (3 to 50%), SiO_2 (35 to 50%), C (1 to 15%) and calcium aluminate cement that provides the strength at the manufacturing stage by means of the hydration reaction.
11. A method according to any of Claims 9 to 10, **characterized in that** the metal jacket (5) extends essentially from the attaching head (2) of the nozzle (1), which is to be cast, to its immersion head (3).
12. A method according to Claim 11, **characterized in that** the metal jacket (5) extends throughout the nozzle (1) that is to be cast.
13. A method according to any of Claims 9 to 12, **characterized in that** sheet steel is selected as the metal jacket (5).
14. A method according to Claim 13, **characterized in that** the thickness of the sheet steel is from 1 to 5mm, preferably from 1 to 3mm.
15. A method according to any of Claims 9 to 14, **char-**

acterized in that before the material is cast, a reinforcement bushing (6) and/or bushings are pre-installed in the mould.

16. A method according to Claim 15, **characterized in that** the reinforcement bushing (6) is installed in the part of the mould that corresponds to the inner surface of the attaching head (2) of the nozzle (1), or to the lower end. 5
17. A method according to Claim 15 or 16, **characterized in that** the material of the reinforcement bushing (6) is selected from a refractory material stronger than the casting mass of the nozzle (1). 10
18. A pouring system of molten metal, consisting of an upper container comprising a pouring hole, a lower container comprising an upwardly open space, and a submerged entry nozzle (1) between the containers, the nozzle comprising an upper attaching head (2) that is attached to the pouring hole and a lower immersion head (3) that is submerged in the open space of the lower container, **characterized in that** the wall of the nozzle (1) consists of refractory casting mass (4) having its strength generated by a hydration reaction at the manufacturing stage, the mass being closely surrounded by the metal jacket (5) that extends essentially from the attaching head (2) to the immersion head (3). 15
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19. A pouring system according to Claim 18, **characterized in that** the upper container is a pouring ladle.
20. A pouring system according to Claim 18 or 19, **characterized in that** the lower container is a casting box. 35
21. A pouring system according to Claims 18 to 20, **characterized in that** the casting mass is essentially $\text{Al}_2\text{O}_3 + \text{TiO}_2$ (3 to 50%), SiO_2 (35 to 50%), C (1 to 15%) and calcium aluminate cement, which provides the strength at the manufacturing stage by means of the hydration reaction. 40
22. A pouring system according to any of Claims 18 to 21, **characterized in that** the metal jacket (5) extends throughout the nozzle (1). 45
23. A pouring system according to any of Claims 18 to 22, **characterized in that** the metal jacket (5) is sheet steel. 50
24. A pouring system according to Claim 23, **characterized in that** the thickness of the sheet steel is from 1 to 5mm, preferably from 1 to 3mm. 55
25. A pouring system according to any of Claims 18 to 24, **characterized in that** a reinforcement bushing

(6) is arranged on the inner wall of the attaching head (2) of the nozzle (1).

26. A pouring system according to Claim 26, **characterized in that** the reinforcement bushing (6) is pre-fabricated, preferably pre-cast.





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