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(54) Discharge nozzle for moulds of continuous casting machines

(57) A discharge nozzle for moulds in continuous casting machines, which comprises: a main body (5) of substantially cylindrical shape; an outflow duct (6) formed inside said main body (5); at least two first outlets (8) arranged in a substantially symmetrical manner along the external perimeter of said main body (5) one respect to the other, and at the lower end of said main body (5) in order to communicate said outflow duct (6) towards the outside; at least two second outlets (9) arranged in a substantially symmetrical manner along the external perimeter of said main body (5) one respect to the other, and above said at least two first openings (8), in order to communicate said outflow duct (6) towards the outside;

characterised in that each outlet of said at least two first outlets (8) has a prevalently upward direction, and in that each outlet of said at least two second outlets (9) has a prevalently downward direction, and in that said outflow duct (6) is optionally downwardly frustoconical.

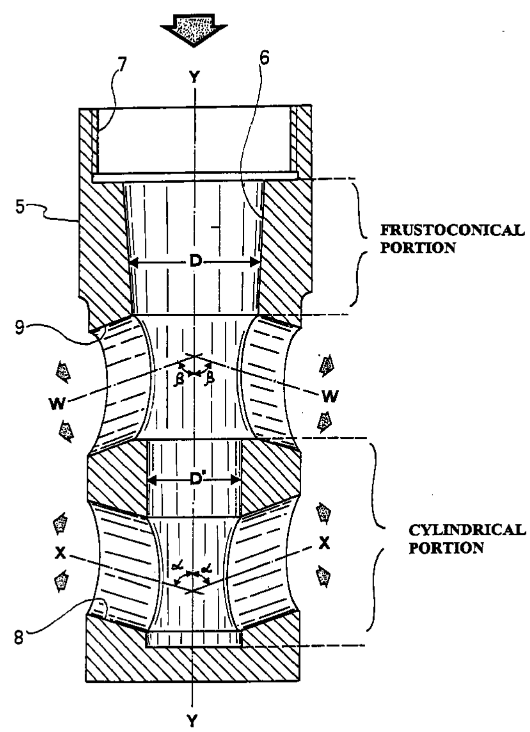

FIG 2

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Description

The present invention relates to a discharge nozzle for moulds in continuous casting machines and, more specifically, to a discharge nozzle of molten metal having directed outlets for moulds in continuous casting machines.

The application of discharge nozzles to transfer the liquid metal from a separator, commonly known as a tundish, to the respective mould is known. During transfer of the molten metal, the speed at which the old is fed has a considerable influence on the quality of the finished product. In fact, one problem that is found is that of a non-homogeneous distribution of the metal in terms of speed and/or temperature. This problem can result in the surface of the bath being too cold or moving too much. In this case, solidification is irregular and the dust covering normally found on the surface of the bath itself can be incorporated into the bath.

Another problem is found if the streams of molten metal from the discharge nozzle hit the side walls of the old with excessive energy, resulting in re-founding of the top skin which, if excessive, can compromise process regularity.

Given the high productivity levels normally required from continuous casting machines, the above problems are very strongly felt when dealing with large flow rates, because any irregularity in the heat exchange and in the possibility to capture surface powders can detract from the quality of both the surface and the inside of the product.

To solve the above mentioned problems a number of methods have been used. One known method is that of using a device external to the old, known as an electromagnetic brake which, by means of an electromagnetic field induced in the bath, influences the movement of the metal, thus reducing stirring in the bath. The disadvantage of a device of this kind is that it involves extremely high costs and, like all external devices in a system, the additional need for maintenance and control.

Another method to solve the above mentioned problems is that of particular care when designing the geometry of the discharge nozzle. From this point of view, the most common practice is that of creating discharge nozzles with outlets that point downwards.

Furthermore, is known another embodiment in which the discharge nozzle has four horizontal holes instead of two, so as to decrease the energy of the jet of metal.

However, the above solutions only partially solve the problems indicated above, because their object is the effect of the phenomenon, that is to say, for example, excessive surface movement, rather than the cause thereof, which is the excessive energy of the metal to be dealt with. Furthermore, improvements are obtained with reduced flow rates, but not with higher flow rates and so at increased machine productivity.

Therefore, the object of the present invention is to solve the above mentioned problems by providing a discharge nozzle having its outlets arranged in such a way as to induce a damping effect on the energy of the jet of metal passing through said outlets, and such that said damping effect increases proportionally to the increase of flow rate, thus decreasing stirring in the bath of the old.

A further object of the present invention is to provide a discharge nozzle for moulds that is of simple construction, provides a high level of reliability and in which only normal maintenance operations are required.

According to the present invention, a discharge nozzle for moulds in continuous casting machines comprises:

a main body of substantially cylindrical shape;
an outflow duct formed inside said main body;
at least two first outlets arranged in a substantially symmetrical manner along the external perimeter of said main body one respect to the other, and at the lower end of said main body, in order to communicate said outflow duct towards the outside;
at least two second outlets arranged in a substantially symmetrical manner along the external perimeter of said main body one respect to the other, and above said at least two first openings, in order to communicate said outflow duct towards the outside;

characterised in that each outlet of said at least two first outlets has a prevalently upward direction, and in that each outlet of said at least two second outlets has a prevalently downward direction, and in that said outflow duct is optionally downwardly frustoconical.

The present invention will be illustrated in greater detail in the following by a description of an embodiment thereof, given as a non-limiting example and with reference to the enclosed drawings, in which:

figure 1 is a schematically perspective view of a discharge nozzle of the prior art; and
figure 2 is a longitudinal cross section view of a discharge nozzle according to the present invention.

With reference to figure 1, a discharge nozzle according to the prior art is shown.

The discharge nozzle has a body 1 with a substantially cylindrical shape, within which an outflow duct 2 for the molten metal is formed. Initially, said duct 2 has a steady cross-section until a predetermined length, at which point two outlets 3 are formed (only one of them is shown in the figure). From that length onwards, the section of the duct 2 decreases and extends for a further determined distance, at which point, in a similar manner to that above, two outlets 4 are formed (only one of them is shown in the figure), which are larger than the two openings 3.

The openings 3 and 4 are arranged in an horizontal direction, that is to say at right angles to the longitudinal direction of the discharge nozzle.

With reference now to figure 2, a longitudinal cross section view of the discharge nozzle according to the present invention is shown.

The discharge nozzle has a body 5 with a substantially cylindrical section, inside which an outflow duct 6 is formed.

In this embodiment, at the top end of said body 5, the duct 6 has a thread 7 for the engaging with the feeder duct of the discharge nozzle (not shown in the figure) in a known manner.

It should be noted that the duct 6 is frustoconical along its length, that is to say it has a cross-section that decreases as said duct advances.

At approximately one third of the total length of the duct 6 and starting from the lower end of the body 5, two outlets 8 are formed, both of same size and arranged in a diametrically opposite position. Said outlets 8 are directed upwards so that their longitudinal axis X forms an angle α with the longitudinal axis Y of the discharge nozzle.

Above said outlets 8 and at approximately two thirds of the total length of the duct starting from the lower end of the body 5, two outlets 9 are formed, both of same size but larger than the openings 8 and arranged in a diametrically opposite position. Said outlets 9 are directed downwards and in such a way that their longitudinal axis W forms an angle β with the longitudinal axis Y of the discharge nozzle.

The arrangement of both upper outlets 9 and bottom openings 8 is such to give to both the flows of metal passing through them a direction that tends to gather the two flows, i.e. in such a way that the upper flow meets the bottom flow, providing a damping effect on the kinetic energy of both flows, said damping effect increasing as the flow rate increases, and therefore during high production function.

For optimum sizing of the cross-sections, that is to say of the outlets and the duct, calculations have been made using numeric simulation with a commercial calculation code (more specifically the PHOENICS code). Then, once optimum sizing was obtained, a 1:1 scale model was prepared, made of Plexiglas and tested in a old using water as working fluid.

When selecting the dimensions, the dissipation of energy in the top surface and at the side walls of the moulds has been taken into account, as well as the temperature of both.

Subsequently, the performance of the discharge nozzle was compared with a standard two-outlets discharge nozzle. The performance concerned to:

1) the impact speed and depth of the jet on the side walls of the old;
2) the tendency to generate a wavy and/or turbulent surface;
3) the level of thermal homogeneity on the surface; and
4) the index of a good metal flow through the upper portion of the old.

Herebelow two tables representing the optimum dimensions for a model of a discharge nozzle according to calculations and the experimental results thereof, are given.

Table 1 illustrates the parameters for optimum sizing of the discharge nozzle, in a non-dimensional form and with reference to figure 2, according to the present invention.

Table 2 illustrates performance parameters, expressed as normalised values, resulting from comparison of the discharge nozzle according to the present invention and a standard two-outlets discharge nozzle.

TABLE 1

DISCHARGE NOZZLE DIMENSIONS	NON-DIMENSIONAL PARAMETERS
Top diameter of duct	D
Bottom diameter of duct (D')	0.7 ~ 0.8 D
Top external diameter of discharge nozzle	1.71 D
Bottom external diameter of discharge nozzle	1.57 D
Position of bottom outlets starting from lower end of discharge nozzle	1.03 D
Position of upper outlets starting from lower end of discharge nozzle	2.32 D

TABLE 1 (continued)

DISCHARGE NOZZLE DIMENSIONS	NON-DIMENSIONAL PARAMETERS
Angle α between X axis of bottom outlets and longitudinal axis Y of discharge nozzle	75° ± 15°
Angle β between W axis of upper outlets and longitudinal axis Y of discharge nozzle	75° ± 15°
Diameter of upper outlets	0.92 D
Diameter of bottom outlets	0.85 D

TABLE 2

PARAMETERS	*Standard discharge nozzle*	*Discharge nozzle according to the invention*
Impact speed (m/s)	0.22	0.13
Impact point (mm)	320	250
Wave index	100	90
Vortex index	100	50
Lack of thermal uniformity	2%	3%

As can be seen, with the discharge nozzle sized according to table 1 and according to the results obtained and illustrated in table 2, the response was extremely positive.

In particular, the impact speed on the side walls of the old decreased by approximately 40%, the wave level by 10% and the formation of vortexes by 50%. Only the index of lack of thermal uniformity is slightly worse, but on the basis of the experience of any technician skilled in the art the overall values give a strong indication of improvement.

The present invention is not limited to the embodiment described above, but comprises any alternative version thereof.

Claims

1. A discharge nozzle for moulds in continuous casting machines, comprising:

   a main body (5) of substantially cylindrical shape;
   an outflow duct (6) formed inside said main body (5);
   at least two first outlets (8) arranged in a substantially symmetrical manner along the external perimeter of said main body (5) one respect to the other, and at the lower end of said main body (5) in order to communicate said outflow duct (6) towards the outside;
   at least two second outlets (9) arranged in a substantially symmetrical manner along the external perimeter of said main body (5) one respect to the other, and above said at least two first openings (8), in order to communicate said outflow duct (6) towards the outside;

   characterised in that each outlet of said at least two first outlets (8) has a prevalently upward direction, and in that each outlet of said at least two second outlets (9) has a prevalently downward direction, and in that said outflow duct (6) is optionally downwardly frustoconical.

2. A discharge nozzle according to claim 1, wherein said at least two second outlets (9) are greater than said at least two first outlets (8).

3. A discharge nozzle according to claim 1 or 2, wherein each outlet of said at least two first outlets (8) has its geometrical axis (X) directed upwards and forming an angle (α) less than 90° with the longitudinal axis (Y) of said outflow duct (6).

4. A discharge nozzle according to any of the preceding claims, wherein each outlet of said at least two second outlets (9) has its geometrical axis (W) directed downwards and forming an angle (β) less than 90° with the longitudinal axis (Y) of said outflow duct (6).

5. A discharge nozzle according to claim 3, wherein said angle (α) is comprised between 60° and 90°.

6. A discharge nozzle according to claim 5, wherein said angle (α) is 75°.

7. A discharge nozzle according to claim 4, wherein said angle (β) is comprised between 60° and 90°.

8. A discharge nozzle according to claim 7, wherein said angle (β) is 75°.

9. A discharge nozzle substantially as described above with reference to the enclosed drawings.

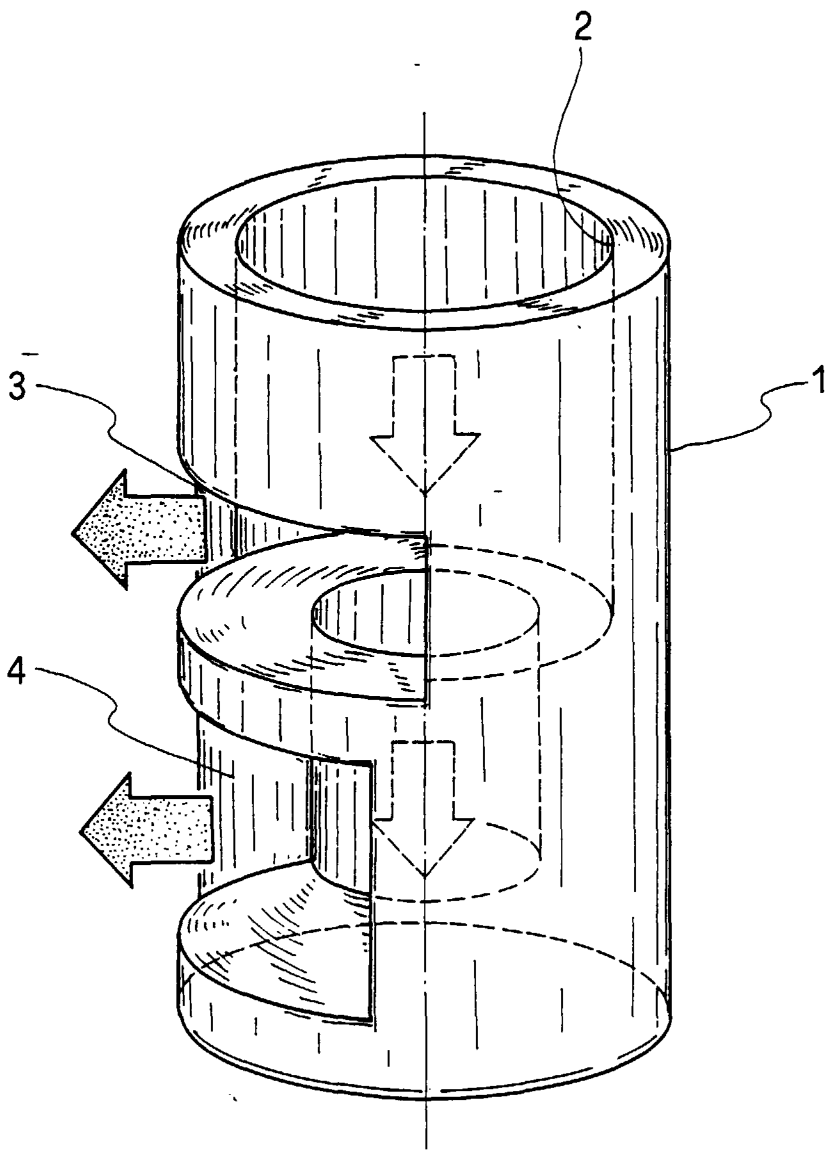

FIG 1

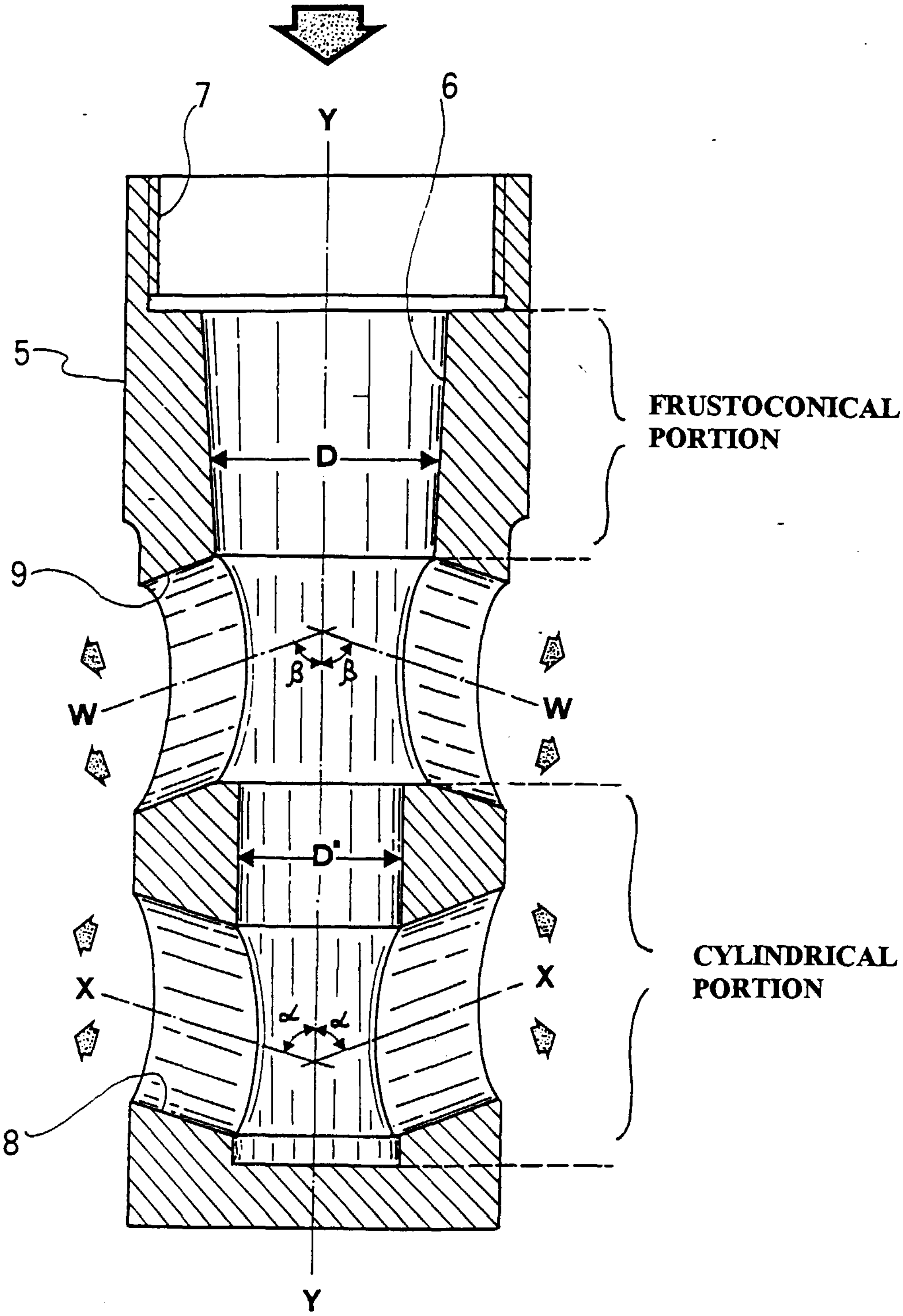
7
6
Y
5
D
FRUSTOCONICAL PORTION
9
β
β
W
W
D'
CYLINDRICAL PORTION
X
X
α
α
8
Y

FIG 2