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3,176,355

METHOD AND AN APPARATUS FOR REGULATING THE COOLING OF CONTINUOUS
CASTING MATERIAL IN THE SECONDARY COOLING ZONE

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Fig. 1

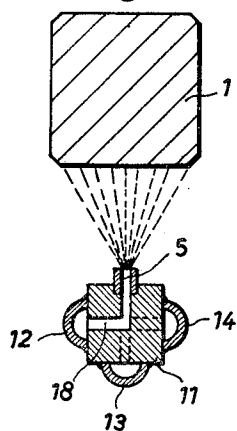


Fig. 3

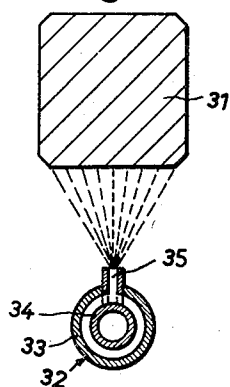


Fig. 4



Fig. 5

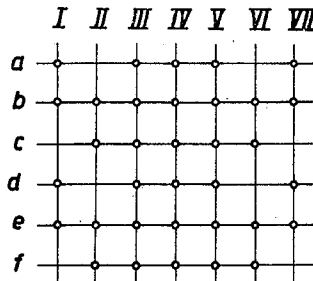
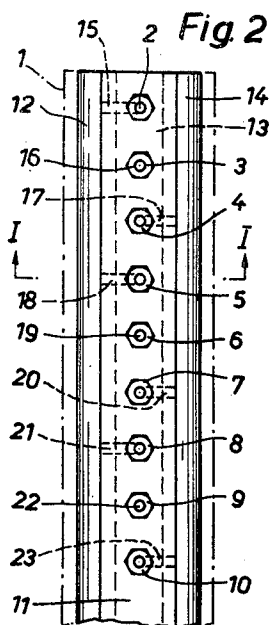
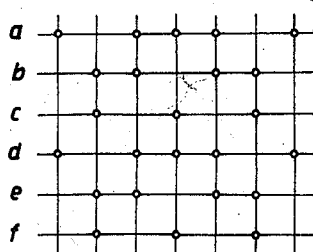


Fig. 6



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METHOD AND AN APPARATUS FOR REGULATING THE COOLING OF CONTINUOUS CASTING MATERIAL IN THE SECONDARY COOLING ZONE

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7,164/61

5 Claims. (Cl. 22—57.2)

This invention relates to continuous casting and, more particularly, relates to an improved method and apparatus for secondary cooling of the strand issuing from a continuous casting mold.

In this art of continuous casting a supply of molten metal is continuously fed to one end of a mold cavity of suitable cross-section, the walls of which in contact with the poured metal are cooled by a circulating fluid in contact with the outside of the mould wall in a primary cooling zone that will cause rapid solidification of metal in contact with the mould walls.

The cast metal, commonly referred to as a strand, having a uniform cross-section corresponding to that of the mould cavity throughout its length, is withdrawn by an appropriate withdrawal mechanism from the opposite end of the mold in continuous manner during the entire process and is then directly cooled in a secondary cooling zone. The present invention relates more particularly to a method and to an apparatus for regulating this secondary cooling that is effected by spraying cooling fluid against the ingot through nozzles arranged in a plurality of planes.

Such a secondary cooling zone with the associated guiding for the ingot is described in more detail in the U.S. Patent No. 2,284,503 "Apparatus for continuous casting" of Edward R. Williams. Accurate control of the cooling in this secondary cooling zone is of outstanding importance for the quality of the product, i.e. of the produced strand. In order to obtain an optimum cooling effect the strand is cooled by water atomized by means of special nozzles. Therefore the position of the nozzles with respect to the strand surface, the dimension and the spraying angles as well as also the water pressure are variable values which may have a decisive influence upon the quality of the cast ingot.

There are several methods and apparatus known for influencing the mentioned values. For example in a known method, the nozzles are arranged in such manner that the atomized cooling fluid is directed only against the plane surfaces of the ingot while the edges of the latter undergo practically no cooling.

A further publication describes a method in which the cooling varies along the periphery of the ingot. This is obtained by a periodical arrangement of the spraying nozzles at different levels. This publication also indicates the possibility of arranging spraying rings whereby the cooling effect may be modified at the circumference of the ingot by appropriate shielding. Spraying rings have the drawback that with them the distance of the spraying nozzles from the ingot surface cannot be modified. It is also known to vary the borings of the spraying rings with respect to their dimension, distance and positioning.

In a further publication it is suggested to arrange spraying nozzles at rings in groups or separately at increasing distances from the mould.

The spraying rings are generally fed with cooling fluid through feeding conduits, whereby either each spraying ring or a group of spraying rings is provided with a respective feeding conduit. In the first case limited modifi-

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cations of the cooling effect may be obtained by closing or adjusting valves, such regulations by means of valves having the drawback that not only the volume of the cooling fluid but simultaneously also the spraying angle, the degree of atomization, the characteristics of the distribution etc., are modified which may lead to the formation of cracks in the ingot. Moreover if billets shall be produced it is generally not possible to provide separate feeding conduits for the spraying rings due to lack of space. Also such separate feeding conduits are mounted on the exchangeable roller bed so that corresponding flexible connections are required. In the second case mentioned above, i.e. when one feeding conduit supplies several spraying rings which of course results in a simpler construction the possibility of regulating the cooling is accordingly very limited.

None of the mentioned known systems renders possible a very general regulation of the cooling without modification of the arrangement of the cooling apparatus. Now if it is desired to use one mould of a particular shape for casting different qualities of steel, which as is well known require different cooling, or if the casting speed must be adjusted to meet particular requirements it should be possible to adapt the cooling in the secondary cooling zone to the quality of steel that is to be casted or to the casting speed that will be used, which in the known systems and more particularly in the system using spraying rings leads to time-wasting disassembling and assembling operations.

It is a primary object of the present invention to provide for means permitting the production of continuous casting products of different qualities and more particularly the production of strands with the same cooling apparatus.

In accordance with the present invention this aim is attained by a method for regulating the cooling of continuous casting material in the secondary cooling zone, by spraying cooling fluid onto it through spraying nozzles arranged in several planes, in which cooling fluid is supplied through feeding conduits to one or several groups of nozzles in accordance with the cooling requirements, whereby each of said groups of nozzles comprising at least one nozzle from at least two planes of a device comprising a plurality of nozzles in each of several planes, the sequence of the nozzles of one group being cyclically interrupted by nozzles of at least one other group.

A further object of the present invention is to provide apparatus for carrying out the above method in which apparatus at least one nozzle arranged in one of said planes is combined with at least one nozzle in another of said planes to form one of said groups, the nozzles of each group being connected with a common feeding conduit for cooling fluid, the sequence of the nozzles being cyclically interrupted by nozzles of at least another group and the passage of cooling fluid through each of such feeding conduits being controllable separately.

Other features and advantages of the present invention will appear from the description, now to follow, of preferred embodiments thereof, given by way of example only, and in which reference will be made to the accompanying drawings, in which:

FIGURE 1 is a cross-section through a billet and through a square nozzle block along the line I—I of FIGURE 2.

FIGURE 2 is a view of the nozzle block of FIGURE 1.

FIGURE 3 is a cross-section through a nozzle block having concentrically arranged feeding pipes.

FIGURE 4 is a cross-section through a slab with a nozzle block associated thereto, and

FIGURES 5 and 6 illustrate examples of different cool-

ings that may be obtained in accordance with the present invention.

Referring now to the drawings and more particularly to FIGURES 1 and 2 thereof, reference numeral 1 designates a strand passing the secondary cooling zone of a continuous casting plant. Nozzles 2 to 10, of the type shown for example in the U.S. Patent 2,621,078, arranged parallel to the axis of this strand, spray cooling fluid against each longitudinal side of the strand. For the sake of simplicity the spraying is shown for one side only of the strand and also the guiding of the strand is not shown. The nozzles 2 to 10 are screwed into a square nozzle block 11 into the side thereof facing the slab. To the other side of the nozzle block 11 feeding conduits 12, 13 and 14 having the shape of semicircular pipes are welded and these feeding conduits are fed with cooling fluid, which preferably is water. The nozzles 2 to 10 are connected to the feeding conduits through borings and this connection is effected in cyclic circuits. In other words and referring to the shown example, the nozzles 2 and 5 and 8, respectively, are connected by borings 15 and 18 and 21, respectively, with the feeding conduit 12, the nozzles 3 and 6 and 9, respectively, are connected by the borings 16 and 19 and 22, respectively, with the feeding conduit 13 and the nozzles 4 and 7 and 10, respectively, are connected by borings 17 and 20 and 23, respectively, with the feeding conduit 14. Thus the nozzles 2, 5, 8 and 3, 6, 9 and 4, 7, 10, respectively, each form a group of nozzles.

Of course it would be possible to obtain different groupings by different arrangements of the borings. For example it would be possible to connect the nozzles 2, 3, and 4, 5 and 6, 7, respectively, to the feeding conduits 12 and 13 and 14, respectively, whereby cyclic groupings 2, 3/8, 9 etc. would result.

A different construction of a nozzle block is illustrated by FIGURE 3. This nozzle block 32 again illustrated for one side of the slab 31 only, consists of feeding conduits 33 and 34 arranged concentrically with respect to each other. The inner pipe 34 is connected with the outer pipe 33 by webs (not shown). The outer pipe 33 carries nozzles 35 the borings of which communicate either with the annular surface or with the inner surface of the nozzle block 32 so that again groups of nozzles are formed.

FIGURE 4 shows the embodiment of FIGURES 1 and 2 in use with the casting of a slab. I and VII designate the nozzle blocks spraying on the narrow sides of the slab, and II to VI designate parallel nozzle blocks spraying on the broad side of the slab.

In FIGURES 5 and 6 there are shown diagrammatical examples of the cooling effect for this slab. The vertical lines represent the nozzle blocks and are again designated by references I-VII. All nozzles of the nozzle block I-VII are arranged in a plane perpendicular to the axis of the slab. This plane is designated by *a* and it corresponds to the level *a* in the secondary cooling zone of the plant. All these nozzles form a group of nozzles in this particular plane. Analogously all nozzles 3 to 10 illustrate further groups *b* to *f* in the corresponding planes which all are parallel to each other.

In accordance with FIGURE 5 the valve of one feeding conduit for the nozzle blocks I and VII is closed so that the cyclic sequence of the action of the nozzles parallel to the axis of the slab is 1, 1, 0, 1, 1, 0 etc. wherein 1 designates an open nozzle and 0 designate a closed nozzle. The state "open" valve is indicated in the points of intersection of the nozzle blocks I to VII with the planes *a* to *f* with a ring. In each of the nozzle blocks II and VI the valve of one other feeding conduit is closed so that the sequence obtained is: 0, 1, 1, 0, 1, 1, etc. In the nozzle blocks III, IV and V all valves are in open position resulting in the sequence 1, 1, 1, etc. The described arrangement of the apparatus results, in the planes

a to *f* perpendicular to the axis of the slab into the following cyclic sequence of the nozzle action:

	I	II	III	IV	V	VI	VII
Plane:							
<i>a</i> -----	1	0	1	1	1	0	1
<i>b</i> -----	1	1	1	1	1	1	1
<i>c</i> -----	0	1	1	1	1	1	0
<i>d</i> -----	1	0	1	1	1	0	1
<i>e</i> -----	1	1	1	1	1	1	1
<i>f</i> -----	0	1	1	1	1	1	0

Both nozzle blocks I and VII arranged on the narrow side of the slab together comprise 12 and the nozzle blocks II to VI associated to the broad side each of the slab (FIGURE 4) include together 60 nozzles so that the represented embodiment has 72 nozzles. Of these 4 nozzles are in action on each narrow side and 26 nozzles are in action on each broad side of the slab so that of the 72 provided nozzles 60 are effective.

In the example shown in FIGURE 6 other valves of the nozzle blocks have been closed so that without any constructive modification of the apparatus with which the action shown above has been obtained only 44 nozzles are active.

In the represented embodiments, only the state "open" or "closed" has been assumed for each valve. Of course, the cooling action could be modified also by throttling the valves into a position between open and closed. This would of course involve the drawbacks mentioned in the preamble. A further adaption of the cooling may be obtained by mounting different nozzle types or nozzles of different dimension.

The vertical arrangement of the nozzle blocks gives the possibility of individually adjusting the distance separating the nozzles of one block from the surface of the ingot.

The number of groups of nozzles for each nozzle block may of course be increased to more than the three of the represented embodiment. In accordance therewith the number of surfaces provided for the securing of the feeding conduits to the blocks should be increased. The number of faces required for the nozzle block will always be $n+1$, where n is the number of groups of nozzles on that particular nozzle block.

The nozzles corresponding in vertical direction with each other must not necessarily be arranged in parallel planes perpendicularly to the axis of the ingot. Applications may be found where the nozzles associated in vertical direction to each other are arranged in planes which form an angle with the axis of the ingot.

In order to reduce the required number of adjusting valves which may be necessary when particularly large slabs are cast which require a great number of nozzle blocks the feeding conduits for nozzle blocks required to have the same cooling action may be connected with each other so as to be controlled by a common valve.

I claim:

1. Apparatus for cooling the strand issuing from a continuous casting mold which comprises a plurality of nozzle blocks positioned in approximately parallel columns adjacent said strand, a plurality of nozzles carried by each of said nozzle blocks and arranged to form approximately parallel rows of nozzles, each of said nozzle blocks including a plurality of conduits, means coupling each conduit to a selected number of spaced apart nozzles, and means for closing said conduits selectively to effect changes of the cooling of said strand by selective control of the nozzles spraying water on said strand without permitting temperature differences in the solidified skin of the casting which would induce cracks therein.

2. An apparatus as claimed in claim 1 which includes multi-edged nozzle blocks, the number of faces of which exceeds about one the number of nozzle groups on the particular block, whereby the nozzles are arranged along one face and on each other face there is arranged one

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feeding conduit feeding one particular selected number of spaced apart nozzles.

3. An apparatus as claimed in claim 1 in which said nozzle blocks are formed of concentrically arranged feeding tubes the number of which corresponding to the number of nozzle groups on that particular block. 5

4. Apparatus in accordance with claim 1 in which said columns are positioned parallel to each other and to the axis of the strand.

5. Apparatus in accordance with claim 1 in which said 10

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rows are positioned parallel to each other and perpendicular to the axis of said strand.

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