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## Translation

European Patent No. 0 327 526Description

The present invention relates to a device for cooling a metal during casting, with a view to casting this metal with a superheat of close to 0 °C or in the viscous phase in a continuous casting ingot mould according to the preamble of Claim 1.

The method of casting with a superheat of close to 0 °C or in the viscous phase has known advantages for the continuous casting of metals, in particular steel. In such a method, the steel is cooled, between the casting vessel and the continuous casting ingot mould, to a temperature close to the temperature of the liquidus or in the solidification range of this steel. This removes the superheat of the steel at least and possibly causes a solidified fraction to appear in the steel, the extent of which depends on the cooling applied. The steel thus displays a state, at least where it enters the ingot mould, which makes it possible to obtain fine and homogeneous structures and to reduce the segregations in the cast products.

In particular, a device for casting a metal with a superheat of close to 0 °C or in the viscous phase is disclosed by the patent LU-A-86.688 (EP-A-269180, on which the preamble of Claim 1 is based). This device essentially comprises a vertical channel, the outside of which is provided with cooling means, and a distributing apparatus ensuring the distribution of the cast metal over the inner wall of this vertical channel.

The object of the present invention is to propose a particular device which makes it possible to carry out the cooling of the metal during casting in optimum conditions.

According to the present invention, a device for cooling a metal during casting in a vertical channel, with an apparatus for distributing metal over the inner wall of the vertical channel located substantially at the entrance of the said vertical channel, is characterised in that it comprises a feed chamber arranged around the said vertical channel and having a front wall which matches, at a distance, the shape of the said vertical channel, and a discharge chamber arranged around the said feed chamber and separated therefrom by an intermediate wall, the said discharge chamber being delimited at the rear by an outer wall, in that the said front wall is pierced with a plurality of passages directed towards the said vertical channel, in that some of the said passages emerge in the said feed chamber, in that the other said passages are connected to tubes which pass through the said feed chamber and the said intermediate wall and which emerge in the said discharge chamber, in that the said feed chamber comprises means for feeding cooling liquid, and in that the said discharge chamber comprises means for discharging the cooling liquid.

According to a particular variant of the device of the invention, the said means for feeding cooling liquid comprise a distribution chamber arranged around the said vertical channel and communicating with the said feed chamber via a series of ducts distributed, preferably uniformly, around the said vertical channel.

In a preferred embodiment, the said feed chamber and the

said distribution chamber have at least one common wall portion, through which the said communication ducts are pierced.

According to an advantageous feature, the said passages pierced in the front wall of the feed chamber emerge in the volume between the said front wall and the said vertical channel, in a direction perpendicular to the surface of the said vertical channel.

Other features and other advantages of the present invention will become evident on reading the description given below by way of example. This description relates to a preferred embodiment of the device of the invention, as illustrated by the attached drawings in which

Fig. 1 illustrates the assembly of a cooling device according to the invention in an installation for casting steel in the viscous phase;  
and

Fig. 2 is an enlarged axial section of the cooling device of Fig. 1.

These two figures are diagrammatic representations, in which there has been a deliberate policy of only reproducing the elements directly necessary for understanding the invention. Similar or identical elements are designated by the same reference numbers, and the directions of circulation of the cooling liquid are indicated by arrows.

Fig. 1 is a diagrammatic representation of an installation for casting steel in the viscous phase, equipped with a steel cooling device according to the invention. Such an installation is presently known in the art and will not be described in detail here. It will simply be recalled that it comprises a continuous casting ingot mould 1, a casting nozzle 2 provided e.g.

on a casting ladle, a vertical channel 3, arranged upstream of the ingot mould 1 and extended by a tubular element 7; the vertical channel 3 is preceded by a refractory section 8, which moreover comprises a plate 6 supported by three arms and ensuring the distribution of the metal. The outside of the vertical channel 3 is provided with cooling means comprising an entrance 4 and an exit 5 for the cooling liquid.

The cooling device according to the invention is illustrated on a larger scale in Fig. 2. It comprises a feed chamber 9 arranged around the vertical channel 3 and having a front wall 10 which matches, at a distance "e", the shape of the vertical channel 3. The feed chamber 9 is in turn surrounded by a discharge chamber 11 delimited on one side by an intermediate wall 12 which separates it from the feed chamber 9 and on the other side by an outer wall 13. The distance "e" constitutes the radial width of an annular volume 14 formed between the vertical channel 3 and the front wall 10.

A distribution chamber 15, equipped with an entrance 4 for the cooling liquid, is also arranged around the vertical channel 3. This distribution chamber 15 communicates with the feed chamber 9 via ducts 16 pierced in a portion of wall which is common to both these chambers 9 and 15. The discharge chamber 11 is provided with an exit 5 for the cooling liquid.

The feed chamber 9 and the discharge chamber 11 are closed at the bottom by individual bases 17, 18 which prevent these two chambers from communicating.

The front wall 10 is pierced with a plurality of passages which emerge in the annular volume 14, perpendicularly to the surface of the vertical channel

3. Some of these passages, marked with the reference 19, emerge at their other end inside the feed chamber 9, which thus communicate with the annular volume 14. The other passages are connected to tubes 20 which pass through the feed chamber 9 and the intermediate wall 12 in an impervious manner and which emerge in the discharge chamber 11. The discharge chamber 11 thus communicates directly with the annular volume 14.

The vertical channel 3 is generally cylindrical; consequently, the chambers 9, 11 and 15 are annular, by reason of symmetry. Moreover, the passages are preferably distributed uniformly in the front wall 10.

The cooling device according to the invention functions in the following manner.

The jet of molten steel 21, originating from a casting nozzle 2 (not shown in Fig. 2), falls on the distributor plate 6, from where it flows off on the refractory section 8 and then in a thin layer 22 along the inner surface of the vertical channel 3 made of copper.

Whilst it passes through the vertical passage 3, the steel 22 needs to be cooled until it reaches the viscous state by formation of a solidified fraction.

To this end, a cooling liquid, which is generally water, is introduced under pressure, via the entrance 4, into the distribution chamber 15 from where it reaches the feed chamber by passing through the ducts 16. Via the passages 19, the cooling liquid enters the annular volume 14 where it circulates along the vertical channel 3 before being discharged via the tubes 20. The cooling liquid then arrives in the discharge chamber 11 from where it escapes via the exit 5.

The perpendicular manner in which the jets of cooling liquid leave the passages 19 and the short journey of this liquid between an injection passage 19 and adjacent take-up tubes 20 ensure a turbulent flow of the cooling liquid in the annular volume 14. As a result, the vertical channel 3 and the steel 22 are cooled with a high level of efficiency for a small flow of cooling liquid.

It goes without saying that the circulation of the cooling liquid may be ensured, partially or entirely, by a suction pump connected to the exit 5.

The device of the invention may comprise means for modifying geometric characteristics such as the width "e" of the annular volume 14 or the diameter of the passages 19, or of the tubes 20, according to the flow speeds desired in each particular application.

Adjustment means may also be provided in order to modify the flow of cooling liquid according to the cooling to be applied in each particular case of application.

By way of example, a steel was cast at 0.8 %C with a flow of 4.8 kg/s, by means of a device illustrated in Fig. 1. The temperature of the steel in the nozzle was 1510 degrees °C. The steel was cast on a distributor plate made of refractory material, and then along the inner wall of a cylindrical vertical channel 3 made of copper, having a length of 350 mm and a diameter of 220 mm. The channel 3 was cooled by water introduced at the ambient temperature and circulating with a flow of 27 m<sup>3</sup>/h. The loss of charge in the cooling device was 3.5 kg/cm<sup>2</sup>. A cooling flux density of 4.2 MW/m<sup>2</sup> was achieved, with an increase in the temperature of the water of 7 °C.

By comparison, a similar cooling process carried out in a conventional device by means of water flowing in a laminar film required a flow of water of  $60 \text{ m}^3/\text{h}$ , encountered a loss of charge of  $12 \text{ kg/cm}^2$  and led to a cooling flux density of  $3 \text{ MW/m}^2$ .

The device of the invention therefore makes it possible to ensure more efficient cooling with the minimum quantity of cooling liquid and under a pressure which is lower than in the former devices.

Moreover, this device may be constructed in a single piece, or may be composed of several elements, independent or not, arranged around the vertical channel, without going beyond the scope of the present invention.

The above description principally presents and illustrates a device in which the vertical channel (3) is cylindrical. However, the invention is not limited to this type of vertical channel; in fact, it also extends to a channel with an exit cross-section which is greater than its entrance cross-section, and to a channel whose cross-section is not circular but oval, for example.

Furthermore, this description refers particularly to the cooling of a vertical pipe leading to a continuous casting ingot mould. It goes without saying that it comes within the scope of the invention to use such a device to cool the actual continuous casting ingot mould, or any other mould or ingot mould requiring cooling.



### Claims

1. A device for cooling a metal during casting in a vertical channel (3), with an apparatus (6) for distributing metal over the inner wall of the vertical channel located substantially at the entrance of the said vertical channel, characterised in that it comprises a feed chamber (9) arranged around the said vertical channel (3) and having a front wall (10) which matches, at a distance (e), the shape of the said vertical channel (3), and a discharge chamber (11) arranged around the said feed chamber (9) and separated therefrom by an intermediate wall (12), the said discharge chamber being delimited at the rear by an outer wall (13), in that the said front wall (10) is pierced with a plurality of passages directed towards the said vertical channel (3), in that some (19) of the said passages emerge in the said feed chamber (9), in that the other said passages are connected to tubes (20) which pass through the said feed chamber (9) and the said intermediate wall (12) and which emerge in the said discharge chamber (11), in that the said feed chamber (9) comprises means (4, 15) for feeding cooling liquid, and in that the said discharge chamber (11) comprises means (5) for discharging the cooling liquid.
2. A cooling device according to Claim 1, characterised in that the said means for feeding cooling liquid comprise a distribution chamber (15) arranged around the said vertical channel (3) and communicating with the said feed chamber (9) via ducts (16) distributed around the said vertical channel (3).
3. A cooling device according to Claim 2, characterised in that the said feed chamber (9) and the said



distribution chamber (15) have at least one common wall portion, and in that the said ducts (16) are pierced in the said common wall portion.

4. A cooling device according to any one of Claims 1 to 3, characterised in that the passages pierced in the front wall (10) of the said feed chamber (9) emerge in the volume (14) between the said front wall (10) and the said vertical channel (3), in a direction perpendicular to the surface of the said vertical channel (3).
5. A cooling device according to any one of the preceding claims, characterised in that it consists of several elements arranged around the said vertical channel (3).
6. A cooling device according to any one of Claims 1 to 5, characterised in that the vertical channel (3) has an exit cross-section which is equal to or greater than its entry cross-section.
7. A cooling device according to any one of Claims 1 to 6, characterised in that the vertical channel (3) has a non-circular transverse cross-section, such as an oval cross-section.