CONTINUOUS CASTING OF METAL

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This invention relates to the continuous casting of metal in a liquid-cooled mould, from the lower end of which a newly-formed ingot is withdrawn progressively in a continuous length by means of power-driven withdrawal rolls.

In the casting of steel and other high-melting-point metals, the newly-formed ingot emerging from the mould is only partially solidified, i.e., it has a solid skin but a molten center. The ingot should be completely solidified by the time it reaches the withdrawal rolls, solidification taking place progressively during the passage of the ingot from the mould to the withdrawal rolls.

In order to accelerate the solidification of the ingot and to enable the vertical space between the withdrawal rolls and the mould, referred to as the secondary cooling zone, to be reduced, it is usual to spray the ingot with water during its passage through this zone. Very considerable amounts of heat are extracted in this way, with the production of large quantities of steam. A great part of this steam is condensed by contact with the water sprays but it cannot all be eliminated in this way, and in order to avoid unsatisfactory working conditions on the mould operating platform and poor working visibility around the mould, it has been proposed to enclose the secondary cooling zone as much as possible and to duct away the steam.

According to the present invention, in a process for the continuous casting of metal in an open-ended liquid-cooled mould, a length of the newly formed metal ingot extending vertically below the mould is enclosed in a shroud spaced around the ingot, the shroud defining a secondary cooling zone within which the ingot is sprayed with cooling liquid, and a forced current of air is caused to flow continuously in the generally upward direction through the interior of the shroud to one or more exhaust apertures adjacent to the upper end.

Thus the shroud acts as a form of cooling tower, the forced air current which passes upwardly through it serves to remove steam from within the shroud, and to reduce the rise in temperature in the sprayed water due to recondensation, and also to remove substantial quantities of heat from within the shroud by evaporating part of the spray water in the manner of a conventional cooling tower.

The velocity of flow of the forced air stream through the shroud should preferably be in the range 200—500 feet per minute.

In one form of the invention, the interior of the shroud is maintained at a sub-atmospheric pressure. For example, the forced air current may be induced to flow by means of an extraction fan or other suction device connected to the exhaust aperture or apertures of the shroud. The fan must be sufficiently powerful to maintain the required negative pressure within the shroud.

The shroud may be formed with one or more air inlets at its lower end, the air inlet or one of them being afforded by a narrow annular space surrounding the ingot between its surface and the lower edge of the shroud through the ingot extends downwardly. The escape of water, which otherwise runs down the surface of the protruding ingot, is substantially reduced or prevented by the air stream drawn in or blown in through the annular gap, possibly aided by water shedder plates or by a ring of steam or air jets directed upwardly around the ingot at the point of exit from the shroud.

In one arrangement the shroud is provided with one or more air inlets at its upper end through which air will be drawn into the shroud through the sub-atmospheric pressure therein, so as to ventilate the region around and above the upper end of the shroud.

Alternatively instead of maintaining the interior of the shroud at a sub-atmospheric pressure and inducing the forced air-stream to flow by means of suction means associated with the exhaust aperture, the forced air stream may be produced in the shroud by blowing air into the lower part of the shroud. For this purpose the jets of compressed air referred to above at the lower part of the shroud may in some cases be relied on alone, although it will usually be desirable to provide one or more additional air inlets in the lower part of the shroud and to blow air under low pressure into the shroud through these inlets, for example by means of low-pressure fans.

According to another of its aspects the invention comprises apparatus for the continuous casting of metal which includes an open-ended liquid-cooled mould beneath which is mounted an elongated shroud positioned to surround a length of the newly-formed ingot depending vertically from the mould, the ingot extending out through the bottom of the shroud, and the side walls of the shroud being spaced from the surfaces of the ingot to define a secondary cooling zone, spray means for spraying the length of ingot in the secondary cooling zone within the shroud with cooling liquid, and means for forcing a continuous current of air to flow in the generally upward direction through the interior of the shroud to one or more exhaust apertures situated adjacent to the upper end of the shroud.

According to a further feature of the present invention, the sides of the water-cooled mould may be surrounded by a mould chamber whose interior communicates with the interior of the shroud, and means may be provided for maintaining the interior of the mould chamber at an air pressure greater than the pressure in the interior of the shroud. This mould chamber may contain equipment such as mechanism for vertically reciprocating the mould, and since its interior is maintained at a greater pressure than that in the shroud with which it communicates, steam from the interior of the shroud will be prevented from passing into the mould chamber where it might damage the equipment referred to.

Moreover, the interior of the mould chamber will normally be maintained at a super-atmospheric pressure by the continuous supply to it of compressed air, so that smoke and fumes produced above the mould by the casting operation will be prevented from being drawn into the mould chamber through any clearance between it and the reciprocating mould.

In one such arrangement a common supply of compressed air is connected both to the mould chamber and to a gas burner for heating a tundish associated with the mould, and valve means is provided whereby compressed air may be delivered from the supply either simultaneously to the burner as combustion air and to the mould chamber, or solely to the mould chamber when the burner is not required to preheat the tundish.

The invention may be carried into practice in various ways, but two specific embodiments will now be described by way of example only with reference to the accompanying drawings, wherein:

FIGURE 1 is a diagrammatic sectional elevation of a part of a continuous casting plant for steel, and
FIGURE 2 is a similar view of a modified form of plant.

In the embodiment of FIGURE 1, a continuous casting plant for the casting of steel is provided with a vertically-
The depression produced within the shroud by the action of the extractor fan must be sufficient to cause a sufficient velocity of flow of the forced air stream through the shroud, for example a velocity of between 200 and 500 feet per minute. It is desirable however that the velocity of the forced airstream should not greatly exceed the later value or a substantial quantity of water droplets will be entrained in the air stream and removed from the shroud as well as the steam. On the other hand, air velocities as low as 150 feet per minute may provide a useful “cooling tower” effect.

It will be appreciated that by virtue of the extraction through the duct 19 of the steam produced in the interior of the shroud 15, and by the action of the auxiliary fan 21 at the top of the shroud, this is prevented from escaping even in relatively small quantities to the region in the vicinity of the mould itself. If the ventilating action of the annular inlet 21 is insufficient, the top wall 20 of the shroud might be formed with one or more additional inlet apertures, preferably of adjustable area.

In the modified embodiment illustrated in FIGURE 2, similar parts are given the same reference numerals. In this case however the interior of the shroud 15 is not maintained at a sub-atmospheric pressure, but the forced upright draught of air through the interior of the shroud is produced by the pressure of air entering the annular gap 26 around and above the mould, acting as a suction nozzle through which smoke and fumes in the region of the mould, for example within the mould chamber 11, are withdrawn.

Air under pressure is supplied to the mould chamber from a source S through a port 37 in the side of the mould chamber, and the compressed air is driven through the annular gap 36 around the base of the mould 10 down into the interior of the shroud 15, whose upper end is covered by the partition 35. This flow of compressed air cools the mould chamber 11 and ventilates it. Moreover since the pressure within the mould chamber 11 is maintained by the introduction of the compressed air at a greater value than the pressure within the shroud 15, any flow of steam from the shroud into the mould chamber, and any resultant damage thereby to the equipment in the mould, bottom of the mould is prevented. In addition a further advantage of this arrangement is that a partition 35 is provided in the side of the mould chamber 11 so that a part of the compressed air may be directed out of the mould chamber for the benefit of the operators. In addition, some air will escape through the small gap 35 between the top of the mould 10 and the cover plate 32, which gap 35 permits the vertical oscillation of the mould.

Thus smoke and fumes produced in the casting op-
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5 eration, which arise almost entirely in the mould or from the stream of metal being poured from the tundish to the mould, are prevented from entering the mould chamber by the pressure differential. Any smoke which might arise inside the mould chamber and might be detrimental to the operation of the equipment in the mould chamber, is carried by the air stream into the interior of the shroud 15 and thence to the exhaust port 18, or is discharged through the upper gap 33 and louvres 38.

The air supply from the source S to the mould chamber 11 is passed through a main air pipe 39 and a branch pipe 40 fitted with a stop valve 41. A second branch pipe 42 leads off the main pipe 39 and is connected via a second stop valve 43 to the gas burner incorporated in the tundish 34. Thus compressed air from the source S can also be supplied as combustion air to the burner in the tundish, to enable the latter to be preheated by the burner at the same time as the mould chamber is receiving compressed air from the same source. When the tundish is not required to be heated by the burner, the air supply to the burner is shut off by means of the stop valve 43 when the total supply of air from the source S will be delivered to the mould chamber 11.

In accordance with the provisions of the patent statutes, I have explained the principle and operation of my invention and have illustrated and described what I consider to represent the best embodiment thereof. However, I desire to have it understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

What I claim is:

1. In a process for the continuous casting of metal workpieces in an open-ended mould, in which a length of a newly formed casting extending below the mould is enclosed in a shroud spaced around the casting, the steps comprising causing the casting to pass through the shroud and away from the mould, spraying the casting with a coolant during at least a portion of its passage through the shroud, and at the same time causing a forced current of air to flow continuously through the shroud to remove steam and heat within the shroud and reduce the temperature of the coolant within the shroud, and causing a stream of air to be directed around the casting at a point substantially where the casting enters the shroud to ventilate the region around and above the upper end of the shroud.

2. In a process according to claim 1 wherein the mould is surrounded by a mould chamber and the interior of the mould chamber communicates with the interior of the shroud, including the additional step of causing the mould chamber to be maintained at an air pressure greater than the pressure in the interior of the shroud.

3. Apparatus for the continuous casting of metal, which comprises an open-ended mould, an elongated shroud mounted beneath the mould positioned to surround a length of the newly formed casting depending from the mould in which the casting extends out through the bottom of the shroud, said shroud comprising side walls spaced from the surfaces of the casting to define a secondary cooling zone, spray means for spraying the length of the casting in the secondary cooling zone within the shroud with cooling liquid, means for forcing a continuous current of air to flow through the interior of the shroud, an exhaust aperture situated adjacent to one end of the shroud to receive the air, a mould chamber surrounding the sides of the mould and communicating with the interior of the mould, and means for maintaining the interior of the mould chamber at an air pressure greater than the pressure in the interior of the shroud.

4. Apparatus as claimed in claim 3 in which the said means for maintaining the interior of said mould chamber at the specified pressure comprises means for admitting a continuous flow of compressed air into the interior of the mould chamber.

5. Apparatus as claimed in claim 4 including a common supply of compressed air connected both to the mould chamber and to a heating burner for heating a tundish associated with the mould, and valve means for delivering compressed air from the supply either simultaneously to the burner as combustion air and to the mould chamber, or solely to the mould chamber.

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