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(54) IMPROVEMENTS IN OR RELATING TO A CONTINUOUS-CASTING MOULD ASSEMBLY PROVIDED WITH AN ELECTROMAGNETIC STIRRING DEVICE

(71) We, UNION SIDERURGIQUE DU NORD ET DE L'EST DE LA FRANCE, "U S I N O R", a French body Corporate of 14, rue d'Athenes, Paris 09, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which is is to be performed, to be particularly described in and by the following statement:—

The present invention relates to continuous-casting mould assemblies.

British Appln. No. 28499/75 (Serial No. 1520293) discloses a continuous casting installation for products of relatively small size, this installation being provided with electromagnetic stirring or agitating means employing an induction current the frquency of which is lower than 10 Hertz. The advantages of this type of stirring are explained in detail in said patent and concerns in particular the metallurgical quality of the product obtained and the simplicity and output of the installation.

In the case of slab blooms, the essential metallurigical interest of the stirring is to achieve an artificial effervescence which brings away from the solidification front by a localised turbulence the inclusions and porosities which adhere to the basaltic skin.

An object of the invention is to provide a continuous-casting mould for casting slab blooms or like products which permits carrying out the electromagnetic stirring process with a satisfactory energy efficiency and a prolonged life.

According to the invention, there is provided a continuous-casting mould assembly comprising a copper mould at least partly surrounded by a cooling box in which a a cooling fluid is intended to flow, wherein the cooling box comprises a first chamber defined by a copper wall of the mould and by a parallel front wall which is made in part from stainless steel and includes ribs and grooves for circulation of the cooling fluid, magnetic poles which are part of an electromagnetic induction stirring device being embedded in said front wall of the box, and also having ribs and grooves so as to ensure the continuity of the passages for the cooling fluid, and a second chamber in which there are disposed the coils and the cores of the electromagnetic induction device.

According to other features:

the second chamber is connected to a second cooling circuit;

the box comprises a primary mould-cooling fluid inlet, an inlet manifold extending practically throughout the length of the mould and connected to the inlet pipe and to the first chamber of the box, said first chamber being connected through an outlet manifold to an outlet pipe of the primary cooling liquid;

the copper wall of the mould has a thickness reduced to its useful thickness, that is to say to the exclusion of the initial grooves, and comprises a plurality of studs or posts projecting from the face thereof facing the cooling chamber and adapted to bear against the adjacent wall of the box, said studs receiving fixing tie rods of magnetic steel which preferably serve as a support for the cores of the stirring device.

The invention will be described in detail hereinafter with reference to the accompanying drawing which is given solely by way of example and in which the single Figure is a perspective view of a part of a mould according to the invention.

The Figure shows a part of a continuous-casting mould defining a casting section of rectangular shape. The mould comprises four elements, two longitudinal elements, such as A, and two transverse elements, such as B, the position of which latter is adjustable to determine the dimensions of the cast product. The longitudinal elements are provided with electromagnetic stirring or agitating devices and are therefore improved in accordance with the invention. Only one thereof will be described hereinafter, since the other element comprises the same arrangements. The two transverse elements

are of conventional design and therefore need not be described here.

The illustrated mould element A mainly comprises a copper plate 1 which may be planar or curved and is fixed to a cooling box 2.

The copper plate has a reduced thickness of the order of 40 mm for example in the major part of its area and includes on the face thereof adjacent the cooling box studs or posts 3 which project from this face and have a thickness of the order of 25 mm for example. These studs act as anchoring means for tie rods 4 which are of magnetic steel and are tightened against the rear wall of the box.

The cooling box proper has a generally parallel-sided shape and consequently mainly comprises a front wall 5, a rear wall 6, lateral end walls 7, a bottom end wall 8 and a top end wall 9. It is divided by longitudinal partition walls 10, 11 and transverse partition walls 12, 13 into five parts namely:

an inlet chamber 14 connected to an inlet pipe 15 for primary mould-cooling fluid;

an inlet manifold 16 located in the lower part of the box and communicating with the inlet chamber 14 and with a cooling chamber 17 defined between the front wall 5 of the box and the copper plate 1; this communication is by way of orifices 18 formed in the front wall 5;

an outlet manifold 19 located in the upper part of the box and communicating with the chamber 17 by way of orifices (not shown) similar to the orifices 18;

an outlet chamber 20 connected to the manifold 19 and to an outlet pipe 21 for discharging the primary cooling fluid;

a central compartment 22 which is separated in a sealed manner from the adjacent compartments and from the chamber 17 defined between the copper plate and the front wall of the box; this central compartment constitutes a second chamber in which are disposed the coils 23 and the cores 24 of the electromagnetic stirring or agitating device; this chamber is connected by pipes 25, 26 to a secondary cooling circuit independent from the aforementioned primary cooling circuit.

The front wall 5 of the cooling box is made mainly from stainless steel and has, on the face thereof confronting the copper plate 1, groups of vertical ribs 27 separated by wider gaps 28 corresponding to the studs 23. The ribs 27 are in contact by their end faces with the adjacent face of the copper plate 1. They define therebetween grooves 29 for the passage of the cooling fluid. According to a particularly advantageous and essential feature of the invention, pole pieces 30 of mild steel are embedded in the stainless steel wall of the box, these pole peices also having ribs 31 and grooves 32 so as to ensure continuity of the passages for the cooling fluid. These pole pieces are in contact with the cores of the stirring device and with the copper plate 1 of the mould.

Note that the orifices 33 and 34, provided respectively in the front wall of the box and in the cores of the stirring device and adapted to allow the passage of the tie rods 4, have an oblong section the major axis of which is parallel to the longitudinal direction of the mould element so as to be capable of accommodating the displacements of these tie rods produced by expansions of the copper plate.

The electromagnetic stirring device adapted to generate a sliding field in the metal cast in the mould, is supplied with the inducing current at a frequency lower than 10 Hertz, for example 3 Herts so as to obtain a speed of synchronism of the order of 1·5 metre per second which is sufficient to drive the metal at a speed lower than 1 metre per second. In order to facilitate the closing of the magnetic fluxes and avoid a heating of the rear wall 6 of the box, the return circuits of the poles are laminated structures. The metal travels vertically along the walls of the mould.

It is unnecessary to repeat here the advantages from the metallurgical point of view of this stirring in a continuous-casting mould and merely the particular advantages resulting from the construction of this mould will be be underlined.

Owing to the grooves formed in the front wall of the cooling box, and to the corresponding reduction in the thickness of the copper plate resulting therefrom, the efficiency of the stirring device is substantially improved and the heating of the copper plate under the effect of eddy currents is considerably reduced, which reduces the wear of the mould.

These cooling grooves also ensure the laminated structure and the cooling of the pole pieces inserted in the stainless steel wall in contact with the cooper plate. These pole pieces are in immediate contact with the copper mould, which contributes the improvement of the energy efficiency.

Further, the cooling box has been arranged to cool the mould and the stirring device with two different circuits, the secondary circuit being regulated to have a much lower flow, which permits reducing in this respect the operating costs of the installation. The overall size of the assembly remains comparable to that of a conventional mould and the stirring device can therefore be incorporated in the installation without any profound, costly adaptation of the surrounding part of the installation.

It is envisaged that the cooling bag may wholly surround the mould.

WHAT WE CLAIM IS:—

1. A continuous-casting mould assembly comprising a copper mould at least partly surrounded by a cooling box in which a cooling fluid is intended to flow, wherein the cooling box comprises a first chamber defined by a copper wall of the mould and by a parallel front wall which is made in part from stainless steel and includes ribs and grooves for circulation of the cooling fluid, magnetic poles which are part of an electromagnetic induction stirring device being embedded in said front wall of the box, an also having ribs and grooves so as to ensure continuity of the passages for the cooling fluid, and a second chamber in which there are disposed the coils and the cores of the electromagnetic induction device.

2. A mould as claimed in claim 1, wherein said first chamber is connected to a first cooling circuit and said second chamber is connected to a second cooling circuit.

3. A mould as claimed in claim 3, wherein the ribs are in contact by their end faces with the copper wall.

4. A mould as claimed in claim 1, wherein the magnetic poles are made from magnetic steel.

5. A mould as claimed in any one of the claims 1 to 4, wherein the copper mould has two substantially parallel longitudinal walls and two substantially parallel transverse walls and the two longitudinal walls of the mould are provided with a cooling box.

6. A mould as claimed in any one of the claims 1 to 5, wherein the cooling box comprises a primary mould-cooling fluid inlet pipe, an inlet manifold extending throughout the length of the mould and connected to the inlet pipe and to the first chamber of the box, said first chamber being connected through an outlet manifold to a primary cooling fluid outlet pipe.

7. A mould as claimed in claim 6, wherein the first chamber communicates with the inlet and outlet manifolds through a series of orifices formed in said front wall of the box.

8. A mould as claimed in any one of the claims 1 to 7, wherein the copper wall of the mould is of reduced thickness and comprises a plurality of studs or posts which project from the face thereof facing said front wall and bear against said front wall, said studs receiving fixing tie rods of magnetic steel.

9. A mould as claimed in claim 8, wherein the tie rods serve to support the cores of the stirring device.

10. A mould as claimed in claim 8 or 9, wherein the orifices through which the tie rods pass have an oblong section the major axis of which is parallel to the longitudinal direction of the mould.

11. A continuous-casting mould, substantially as hereinbefore described with reference to and as shown in the accompanying drawing.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale