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Casting Mould Made of Copper

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(71) Applicant(s)
KM Europa Metal Aktiengesellschaft

(72) Inventor(s)
Hugenschuett, Herhard; Rode, Dirk; Merker, Juergen; Rethmann, Ralf; Henschemeier, Hans-Juergen ; Wobker, Hans-Guenter; Maiwald, Frank; Schulze, Hark

(74) Agent/Attorney
Spruson & Ferguson, GPO Box 3898, SYDNEY, NSW, 2001

Abstract

Casting Mould Made of Copper

A casting mould (1) of copper for the continuous casting of steel melts containing zinc or sulfur is provided with an at least single-ply diffusion barrier layer (3) in the thermally maximally stressed area (2) of contact with the steel melt.

(Figure 1)

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Name and Address of Applicant :	KM Europa Metal Aktiengesellschaft Klosterstrasse 29 49074 Osnabruck Germany
Actual Inventor(s):	Hans-Juergen Henschemeier Ralf Rethmann Juergen Merker Dirk Rode Herhard Hugenschuett Hark Schulze Frank Maiwald Hans-Guenter Wobker
Address for Service:	Spruson & Ferguson St Martins Tower Level 35 31 Market Street Sydney NSW 2000 (CCN 3710000177)
Invention Title:	Casting Mould Made of Copper

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

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Casting Mould Made of Copper

Technical Field

The invention relates to a casting mould made of copper for the continuous casting of steel melts containing zinc and/or sulfur.

Background of the Invention

When casting moulds of copper are used for the continuous casting of steel melts containing zinc or sulfur, early damages develop in the thermally maximally stressed areas of contact with the steel melt.

Zinc as a component of, for example, melted scrap metal from motor cars (zinc as anti-corrosion protection) reacts with the hot copper surface and, in a diffusion process, forms brittle $\alpha/\beta/\gamma$ brass phases. These chip off and subsequently result in the development of cracks.

Sulfur, which is present, for example, as a casting additive, reacts with copper and forms voluminous, brittle copper sulfides. These may likewise flake off. The scarring resulting therefrom by local corrosion is an ideal starting point for the development of cracks.

Summary of the Invention

Starting from the state of the art, the problem underlying the invention is to provide a casting mould of copper for the continuous casting of steel melts containing zinc and/or sulfur, which mould has a distinctly longer service life without the heat flow and the cooling effect of the casting mould of copper being affected in a relevant manner.

According to an embodiment of the invention, there is provided a casting mould of copper for the continuous casting of steel melts containing zinc or sulfur, which is provided with a diffusion barrier layer in the thermally maximally stressed area of contact with the steel melt.

Such a diffusion barrier layer comprises at least one ply and, according to a preferred aspect, is formed of at least one metal or metalloid the solubility of which in the presence of zinc and/or sulfur is negligible in the range of operating temperatures. These materials include, in particular, ruthenium (Ru), rhenium (Re), tantalum (Ta), silicon (Si), boron (B), tungsten (W), chromium (Cr), and niobium (Nb). If only zinc is present, also molybdenum (Mo), titanium (Ti), rhodium (Rh), and tellurium (Te) can be employed.

The diffusion barrier layer can be applied directly onto a copper surface of a casting mould made of copper by means of a CVD (chemical vapour deposition) or PVD (physical vapour deposition) process.

Furthermore, it is conceivable to apply the diffusion barrier layer onto chromium or onto some other electrodeposition layer.

Furthermore, a diffusion barrier layer can be configured as an intermediate layer prior to application of a wearing layer, e.g., of chromium and/or nickel.

The selection of the type of layer is determined by two considerations. On the one hand, the overriding goal of a diffusion barrier must be met. On the other hand, the necessary condition of excellent adhesion as an intermediate layer or cover layer must be satisfied.

A further option of forming a diffusion barrier layer is given by chromium oxide as cover layer. Its solubility in the presence of zinc and/or sulfur is negligible in the range of operating temperatures of a casting mould made of copper. The chromium oxide can be produced by thermal/chemical treatment of a chromium coating, for example, in an oxidising atmosphere. This implies the advantage that not only is the surface proper protected by an oxide against the diffusion of zinc and/dor sulfur into the chromium but that also the typically omnipresent microcracks and macrocracks of the chromium coating are closed by the oxide.

In addition, it is conceivable within the purview of the invention that at least one type of chromium is deposited as diffusion barrier layer. To this end, so-called crack-free, microcrack, and standardised hard chromium layers can be combined. The combination is effected in a manner such that no cracks extend from the layer surface to the base material or become fully extended during the work. There may be particularly suitable, for example, a layer structure which consists of an intermediate layer of crack-free or microcrack chromium with a following cover layer of standardised hard chromium.

The invention further encompasses the diffusion barrier layer to be formed as a layer of carbides, nitrides, borides or also oxides and their mixed forms, e.g., on the basis of titanium/aluminium (Ti/Al) and chromium (Cr). In this connection, particularly carbides, nitrides, and borides are preferred as intermediate layers. Oxides are more conveniently used as cover layers. The invention assumes advantageous characteristics particularly with the use of aluminium nitride (AlN), aluminium oxide (Al_2O_3), chromium carbide (CrC), chromium nitride (CrN), titanium carbide (TiC), titanium nitride (TiN),

titanium carbon nitride (TuCN), titanium aluminium nitride (TiAlN), and titanium boride (TiB_2).

A diffusion barrier layer can also be formed by applying an aluminium compound, for example, aluminium nitrate, onto the surface of a casting mould of copper, e.g., a chromium-plated surface. By this application, the surface layer of the casting mould is fully wetted and infiltrated by the salt solution. Annealing at a moderate temperature causes decomposition into γ aluminium oxide (Al_2O_3) on the entire surface, as well as in the microcracks and open pores. Also on this occasion, the diffusion of zinc and sulfur and, hence, the formation of brass and the development of corrosion by sulfur are prevented. The aluminium nitrate solution can be applied by immersion, spraying, or application by brush or roller. The protective effect of the infiltration can be enhanced by multiple immersion or application.

Also contemplated by the present invention is a combination of copper as material of the chill mould with nickel as protection against wear, and, in addition, one of the aforementioned diffusion barriers.

According to another preferred aspect, a diffusion barrier layer can be produced by application of suitable varnishes, resins or synthetic materials onto the surface of a casting mould made of copper, e.g., onto a chrome-plated surface. Varnishes, resins or synthetic materials based on silicone or epoxide are particularly suitable materials. By this application, the surface layer of the casting mould is completely wetted and infiltrated. By settling at room temperature or at a higher temperature, the coating hardens or oxidises on the entire surface, as well as in the microcracks and pores of the subjacent coating. Also in this case, the diffusion of zinc and sulfur and, hence, the formation of brass and the development of corrosion by sulfur are prevented.

According to another preferred aspect, there is contemplated a diffusion barrier layer formed by a ceramic material.

According to another preferred aspect, when the casting mould of copper consists of a tube-shaped or plate-shaped chill mould, the diffusion barrier layer is preferably applied in the upper half and, there, conveniently in the upper quarter or third of the length of the chill mould.

According to another preferred aspect, the diffusion barrier layer, in a tube mould or plate mould, is provided especially on the level of the melt surface. The diffusion barrier layer is applied with a height sufficing to positively cover the thermally highly

stressed contact area during oscillation of the melt surface. This range is typically within ±50 mm above or below the level of the melt surface or in a range of up to about 250 mm from the upper edge of the tube-shaped or plate-shaped chill mould. The range is advantageously at a distance of 50 mm to 250 mm, preferably of 150 mm to 200 mm, from the upper edge.

According to another preferred aspect, a travelling mould (casting roll, casting roller) is provided with a diffusion barrier layer which is situated on the entire periphery in contact with the steel melt.

Internal tests have shown that, the diffusion barrier layer should have a thickness of 0.002 mm to 0.3 mm.

According to a preferred aspect, the thickness of the diffusion barrier layer ranges from 0.005 mm to 0.1 mm.

According to another preferred aspect, the diffusion barrier layer can be formed as a multi-ply coating. In the case of a multi-ply coating, a plurality of layers and layer materials are combined.

Brief Description of the Drawings

In what follows, the invention is explained in detail by way of embodiments shown in the drawings, which show:

Figure 1: schematic of a chill mould plate viewed onto the casting plate;

Figure 2: schematic of a perspective view of a mould tube;

Figure 3: the longitudinal section of a single-ply diffusion barrier layer applied onto a base material of a casting mould;

Figure 4: the longitudinal section of a multi-ply diffusion barrier layer applied onto a base material of casting mould;

Figure 5: the longitudinal section of single-ply diffusion barrier layer with an intermediate layer applied onto a base material of the casting mould; and

Figure 6: the longitudinal section of a barrier layer applied onto a protective coating of the base material of a casting mould.

Detailed Description of the Preferred Embodiments

In Figure 1, a chill mould plate made of copper is denoted by 1. The shaded area 2 indicates the thermally maximally stressed area of contact with the steel melt. It is provided with a diffusion barrier layer 3. The melt surface is indicated by a dash-and-dot line. The melt surface 4 can oscillate in the vertical direction so that, in order to cover the

range 2, the diffusion barrier layer 3 extends about 50 mm above or below the melt surface 4. In other words, the melt surface 4 may be at a distance of about 150 mm to 200 mm from the upper edge 5 of the plate-shaped mould. The diffusion barrier layer 3 is made of a metallic material.

Figure 2 shows schematically a tube-shaped mould 6. There is also shown a diffusion barrier layer 7 of a metallic/metalloid material in the region 8 which is at a distance of about 150 mm to 200 mm from the upper edge 9 of the tube-shaped mould 6. The range to the melt surface 10 is about 50 mm.

Figure 3 shows a longitudinal section of the base material copper 11 of a casting mould 12 such as a plate mould or tube mould 1, 6 or a travelling mould such as a casting roller or casting roll not shown in detail. A single-ply diffusion barrier layer 13 of, for example, aluminium oxide (Al_2O_3) is applied onto this base material.

In Figure 4, the base material copper of a casting mould 12 is again denoted by 11. Onto the base material 11 there is applied a multi-ply layer 14 which, in this embodiment, is formed by a layer 15 of chromium nitride (CrN) contacting the base material 11, a layer 16 of aluminium oxide (Al_2O_3), and a layer 17 as cover layer made of titanium nitride (TiN).

In Figure 5, the base material copper of a casting mould 12 is again denoted by 11. Onto the base material 11 there is applied a single-ply diffusion barrier layer 18 made, for example, of aluminium nitride (AlN). Furthermore, there is provided a single-ply wearing layer 19, for example of chromium and/or nickel, in the transition region from the base material 11 copper to the diffusion barrier layer 18.

Finally, Figure 6 shows once more the base material copper 11 of a casting mould 12. Onto the same there is applied a protective layer 20 of chromium which is provided with a diffusion barrier layer 21, for example, of aluminium oxide (Al_2O_3), merging in its thickness with the surface of the protective layer 20.

List of reference numbers

1	Chill mould plate
2	range of 1
3	diffusion barrier layer
4	melt surface
5	upper edge of 1
6	tube-shaped mould
7	diffusion barrier layer
8	range of 6
9	upper side of 6
10	melt surface
11	base material of 12
12	casting mould
13	diffusion barrier layer
14	multi-ply layer
15	ply of 14
16	ply of 14
17	ply of 14
18	diffusion barrier layer
19	wearing layer
20	protective layer
21	diffusion barrier layer

The claims defining the invention are as follows:

1. A casting mould of copper for the continuous casting of steel melts containing zinc or sulfur, which is provided with a diffusion barrier layer in the thermally maximally stressed area of contact with the steel melt.

2. The casting mould of copper according to Claim 1, wherein the diffusion barrier layer is formed by at least one metallic or metalloid material.

3. The casting mould of copper according to Claim 1, wherein the diffusion barrier layer is formed by varnishes, resins or synthetic materials.

4. The casting mould of copper according to Claim 1, wherein the diffusion barrier layer is formed by a ceramic material.

5. The casting mould of copper according to any one of Claims 1 to 4, wherein the diffusion barrier layer is provided in the upper half of a tube mould or plate mould.

6. The casting mould of copper according to any one of Claims 1 to 5, wherein the diffusion barrier layer is provided within the altitude interval of the melt level of a tube mould or plate mould.

7. The casting mould of copper according to any one of Claims 1 to 4, wherein the diffusion barrier layer is provided on the entire steel melt-contacting periphery of a travelling chill mould.

8. The casting mould of copper according to any one of Claims 1 to 7, wherein the diffusion barrier layer has a thickness of 0.002 mm to 0.3 mm.

9. The casting mould of copper according to any one of Claims 1 to 8, wherein the diffusion barrier layer has a thickness of 0.005 mm to 0.1 mm.

10. The casting mould of copper according to any one of Claims 1 to 9, wherein the diffusion barrier layer is configured as a multi-ply layer.

11. A casting mould of copper for the continuous casting of steel melts containing zinc or sulfur, substantially as hereinbefore described with reference to any one of the embodiments illustrated by the accompanying drawings.

Dated 17 June, 2003

KM Europa Metal Aktiengesellschaft

Patent Attorneys for the Applicant/Nominated Person

SPRUSON & FERGUSON

[PAL Specifications639552spec

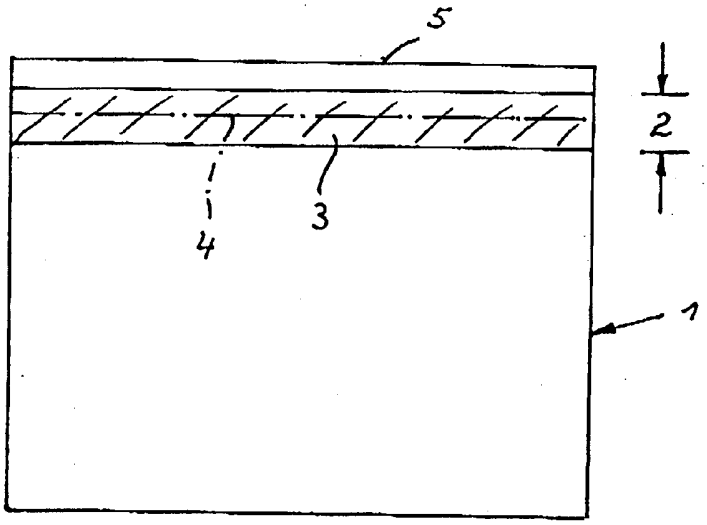

Fig. 1

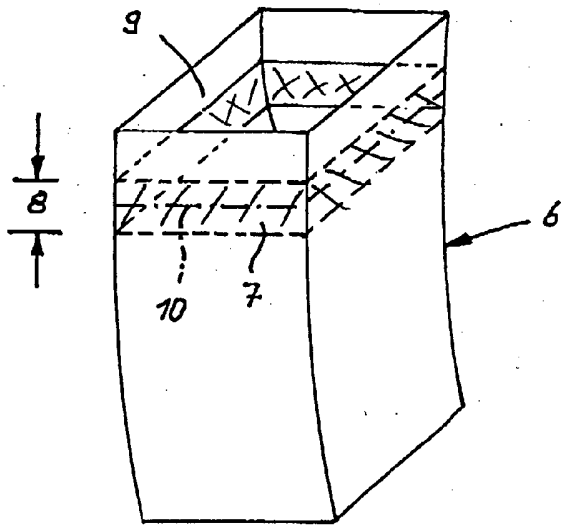

Fig. 2

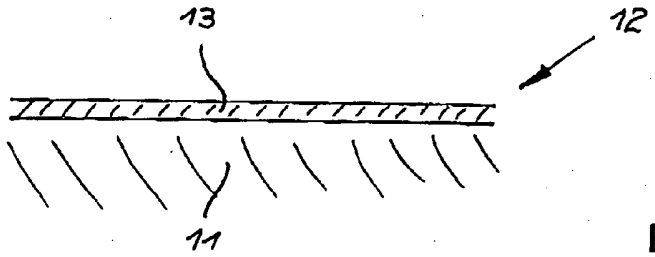

Fig. 3

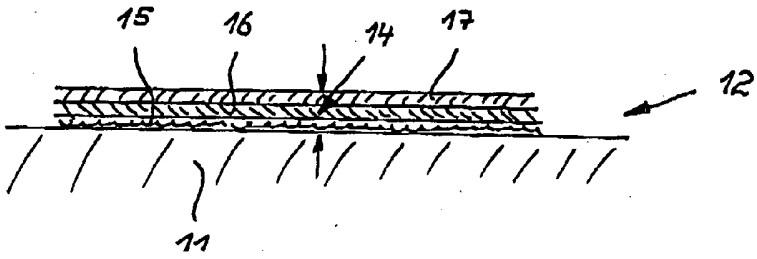

Fig. 4

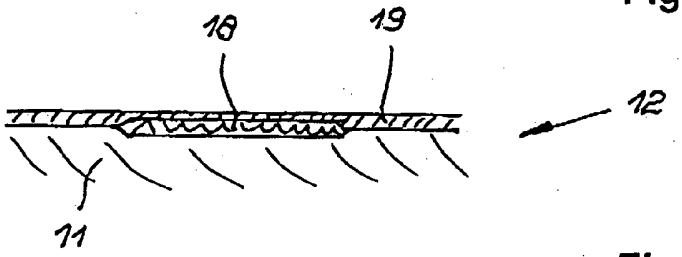

Fig. 5

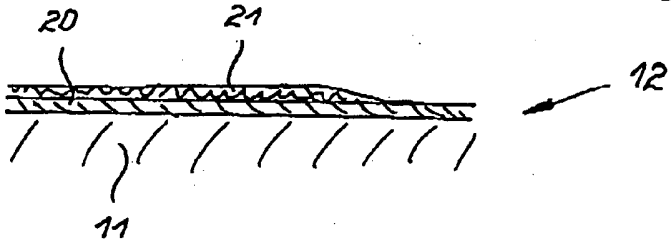

Fig. 6