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[54] **PRODUCTION OF METAL INGOTS, SLABS AND BILLETS**
13 Claims, No Drawings

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ABSTRACT: Methods of treating metal casting moulds in order to give improved surface to ingots and the like cast in such moulds are described which deposit on the inner walls of the mould an even layer of vaporisable material. Compositions for effecting such a coating are also described.

PRODUCTION OF METAL INGOTS, SLABS AND BILLETS

This invention relates to the production of ingots by the method in which molten metal is poured into metal moulds and is particularly concerned with the production of ingots of steel or of slabs or billets of copper, nickel or alloys or either of these.

When pouring molten steel into metal ingot moulds there is a tendency towards the formation of an oxide skin on the surface of the stream of molten metal which is exposed to the atmosphere. Such oxide formation is more prevalent in the case of top-poured ingots since on striking the bottom of the ingot mould, or the rising surface of the poured metal, splashed metal impinges on the side walls of the mould and remains as flattened droplets with oxidised surfaces. Most of these oxidised droplets cannot be redissolved into the body of the molten ingot metal and remain to form defects and blemishes on the ingot skin and, possibly, inclusions in the body of the ingot. Similarly, oxide floating on the surface of the rising metal as the molten metal is poured into the mould may become trapped between the molten metal and the mould walls, giving rise to similar defects.

It is known to use mould dressings or mould additives which reduce oxidation of the molten metal by their fluxing or reducing action and thus help to prevent the above defects. For example, there are, on the one hand, slags, with a melting point considerably lower than that of the metal being cast, which form a molten fluxing layer on the rising surface of cast metal and, on the other hand, there are the commonly used types of mould dressing including those based on tar, pitch, bitumen or heavy oil compositions.

The simple use of such materials as aforesaid has not proved wholly satisfactory and efforts have been made to find alternative procedures of improved effectiveness. Thus in our copending U.S. Pat. application Ser. No. 407,240, now issued as U.S. Pat. No. 3,376,914, there is described a method for the production of ingots of steel or slabs or billets of copper, nickel or alloys of either which comprises pouring the molten said metal into a metal mould, characterized in that there is placed in the mould a carbocyclic chemical substances which comprises carbon, hydrogen and optionally also oxygen and/or nitrogen and which will on burning cause a deposit of carbon particles on the walls of the mould, the said particles being adherent to the said walls by reason of the adhesive action of a portion of the said substance or of a combustion product of said substance which deposits on the walls of the mould by sublimation or condensation, or which exists as a coating on the carbon particles, the said substance generating, on burning, a nonoxidising noncorrosive gas or vapour, and burning the said substance to establish a said deposit prior to or simultaneously with the pouring of the said molten metal into the mould.

Suitable compounds for the indicated purpose include carbocyclic hydrocarbons such as naphthalene, phenanthrene, anthracene, biphenylene, naphthacene, rubrene, pentacene, heptacene, pyrene, perylene and acenaphthene. Other suitable substances are phenolic compounds (*e.g.*, resorcinol, hydroquinone, alpha and beta-naphthol, anthraquinone and quinol), esters of carbocyclic acids (*e.g.*, pentaerythritol and glycerol esters of rosins, such as ester gum), terpene compounds (*e.g.*, camphor, borneol, pinene or abietic acid), or certain natural or synthetic resins containing carboxylic groups (*e.g.*, phenolformaldehyde, copal, terpene resins) may be used. Nitrogenous compounds may also be used, *e.g.*, α-naphthylamine and the aminoanthraquinones.

Further, in our copending U.S. Pat. application Ser. No. 473,816, now forfeited in favor of Ser. No. 608,239, which issued as U.S. Pat. No. 3,322,816, there is described a method for the production of ingots of steel or slabs or billets of copper, nickel or alloys of either which comprises pouring the molten said metal into a metal mould, characterized in that there is placed in the mould a mixture of (1) a carbocyclic chemical substance which contains carbon, hydrogen and optionally also oxygen and/or nitrogen and which will on burning cause a deposit of carbon particles on the walls of the mould, the said particles being adherent to the said walls by reason of the adhesive action of a portion of the said substance or of a combustion product of said substance which deposits on the walls of the mould by sublimation or condensation, or which exists as a coating on the carbon particles, (2) an inflammable liquid and (3) a gelling agent in a quantity sufficient to render the mixture of said constituents into gel form, the said constituents in vapour form, and the gaseous products of combustion thereof, being nonoxidising and noncorrosive, and igniting the gel to cause it to burn and establish a said deposit prior to or simultaneously with the pouring of the said molten metal into the mould.

The substance (1) may be any of those referred to above, the substance (2) may be for convenience a common inflammable solvent such as solvent naphtha, turpentine, white spirit or isopropyl alcohol.

The substance (3) may be, for example, a metal soap such as aluminium stearate, napthenate, octoate, or 2-ethyl hexoate, alkyl ammonium montmorillonite or silica gel.

It has now been found that in the use of the conventional material *e.g.*, pitch, as well as in the use of the materials, of the aforesaid applications, an advantage is obtained in terms of the avoidance of faults due to oxidation of the cast metal by providing that there is provided a localised source of heat to volatilise the material being used and by providing that the material is not subjected to complete combustion. Thus, a "-sticky" rather than a "sooty" layer is deposited on the mould walls. The less sooty the coating, the more effective generally, is the coating in imparting a fault free surface to the cast metal.

According to the present invention therefore there is provided a method for conditioning a mould for use in the production of ingots of steel or slabs or billets of copper, nickel or alloys of either, which comprises, introducing into the mould a body of a volatilisable substance which will on heating cause a deposit of the substance and/or its decomposition products on the walls of the mould, the said body of volatilisable substance having associated there with a product of which the ingredients will react exothermically when fired, igniting the said exothermic product thereby to cause volatilisation of the volatilisable substance, and restricting access of oxygen to the interior of the mould thereby to prevent total combustion of said volatilisable substance.

The volatilisable substance may be a pure chemical compound or a mixture of compounds.

It is found that by the foregoing process there is deposited on the walls of the mould, possibly by sublimation or condensation, a very thin layer of volatilisable compound or of an ingredient of a volatilisable composition, usually together with some carbon in the form of soot.

Subsequently (the residue of the exothermic product having been removed if necessary) molten metal is poured into the thus conditioned mould. The resulting cast metal has an improved surface as compared with cast metal obtained in a mould not so conditioned and it is believed that this is at least in part due to the fact that when the molten metal is poured into the mould, volatilisable substance on the wall of the mould is again volatilised at the mould/molten metal interface and such volatilisation causes oxide scum on the metal surface to be driven away from the mould walls.

As already indicated, any of the volatilisable substances hitherto proposed for the purpose may be used in the method of the present invention, *e.g.*, pitch, or a carbocyclic compound as described in U.S. Pat. application Ser. No. 407,240 as a powder or tablet or a gel composition as described in U.S. Pat. application Ser. No. 473,816. Examples, apart from pitch itself are the following:

A. Mixtures of ester gum, and phenol-formaldehyde or melamine-formaldehyde resin (with or without a filler wood flour), optionally also containing carbon black.

A suitable range of these ingredients is:

	Parts by weight
Ester gum	65–96
Resin (as aforesaid)	5–30
Carbon black	0–5

B. Mixtures of camphor, and naphthalene, optionally also containing urea.

A suitable range of these ingredients is:

	Parts by weight
Camphor	5–95
Naphthalene	95–5
Urea	0–10

A specific composition of this class is:

	Parts by weight
Camphor	80
Naphthalene	10
Urea	10

The exothermic product may be employed in the form of a cup-shaped body into which the volatilisable substance may be placed but it is also practical to employ two layer slab additives, one layer being of the exothermic product and the other of the volatilisable substance. When using such shapes of exothermic body, the exothermic product is generally an aluminothermic composition of which a wide variety are known for use in other connections in the foundry and steel making industries. The following exothermic composition has been found very suitable:

Percentages are by weight:

	Percent
Aluminium powder, grindings etc	23
Sodium nitrate	10
Hematite	5
Fluorspar	5
Gum arabic	2
Coarse sand (−22 +44 BSS)	50
Crushed grog (−10 +30 BSS)	5

The above composition has been used to mould cups of 3 different sizes as follows:

	Unit 1	Unit 2	Unit 3
External diameter (ins.)	4½	4½	2
External height (ins.)	3¾	3¾	3½
Internal diameter (ins.)	3½	2½	1
Internal height (ins.)	3	3	2½

Unit 1 will accommodate 5½ ounces of powdered pitch of 8 ounces of fused material. Unit 2 accommodates 4 ounces of powder and unit 3 one-third of an ounce of powder. The rate of application is recommended as:

½ ounce of organic material per ton of steel for moulds of less than 1 ton capacity;

1 ounce per ton for moulds from 1—4 tons capacity; and

1½ ounces per ton for moulds over 4 tons capacity

In use, a cup or layered product of appropriate size is ignited and lowered into an empty ingot mould, using a wire or other suitable support, and the mould mouth is immediately covered to prevent ingress of atmospheric oxygen, thus restricting the degree of combustion of the volatilisable material. The exothermic composition, however, does not depend upon an external source of oxygen for its reaction and the reaction is not inhibited by exclusion of the atmosphere. As the exothermic reaction proceeds, the heat liberated causes the volatilisable material to deposit on the mould walls, possibly with a minor amount of combustion products. After the exothermic composition has completely burned, the spent body is removed from the mould which is then ready to receive molten metal.

According therefore to a further feature of the invention there are provided mould additives for the purpose described above which comprise a body of a volatilisable substance as aforesaid associated with an exothermic composition. The exothermic composition may be an aluminothermic composition, and may be in the form of a cup, adapted to contain the volatilisable substance within the cup-cavity.

Very satisfactory results may also be obtained by providing that the additive to the mould consists of a body of combustible porous material impregnated with an oxidising agent, and having a coating of a desired volatilisable substance thereon, the combustible porous material and the oxidising agent being such that the combustion of the porous material is sustained by the oxidising agent even though air supply is restricted.

This additive is used in exactly the same manner as the additive described above, *i.e.*, its combustion is hindered, but not wholly prevented, by limiting access of oxygen to the mould The heat generated exothermically by the reaction of the oxidising agent with the porous support material serves to volatilise and in some cases also to decompose, the said volatilisable substance.

The porous support material may be, for example, paper or other matted cellulosic fibre. The oxidising agent may be chosen from a large variety known per se but is preferably a nitrate or perchlorate, *e.g.*, sodium nitrate. The volatilisable substance may be any of those described above.

A product found to be of particular value for the indicated purpose is paper impregnated with sodium nitrate and coated with pitch. To use it, this product is simply ignited and dropped into the mould cavity where it smoulders and deposits pitch and/or decomposition products of pitch on the mould walls.

A further type of mould additive suitable for use in the process of the present invention is one in which the exothermic composition is in finely divided form dispersed throughout the body of volatilisable substance.

A suitable exothermic material is a finely divided combustible material impregnated with or in close contact with an oxidising agent such as sodium or potassium nitrate. Suitable materials are cellulosic materials and expanded polystyrene. Sawdust impregnated with oxidising agent is the preferred material for economic reasons. Volatilisable materials preferred in this type of additive are bitumens, pitches and tars.

If in a product so formulated there is found to be difficulty in effecting its ignition the problem may be readily solved by packing the product in a readily combustible container itself comprising an oxidising agent, *e.g.*, a paper bag impregnated with an alkali metal nitrate.

The quantity of nitrate used to impregnate the sawdust or like material is selected such that the heat generated is enough to vapourise the bituminous material, but not wholly to carbonise it. On the other hand, if the amount of nitrate present is too low, the coating of bituminous material deposited on the walls will be too thick and this may lead to the generation of gas below the surface of the molten metal during teeming of the molten metal into the mould.

Particularly preferred products are those in which the ingredients are present in substantially the following proportions, by weight:

Sawdust—20–30% preferably 24%.
Sodium or potassium nitrate—35–45% preferably 39%.
Bituminous material—32–42% preferably 37%.

The nitrate is preferably impregnated into the sawdust and this then impregnated with the bituminous material. The product is packed in paper bags which have been immersed in a solution of sodium nitrate, *e.g.*, at 35—40 percent by weight concentration, and subsequently dried out by stoving at 80J—95°C. preferably about 90°C.

In use, the paper bag is ignited and the whole then thrown into the mould to be treated. The mould is then covered to prevent the ingress of atmospheric oxygen. The composition burns out to leave almost no residue and an even bituminous coating of the mould walls. Generally, if the mould is to be used for steel casting about 200 to 300 grams of such a product are required per ton of steel to be cast. For 7-ton steel ingots, quantities of 1.8 kg. have been found to give optimum results.

The optimum amount of additive needed may alternatively be calculated if the mould wall area is known. Generally, an application rate of about 140 gm/sq. metre of mould wall to be coated is found to give satisfactory results, when used in cold moulds (*i.e.*, at about 50°C.) having hot base plates. If the mould is hot as well as the base plate, then a higher application rate is generally necessary to ensure an adequate coating.

The process and additives of the present invention are simple to use and have the great advantage that they may be used on moulds at temperatures from 50 to 500°C. If the temperature of the mould is greater than 500°C., the deposited layer tends to be sooty and this is less desirable, as explained above. In addition, the method of the present invention produces a far more even coating on the inner mould walls then is normally obtained by manually operated spraying, painting or like processes.

I claim:

1. In a method of conditioning a mould for use in the production in ingots of steel, slabs and billets of copper, nickel, and alloys of either by applying a coating on the mould walls, the steps, prior to teeming, comprising:

igniting an exothermic material having a composition such that the combustion thereof does not depend on an external source of oxygen;

burning said material in said mould, while the mould walls are at a temperature of 50—500°C., while in combination with a body of a volatilizable substance which upon heating will deposit on said mould walls a member of the group consisting of said volitilizable substance and decomposition products thereof; and

restricting access of oxygen to the interior of said mould during burning of said exothermic material so as to prevent total combustion of said volatilizable substance, thereby volatilizing said member and depositing said member as a coating on the mould walls.

2. A method according to claim **1** wherein the exothermic material is ignited prior to the introduction of the body into the mould.

3. A method according to claim **1** wherein the volatilizable substance is selected from the group consisting of bituminous materials, carbocyclic chemical substances, mixtures of ester gum and formaldehyde resins and mixtures of camphor and naphthalene.

4. A method according to claim **1** wherein the exothermic material is an aluminothermic composition.

5. A method according to claim **1** wherein the exothermic material is a body of combustible porous material impregnated with an oxidising agent.

6. A method according to claim **5** wherein the oxidising agent is selected from the group consisting of nitrates and perchlorates.

7. A method according to claim **5** wherein the combustible porous material is matted cellulosic fibre.

8. A method according to claim **1** wherein the exothermic material is in finely divided form throughout the body of volatilizable substance.

9. A method according to claim **8** wherein the finely divided exothermic material comprises finely divided cellulosic material impregnated with oxidising agent.

10. A method according to claim **8** wherein the body of volatilisable substance is packaged in a combustible casing.

11. A method according to claim **10** wherein said combustible casing comprises a paper bag impregnated with oxidising agent.

12. A method according to claim **8** wherein the volatilizable substance containing the exothermic material is used in amounts of from 200 to 300 grams per ton weight of a steel ingot cast in the mould to which the coating is to be applied.

13. A method according to claim **8** wherein the volatilizable composition containing the exothermic material is used in amounts of about 140 grams per square metre of mould wall to be coated.