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(54) **CASTING POWDER FOR USE IN BOTTOM POUR INGOT STEEL PRODUCTION AND METHOD FOR EMPLOYING SAME.**

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Description

BACKGROUND OF THE INVENTION

5 This invention relates to mold powders employed in ingot steel production. More specifically, the present invention discloses a casting powder to be employed in bottom pour steel molds which has the unique ability to act as both a bottom pour flux and a hot topping compound.

The use of bottom pour process to produce ingot steel has enjoyed substantial recent success with millions of tons of steel each year produced with this process. In order for the process to work effectively, 10 fluxes must be added on the surface of the molten steel as it begins to enter the mold. These fluxes are crucial both to prevent reoxidation through a complete covering of the rising steel and to insulate the steel and prevent premature solidification and skulling.

Presently two separate casting powders are applied in the production of each bottom poured ingot. First, a sealed bag of bottom pour flux is suspended in the mold approximately six to eighteen inches 15 above the inlet for the molten steel. The bottom pour flux consists of chemical compounds which melt and spread rapidly across the surface of the molten steel. The molten slag coating the surface of the steel acts to create the correct meniscus shape and prevents oxidation of steel surface. Additionally, the molten slag insulates the surface of the molten steel to slow solidification, and spreads a thin coat of homogenous glass between the mold and the molten steel to allow constant heat transfer and solidification and thus lessen 20 thermally induced stresses and resultant cracking. Further the flux absorbs impurities such as deoxidation and reoxidation products and refractory particles. The bag containing the bottom pour flux burns upon the introduction of the molten steel into the mold thus automatically releasing the flux.

Although traditional bottom pour fluxes are crucial for efficient production of steel ingots they are not sufficient. In order to assure the surface quality of the ingots and maximizing yield by avoiding "pipe" (i.e. shrinkage and segregation), an additional layer of insulative material must be added immediately after the 25 molten steel has filled the mold and entered "hot top" region. This material is referred to as "hot topping compound." Without the addition of hot topping compound, the molten steel would freeze in the hot top, thus not providing liquid steel to feed the shrinkage cavity (i.e. pipe) formed due to ingot solidification. The result would be to discard an entire segment of the steel ingot causing reduction in yield.

30 However, the application of hot topping compounds is not without its detractions. Adding hot topping compound is cumbersome, labor intensive, environmentally disruptive, and may contaminate the ingot steel.

Personnel, who could be better utilized elsewhere, must be stationed on the pouring platform above the molds to distribute the hot topping compound bags onto the molten steel. In addition to the cost of personnel, this process has two serious drawbacks. First, the pouring of the fine grained hot topping 35 compound some two to ten feet onto the top of the powdery flux layer generates extensive clouds of environmentally harmful dust and smoke. Second, the addition of hot topping compound has been associated with a condition known as "core of debris." Core of debris occurs when the chilling effect of the hot topping compound causes steel to solidify around refractory inclusions which then sink into and contaminate the steel ingots.

40 A method of ingot casting is known from US-A-3 934 637 including bottom pouring molten metal into an ingot mold to form an ingot wherein there is located in the ingot mold prior to the commencement of pouring, a bonded composition comprising one or more fluxing agents and expandable graphite. During casting, the bonded composition is borne up on the rising metal surface. The composition serves to protect the walls of the casting mold. Expandable graphite means particulate graphite the particles of which on 45 heating, intumesce to give a low density highly heat insulative vermicular structure. The patent specification is silent on the exact rate of expansion of the graphite. It is only stated that the graphite is to expand to many times its original volume. Within the bonded composition, the expandable graphite may be present in a range of 0.5 % to 10.0 % by weight.

A heat-insulating antipiping composition is known from US-A-3 811 898. This molten metal is applied to 50 the surface of the molten metal in the feeder head after the metal has been poured into the mold. The amount of antipiping composition applied is sufficient to give a layer of expanded heat insulative material on the top of the molten metal to prevent excessive piping during the solidification of the metal.

It follows from the above that the first mentioned patent discloses a composition serving to protect the walls of the casting mold, while the second mentioned patent discloses a composition serving to prevent 55 excessive piping during solidification. The composition according to the second mentioned patent is applied only after the molten metal has been poured into the mold.

Proceeding from this state of the art, it is the underlying objective of the invention to create a method using a one-step casting powder which provides the benefits of both a bottom pour flux and a hot topping

compound. The invention also aims at providing a casting powder for use in this method.

This object is achieved by the invention by a method for increased efficiency of protecting a steelmaker's mold and a steel ingot as bottom poured into the mold, including protecting against excessive piping of the steel which tends to occur when the molten steel cools too rapidly in the mold, comprising

5 introducing into the mold a predetermined quantity of a casting powder, comprising chemical components combined to produce a bottom pour flux, and including an expandable graphite,

pouring molten steel into said mold and covered with said casting powder to cause a substantial portion of said casting powder to rise to the vicinity of the top of said mold, thinly coating the side walls of said mold as it rises, and expanding into a thick insulative blanket on top of the molten steel of a sufficient
10 insulative quality to avoid need for a hot topping compound limiting the steel's rate of cooling and thereby minimizing the piping of the ingot,

wherein an expandable graphite is used that expands to 100 - 300 times its volume and comprises 4.0 to 12.0 % by weight of the composition of said casting powder.

The casting powder used in this method may be automatically dispensed, is economic to produce and
15 use, entails little environmental risk, and does not contribute to ingot contamination. The casting powder provides the benefits of both the prior methods and products separately and individually serving to protect the walls of the casting mold and to prevent excessive piping during the solidification of the cast metal.

The method according to the invention entails introducing a compound known as "expandable graphite" in place of a portion of the carbon component of a standard bottom pour flux.

20 The resulting mixture provides all the insulative and protective benefits of standard bottom pour fluxes as well as the full insulative requirements of hot topping compounds.

The casting powder used in the method according to the invention is cleanly and automatically dispersed upon introduction of molten steel into the steel ingot molds. It eliminates the noxious by-products of hot topping compound and its potentially contaminating effect of "core of debris", and does not require
25 the labor input demanded for application of hot topping compound.

The invention also relates to a casting powder for use in the aforementioned method. This powder comprises a mixture of chemical components to produce a bottom pour flux which coats and protects the top and sides of molten steel as it is introduced into the mold and including an expandable graphite component,

30 which expands to form a thick insulative blanket on top of the molten steel of sufficient insulative quality to avoid need for a hot topping compound, limiting the steel's rate of cooling and thereby minimizing piping of the ingot,

wherein the expandable graphite is of a type that expands 100 - 300 times its volume and comprises 4.0 to 12.0 % by weight of the composition of said mixture.

35 SUMMARY OF THE INVENTION

The present invention is directed to casting powders for use in ingot steel production through bottom pour process. Instead of the bottom pour flux and the hot topping compound presently employed, the
40 present invention substitutes a single casting powder which provides the benefits of both the prior products.

The present invention entails introducing a compound known as "expandable graphite" in place of a portion of the carbon component of a standard bottom pour flux. The resulting mixture provides all the insulative and protective benefits of standard bottom pour fluxes as well as the full insulative requirements of hot topping compounds.

45 The present invention is cleanly and automatically dispersed upon introduction of molten steel into the steel ingot molds. It eliminates the noxious by-products of hot topping compound and its potentially contaminating effect of "core of debris," and does not require the labor input demanded for application of hot topping compound.

50 DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a mixture of chemical components which function as a unique casting powder for bottom pour ingot steel production. The present invention combines the crucial properties of both bottom pour fluxes and hot topping compounds into a single, easily dispensed, composition.

55 Bottom pour fluxes (or powders) presently employed are required to have specific qualities for covering and protecting molten steel rising in an ingot mold. These include: molten slag layer to completely coat the molten steel, to insulate, maintain a proper surface shape, protect against oxidation, and absorb deoxidation and reoxidation products; and an ability to form a thin layer of homogenous glass between the molten steel

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and the side walls of the mold so as to insulate, reduce thermally induced stresses and thus decrease cracking.

To this end, a composition of a traditional bottom pour flux may comprise the following:

Constituent	Percentage (%) Range by Weight
Silica (SiO ₂)	30.0 - 35.0%
Aluminum Oxide (Al ₂ O ₃)	15.0 - 17.0
Calcium Oxide (CaO)	6.5 - 8.0
Iron Oxide (Fe ₂ O ₃)	4.0 - 6.0
Alkali Oxide	5.5 - 8.0
Carbon (C)	5.0 - 27.0

Hot topping compounds have only one primary purpose: to provide a thick insulative blanket on top of the molten steel to reduce the heat loss from the top to avoid "pipe." Pipe is a condition which occurs when there is no molten steel to feed the shrinkage cavity formed due to ingot solidification. Due to the expansion of the steel while molten, this discrepancy leaves the sides too high in respect to the core. Thus, without proper insulation, the center of the steel ingot will solidify in a sunken position or with severe imperfections -- creating an entire segment of the ingot which must be excised and discarded.

To accomplish the necessary insulation, a wide variety of compositions have been utilized. Typical ranges are as follows:

Constituent	Percentage (%) Range by weight
Silica (SiO ₂)	5-30%
Aluminum Oxide (Al ₂ O ₃)	25-75
Calcium Oxide (CaO)	0-2
Iron Oxide (Fe ₂ O ₃)	0-4
Sodium Oxide (Na ₂ O)	0-2
Potassium Oxide (K ₂ O)	0-3
Carbon (C)	0-15
Magnesium Oxide (MgO)	5-60
Chloride (cl)	0-5
Aluminum (Al)	0-40
Aluminum Nitride (AlN)	0-4

Any attempt to combine the properties of bottom pour flux and hot topping compound is confronted with a paradox -- how to provide a viscous coating material on the molten steel as it rises in the mold and also provide a highly insulative blanket in the upper (or "hot top") region of the steel ingot mold. The present invention accomplishes this through use of "expandable graphite."

Expandable graphite is produced through treatment of high grade natural crystalline graphite through oxidation or electrolysis by various oxidising materials. It is commercially available in a number of grades from graphite suppliers.

When expandable graphite is heated rapidly it expands along the C-axis of the crystal to a magnitude of 40 to 300 times its original size.

By substituting expandable graphite for a portion of the carbon component usually employed in bottom pour fluxes, an entirely new and unique casting powder is provided. The composition of this casting powder is as follows:

Constituent	Percentage (%) Range by Weight
Silica (SiO ₂)	30.0 - 35.0%
Aluminum Oxide (Al ₂ O ₃)	15.0 - 17.0
Calcium Oxide (CaO)	6.5 - 8.0
Iron Oxide (Fe ₂ O ₃)	4.0 - 6.0
Sodium or Potassium Oxide ((Na,K) ₂ O)	5.5 - 8.0
Total Carbon (C)	5.0 - 27.0
Expandable graphite	4.0 - 12.0

In all other respects, the present invention is prepared in the same manner as standard bottom pour flux.

Expandable graphite has different expansion rates according to its quality. It is desired to use expandable graphite that expands between 100 and 300 times its volume within the percentage weight range provided above. It is believed that ideally an expansion of 200 to 250 times its volume at a percentage weight of 6.0 to 8.0% should be employed.

Due to the affinity of the expandable graphite particles for one another, a highly expanded layer is produced which is as heat resistant and chemical resistant as standard graphite. The result is a thick insulative blanket which functions very well in place of hot topping compound.

However, the casting powder has a viscosity nearly identical to that of standard bottom pour flux (i.e. at 1500 °C, bottom pour flux has a viscosity of approximately 50-200 poise, the present invention produces a flux with a viscosity of 50-200 poise). Moreover, under pressure the present invention produces a unique quality compressio product having anisotropy. This results in a substance perfectly suitable to properly coat between the molten steel and the side walls of the ingot mold during pouring. Thus, the casting powder produced provides superior results as both a bottom pour flux and a hot topping compound.

The casting powder is dispersed in the same manner as standard bottom pour flux. It is placed in a combustible container or bag, such as paper bag with grommet reinforcements, and suspended six to eighteen inches above the bottom of the ingot mold. It can also be preformed into a board and placed at the bottom of the mold. The incoming molten steel consumes the container or dissolves the board causing the release of the powder. The powder then rapidly spreads across the surface of the incoming molten steel. This is a clean, automatic process which requires little human input and supervision.

The benefits of the present invention are realized through the elimination of hot topping compound. Personnel are no longer required to be stationed above the molds to apply the insulative material. Atmospheric dust from the hot topping compound and "core of debris" are also eliminated. Additionally, no smoke products are produced whatsoever. Despite the somewhat higher cost of substituting expandable graphite for standard graphite, the elimination of hot topping compound and the considerable cost savings in application provide a considerable overall cost savings.

While particular embodiments of the present invention have been disclosed herein, it is not intended to limit the invention to such a disclosure and changes and modifications may be incorporated and embodied within the scope of the following claims.

Claims

- Method for increased efficiency of protecting a steelmaker's mold and a steel ingot as bottom poured into the mold, including protecting against excessive piping of the steel which tends to occur when the molten steel cools too rapidly in the mold, comprising
 - introducing into the mold a predetermined quantity of a casting powder, comprising chemical components combined to produce a bottom pour flux, and including an expandable graphite,
 - pouring molten steel into said mold and covered with said casting powder to cause a substantial portion of said casting powder to rise to the vicinity of the top of said mold, thinly coating the side walls of said mold as it rises, and expanding into a thick insulative blanket on top of the molten steel of a sufficient insulative quality to avoid need for a hot topping compound limiting the steel's rate of cooling and thereby minimizing the piping of the ingot,
 - wherein an expandable graphite is used that expands to 100 - 300 times its volume and comprises 4.0 to 12.0 % by weight of the composition of said casting powder.
- Method in accordance with claim 1, characterized by the use of an expandable graphite that expands 200 - 250 times its volume and comprises 6.0 to 8.0 % by weight of the composition of said casting

powder.

3. Method in accordance with claim 1, characterized in that the casting powder is placed in a combustible container suspended at least 150 mm above the bottom of said mold.

4. Method in accordance with claim 3, characterized in that the combustible container is a combustible bag.

5. Method in accordance with claim 1, characterized in that the casting powder is formed into a board shape and placed at the bottom of said mold.

6. Casting powder for use in the method according to anyone of the preceding claims, comprising a mixture of chemical components to produce a bottom pour flux which coats and protects the top and sides of molten steel as it is introduced into the mold and including an expandable graphite component

which expands to form a thick insulative blanket on top of the molten steel of sufficient insulative quality to avoid need for a hot topping compound, limiting the steel's rate of cooling and thereby minimizing piping of the ingot,

wherein the expandable graphite is of a type that expands 100 - 300 times its volume and comprises 4.0 to 12.0 % by weight of the composition of said mixture.

7. Casting powder in accordance with claim 6, characterized in that the expandable graphite is of a type that expands 200 - 300 times its volume and comprises 6.0 to 8.0 % by weight of the composition of said mixture.

Patentansprüche

1. Verfahren zum Erzielen eines besseren Schutzes einer Stahlkokille und eines Stahlblocks beim Bodenguß und zum Schutz vor übermäßiger Lunkerbildung des Stahls, was bei einem zu schnellen Abkühlen der Stahlschmelze in der Kokille auftritt, bestehend aus

Eingeben einer vorgegebenen Menge eines Gießpulvers in die Kokille bestehend aus chemischen Bestandteilen kombiniert zum Erzeugen eines Bodengußflußmittels und aus einem expandierbaren Graphit,

Eingießen von geschmolzenem Stahl in die Kokille und abgedeckt mit dem Gießpulver um zu bewirken, daß ein wesentlicher Teil des Gießpulvers bis in den Bereich des oberen Endes der Kokille ansteigt, dünnes Beschichten der Seitenwände der Kokille beim Ansteigen und Expandieren in eine dicke isolierende Decke auf der Oberseite der Stahlschmelze mit ausreichender isolierender Qualität zum Vermeiden der Notwendigkeit einer hot topping-Verbindung, was die Abkühlgeschwindigkeit des Stahls begrenzt und damit die Lunkerbildung des Stahlblocks herabsetzt,

wobei ein expandierbarer Graphit verwandt wird, der auf das 100- bis 300-fache seines Volumens expandiert und 4 bis 12 Gewichts-% der Verbindung des Gießpulvers ausmacht.

2. Verfahren nach Anspruch 1, gekennzeichnet durch die Verwendung eines expandierbaren Graphits, der um das 200- bis 250-fache seines Volumens expandiert und 6 bis 8 Gewichts-% der Verbindung des Gießpulvers ausmacht.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das Gießpulver in einen mindestens 150 mm über dem Boden der Kokille aufgehängten brennbaren Behälter eingebracht wird.

4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß der brennbare Behälter ein brennbarer Beutel ist.

5. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das Gießpulver in eine Tafel verformt und am Boden der Kokille eingesetzt wird.

6. Gießpulver zur Verwendung bei dem Verfahren gemäß irgendeinem der vorhergehenden Ansprüche, bestehend aus einer Mischung von chemischen Bestandteilen zum Erzeugen eines Bodengußflußmittels, das die

Oberseite und die Seiten der Stahlschmelze während des Einfüllens in die Kokille schützt und expandierbaren Graphit enthält,

der unter Bildung einer dicken isolierenden Decke auf der Oberseite der Stahlschmelze von ausreichend isolierender Qualität expandiert zum Vermeiden der Notwendigkeit einer hot topping-Verbindung, was die Abkühlgeschwindigkeit des Stahls begrenzt und damit die Lunkerbildung des Stahlblocks herabsetzt,

wobei es sich um einen expandierbaren Graphit handelt, der um das 100- bis 300-fache seines Volumens expandiert und 4 bis 12 Gewichts-% der Verbindung des Gemisches ausmacht.

7. Gießpulver nach Anspruch 6, dadurch gekennzeichnet, daß es sich um einen expandierbaren Graphit handelt, der um das 200- bis 300-fache seines Volumens expandiert und 6 bis 8 Gewichts-% der Verbindung des Gemisches ausmacht.

Revendications

1. Procédé pour augmenter l'efficacité de protection d'une lingotière d'aciérie et d'un lingot d'acier à l'état de coulée par le fond dans la lingotière, incluant la protection contre une formation excessive de retassures dans l'acier, qui tend à se produire quand l'acier fondu refroidit trop rapidement dans la lingotière, comprenant :

l'introduction dans la lingotière d'une quantité prédéterminée d'une poudre de coulée, formée de composants chimiques combinés pour produire un fondant de coulée par le fond, et incluant un graphite expansible,

la coulée de l'acier fondu dans la lingotière et recouvert par cette poudre de coulée pour amener une partie substantielle de cette poudre de coulée à monter à proximité du sommet de la lingotière, recouvrant finement les parois latérales de la lingotière lors de la montée, et la l'expansion en une épaisse couche isolante au sommet de l'acier fondu d'une qualité suffisamment isolante pour éviter la nécessité d'un agent de masselotte chaude, limitant la vitesse de refroidissement de l'acier et minimisant ainsi la formation de retassures dans le lingot,

dans lequel il est fait usage d'un graphite expansible qui s'expande de 100 à 300 fois son volume et forme 4,0 à 12,0% en poids de la composition de cette poudre de coulée.

2. Procédé suivant la revendication 1, caractérisé par l'utilisation d'un graphite expansible qui s'expande de 200 à 250 fois son volume et forme 6,0 à 8,0% en poids de la composition de cette poudre de coulée.

3. Procédé suivant la revendication 1, caractérisé en ce que la poudre de coulée est placée dans un récipient combustible suspendu à au moins 150 mm au-dessus du fond de la lingotière.

4. Procédé suivant la revendication 3, caractérisé en ce que le récipient combustible est un sac combustible.

5. Procédé suivant la revendication 1, caractérisé en ce que la poudre de coulée est façonnée en forme de plaque et placée au fond de la lingotière.

6. Poudre de coulée utilisée dans le procédé suivant l'une quelconque des revendications précédentes, comprenant :

un mélange de composants chimiques pour produire un fondant de coulée par le fond qui recouvre et protège le sommet et les côtés de l'acier fondu quand il est introduit dans la lingotière, et incluant un graphite expansible, qui s'expande pour former une épaisse couche isolante au sommet de l'acier fondu, d'une qualité suffisamment isolante pour éviter la nécessité d'un agent de masselotte chaude, limitant la vitesse de refroidissement de l'acier et minimisant ainsi la formation de retassures dans le lingot,

dans laquelle le graphite expansible est d'un type qui s'expande de 100 à 300 fois son volume et forme 4,0 à 12,0% en poids de la composition de ce mélange.

7. Poudre de coulée suivant la revendication 6, caractérisée en ce que le graphite expansible est d'un type qui s'expande de 200 à 300 fois son volume et forme 6,0 à 8,0% en poids de la composition de ce mélange.