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MOLD COATING AND METHOD OF POURING INGOTS

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ABSTRACT OF THE DISCLOSURE

A novel mold coating comprising humic acid and/or humic acid salts and organic bonding agents, and a method of forming ingots in which molten steel is poured into molds whose surfaces are covered with the coating.

It has been the practice in the processing of molten metals to apply a coating to the surface of molds prior to pouring metal into the molds. This practice has been followed extensively in the steel industry, where ingot molds are normally coated prior to the forming of steel ingots. The recognized purpose of all of these coatings has been to improve the surface qualities of the molded metal. The function that most mold coatings are designed to perform is one of repelling splashes of molten metal and preventing them from solidifying on the mold walls.

The surface of solidified metal, which results from splashes adhering to the mold walls, normally oxidizes very rapidly. This surface oxidation plus high heat capacity acquired by adhering to the mold prevents the metal, which results from the splashes, from being incorporated into the main body of the ingot after the mold has been completely filled.

The failure of the metal from the splash to be incorporated into the main body of a metal ingot results in surface discontinuities, which must be removed from the ingot by burning, scarfing, grinding or other suitable means prior to fabrication of the ingot into shapes or sheets. If the discontinuities are not removed by one of these types of operations, they will result in defects in the finished metal products.

Various organic and inorganic materials have been tested in prior art endeavors to solve the problem of surface defects in metal, which are caused by splashes adhering to mold walls. Coal tar, graphite, asphalt and various combinations of these and similar materials have been most widely used. These materials have all been unsatisfactory in that the improvement in metal surface resulting from their use has been relatively slight in comparison to the expense and difficulty involved in applying them to molds.

The flammability of some of the prior art materials is undesirable from a safety point of view and all of the materials result in smoke and/or noxious fumes of one form or another. The materials containing a higher percentage of graphite are the least flammable and result in the lowest amount of smoke; however, they are extremely dirty and difficult to handle and apply to the mold walls.

Various inorganic materials have been tested for use as mold coatings with varying degrees of success, as to improvement of the surface qualities of the metal. None of these materials have been truly satisfactory or acceptable to the steel industry, due to non-metallic inclusions, which they have a tendency to introduce into the metal.

It is, therefore, an object of the invention to provide a mold coating which is easy to apply, adheres well to mold walls and results in a substantial improvement in the surface quality of the metal.

Another object of the invention is to provide a mold coating which is capable of being shipped and handled in a liquid phase.

A further object of the invention is to provide an improved method of forming steel ingots which comprises coating an ingot mold with an adherent organic coating, which is characterized as being efficient in repelling splashes of molten steel, and pouring molten steel into the ingot mold to form an ingot which has greatly improved surface characteristics.

In accordance with the subject invention, an improved mold coating has been discovered. The coating is characterized as being extremely adherent to mold surfaces, when applied by brushing, spraying or other suitable methods to a mold which is at a temperature of from room temperature to 900° F. The coating is further characterized as being extremely efficient in repelling splashes of molten metals and preventing their adherence to the surface of the mold.

The characteristics of the mold coating of the subject invention make it extremely useful in a process whereby steel ingots are formed which have extremely good surface characteristics. The ingots are formed by pouring molten steel into a cast iron mold which is coated with the coating of the subject invention.

The mold coating of the subject invention comprises a humic acid compound exemplified by alkali metal salts of humic acid and alkali earth metal salts of humic acid. Particularly, for applications in which the coating is applied to molds at an elevated temperature, it is essential that the coating contain an organic bonding agent in addition to the humic acid or humic acid salt.

The alkali metal salts of humic acid which are useful in the subject invention are sodium humate, potassium humate and ammonium humate. For purposes of this invention the term "alkali metal salt" will be construed to include ammonium salts.

The alkali earth metal salts of humic acid which are particularly useful in the subject invention are calcium humate and magnesium humate.

The humate salts which are useful in the subject invention are products of the reaction of humic acid with alkali metal or alkali earth metal hydroxides or ammonia. The humic acids are a generic group of acids which are derived from humus, which is most often concentrated in top layer of soil and contains the organic decomposition products of vegetation and other organisms. Sources of humic acid are brown coal, lignite and the like.

One of the preferred sources of humic acid for use in the subject invention is leonardite, which is often found in association with lignite. Leonardite is primarily mined in Bowman County, N. Dak., Divide County, N. Dak., and in and around Alpine, Tex. Spectral analysis has indicated that leonardite is generically a mixture of humic acid and salts thereof. Leonardite is considered to be made up of a large condensed ring polymeric molecule containing carboxyl groups; however, the exact nature of the molecule has not been proven conclusively.

A typical leonardite sample, which is comprised of calcium, sodium, magnesium, potassium, etc., salts of com-

plex organic acid and free organic acid is partially analyzed as follows:

Ash	14.01
C	48.75–53.98
H	3.79–4.70
N	1.25
O	31.99
CH_3	1.26
CH_3O	0.44
CH_3CO	0.38

The equivalent weight of the above sample of leonardite was determined to be 256.

In order to synthesize the humate salts of the invention it is only necessary to add an alkali metal or alkali earth metal hydroxide or ammonia to the humic acid. The salt-forming reaction is preferably carried out in the presence of water. A more preferred humate salt is sodium humate and most preferably sodium leonardite.

The particular organic bonding agent for use in the subject invention is not critical except that it must be one which is capable of adhering to a hot or cold metal surface when applied in spray or droplet form. Preferred organic bonding agents are lignosulfonic acid, alkali metal salts of lignosulfonic acid, alkali earth metal salts of lignosulfonic acid, sugars and dextrins. In a particularly preferred embodiment of the subject invention, the organic bonding agent used is sodium lignosulfonate.

The sugars which are useful in the subject invention are any of the materials having the general formula, $(C_nH_{2n}O_n)$. These materials are classified generally as carbohydrates, monosaccharides, furanoside or pyranoside. A broad range of these materials have proven to be useful as organic binders in the mold coating of the subject invention. The most preferred of the sugars for use in the subject invention are monosaccharides.

Glycols are useful as aids to organic bonding as they raise the boiling point of the mixture when it is used in an aqueous slurry. The aqueous slurry then has less of a tendency to spatter when applied to a hot mold surface. The glycols are considered to be the group of diatomic alcohols of the aliphatic series. The most preferred material from this series for use in the subject invention is ethylene glycol. Ethylene glycol is also useful as a freezing point depressant for use when the mold coating is shipped or used as an aqueous mixture in cold weather.

The lignosulfonates which are useful in the subject invention are the ammonium, alkali metal and alkali earth metal salts of lignosulfonic acid and lignosulfonic acids themselves. Methods of manufacture of lignosulfonic acid and various lignosulfonate salts are well known to the art. Suitable methods for the production of lignosulfonic acid and the isolation of various lignosulfonate salts are given by Friedrich Emil Brauns in the Chemistry of Lignin, published in 1952 by the Academic Press, Inc. of New York. A particlar method for isolating lignosulfonic acid and manufacturing the various lignosulfonate salts is discussed on pages 111–125.

It is understood, however, that the practice of the subject invention is not limited to the use of lignosulfonates which are manufactured by any particular process.

All of the various ammonium, alkali metal and alkali earth metal salts and the free acids are useful in the practice of the invention. The preferred lignosulfonates are the ammonium, sodium, and calcium lignosulfonates and combinations thereof.

In coating molds with the mixture of the subject invention, the mixture may be blown or dusted on to the mold surface as a dry powder, or applied to the surface in an aqueous slurry by means of brushing, dipping, pouring, spraying or other suitable means. In the most preferred embodiment of the invention, the mixture is in an aqueous slurry consisting of from about 20% to about 80% by weight of the mixture of the subject invention, and from about 20% to about 80% by weight of water. More preferably, the aqueous slurry contains from about 30% to about 60% by weight of the mixture of the invention, and from about 40% to about 70% by weight of water. In one particularly preferred embodiment of the subject invention, the slurry contains about 40% of the mixture of the subject invention and about 60% water.

Ingot molds are usually coated hot, at a temperature of from about 200° F. to about 800° F. However, the coating of the subject invention can be used at temperatures ranging from room temperature to temperatures in excess of 1000° F. The most preferred temperature for coating when an aqueous slurry is used is approximately 300° F. This temperature is preferred, as it provides an efficient coating with a minimum of spattering, and violent steam emission with the attendant waste of material.

A wide range of compositions has been found to be useful in the subject invention. Preferably, the humic acid or humic acid salt should be present in an amount equal to from about 20% to about 80% by weight of the dry mixture. More preferably, the humic acid or humic acid salt should be present in an amount of from about 30% to about 60% by weight. In a greatly preferred embodiment of the invention the humic acid salt is sodium humate, present in an amount equal to about 40% by weight of the dry mixture.

Other useful adjuvants may be added to the mixture in minor quantities in an aqueous slurry. The addition of these adjuvants is made to enhance the properties of the slurry as to characteristics such as bacterial stability and freezing point.

A variety of bactericides has been used in quantities of less than 1% by weight to enhance the stability of the mixture in an aqueous slurry. It is of course understood that the invention is not limited to the use of any particular bactericide or to any particular amount of bactericide. Any of a number of known agents can be used to inhibit bacterial growth in an aqueous system which is high in organic bonding agents such as sugars.

Other useful adjuvants that may be used in an aqueous slurry of the mixture of the subject invention are freezing point depressants, for use when the slurry is shipped or used in cold weather. The glycols are particularly useful as freezing point depressants for use in the subject invention, as pointed out above. A particularly preferred glycol is ethylene glycol.

The invention will be better understood with reference to the following example:

EXAMPLE

A typical mold coating composition of the subject invention was made up as follows:

Component:	Weight percent
Water	59.5
Sodium humate	16.5
Lignosol X–D [1]	13.5
Crystalline caustic	0.15
Ethylene glycol	10.2
Pentachlorophenol	0.15

[1] The lignosol X-D is an alkali earth metal lignosulfonate of the following typical analysis:

Ingredient:	Percent
Moisture	4
Lime as CaO	0.4
Ash	20.0
Red. bodies	20.0
Sulphur	5.6
Iron (max.)	0.05
Insolubles (27% sol'n) vol.	0.4
Methoxyl	7.4
Sulphonate sulphur	3.5
Sodium as Na	6.1

The sodium humate which was used in the preparation of this mold coating was made by causticizing a crude leonardite mud. A small amount of crystalline caustic was added to the mold coating to provide an excess of sodium for reaction with any humic or lignosulfonic acid from the sodium humate or lignosol and to produce a coating mixture at a pH of over 9.5. It was found that maintaining a pH above 9.5 was desirable for adherence to mold walls when the coating was applied in the form of a spray.

The coating was applied to a series of over 100 ingot molds. Various carbon and alloy steels, which were made in a basic oxygen furnace, were poured into the ingot walls and metallurgical analyses were run on the ingots which were formed. All of the ingots were found to have surface properties which were superior to ingots formed in uncoated molds and to ingots which were formed in molds where a prior art graphitic mold coating was used. The ingots were also tested for the presence of non-metallic inclusions which might have resulted from the mold coating. No unusual inclusions were discovered and the conclusion was reached that the mold coating had no deleterious effect upon the steel. Furthermore, no build-up of the coating was noted on the molds after the mold had been stripped.

It can be seen by the foregoing example that the objects of the invention, to provide a mold coating which is easy to apply, adheres well to mold walls and results in a substantial improvement in the surface quality of metal, have been achieved. Since the mold coating, as typically made in the above example, is in the form of a stable slurry, it can be shipped as a bulk liquid; therefore, the additional object of the invention to provide a mold coating which is capable of being shipped and handled in a liquid phase has also been accomplished.

The improved surface characteristics on ingots formed by a process utilizing the mold coating of the subject invention, as shown in the above example, demonstrates that the object of providing an improved method of forming steel ingots has also been achieved.

Although the subject invention refers primarily to a mold coating and a method of forming steel ingots, an improved surface for contacting any molten metal can be achieved by coating the surface with a humic acid compound or a mixture of a humic acid compound with other useful adjuvants, as disclosed above. A specific example of a surface which can be improved by use of the coatings of the subject invention is the surface of sand or ceramic cores and molds for use in the casting of metals. Another example of a coated surface is the surface of graphite or ceramic crucibles for use in the melting or containing of molten metals.

The invention is claimed as follows:

1. In a method of forming steel ingots which comprises pouring molten steel into a mold, the improvement which comprises coating the mold prior to pouring the steel with a humic acid compound.

2. In a method of forming steel ingots which comprises pouring molten steel into a mold, the improvement which comprises coating the mold prior to pouring the steel with a mixture comprising:

(A) at least one member of the group consisting of alkali metal salts of humic acid and alkali earth metal salts of humic acid, and

(B) an organic bonding agent.

3. The method of claim 1 in which the bonding agent is sodium lignosulfonate.

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