Patented Nov. 18, 1952

2,618,032

UNITED STATES PATENT OFFICE

2,618,032

SURFACE TREATMENT OF MOLDS

Frederick O. Traenkner, Massena, N. Y., assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

No Drawing. Application August 17, 1949, Serial No. 110,883

8 Claims. (Cl. 22—192)

1

This invention relates to the surface treatment of certain types of molds used for making metal castings and it has special application to those cases where there is relative movement between the cast body and the mold during the casting operation such as occurs in the so-called continuous ingot casting process.

In those casting operations wherein a porous mold is employed and the cast article must slide over the walls of the mold cavity, the molten metal tends to enter the pores of the mold with resultant separation of a portion of the surface layer of the casting as it moves or slides through the mold. The adherence of metal to the mold results in a tearing of the casting which generally would be cause for rejection even though but a small part of the total surface of the cast article is thus affected. This is especially objectionable in continuous casting processes where the ingot passes through a mold and a small area of adhering metal can cause a long broken streak on the ingot surface. It has also been observed that adherence of metal to the mold often occurs in certain regions of the mold surface which are related to certain combinations of freezing and heat extraction that develop during solidification of the casting.

The material of which a mold is made generally exerts an influence upon the surface quality of the casting formed therein. For example, some materials may be "wetted" by molten metal while others are not so affected. Furthermore, some of the materials are porous to the extent that the pores tend to be filled with molten metal as mentioned above. Generally a metal mold made from plate or heavy sheet is not sufficiently porous to offer any difficulty on this account, however, if the mold is a casting or a sintered product made from powdered materials, or if it is made from non-vitrified or compressed non-metallic substances it may have a degree of porosity which interferes with obtaining a cast body with a smooth surface. Inasmuch as porous molds often have certain other highly desirable qualities, it is particularly important that the difficulties associated with their porosity should be overcome and thus permit the production of highest quality castings. One of the mold materials which is highly desirable in many ways is graphite but molds of this material usually are porous to some degree and therefore subject to the disadvantage stated above.

Mold washes and lubricants have been proposed and used for dressing mold surfaces. Generally speaking, mold washes are employed because of

2

their heat insulating properties and are not used where there is relative movement between casting and the mold during the casting operation because of their low resistance to wear and relatively rough surface. Liquid and semi-solid oils and greases of animal, vegetable or mineral origin have been applied to mold surfaces but such substances usually introduce problems such as burning, excessive fumes and the production of a carbonaceous deposit. Solid lubricants such as graphite either alone or associated with other materials have been sprayed or brushed on mold surfaces but such coatings require frequent renewal because they are only applied superficially and therefore are easily worn or rubbed off. None of these materials or methods of application have been successfully used for providing durable, very smooth coatings which are substantially non-porous.

It is an object of this invention to provide very durable, dry, smooth surfaces on porous molds and mold parts. A further object is to provide a method of treating porous mold surfaces which is simple and effective in rendering the mold surfaces substantially non-porous. Still another object is to provide a surface on porous molds which does not spall or become loosened in contact with molten metal. Yet another object comprises the provision of a method of applying a material to the mold surface in such a manner as to cause it to penetrate the surface of the mold body. Another object is to provide a method of treating the surface which will insure that the surface is dry at the time it comes in contact with molten metal. These and other objects will become apparent from the following description and claims.

In speaking of mold surfaces herein, it is to be understood that this refers to that surface of a mold or any part thereof which comes in contact with molten metal. Thus, for example, cores used in forming hollow portions of the castings are considered to be mold parts and they may be treated in the same manner as the main mold body if composed of porous material.

I have found that a highly useful, durable, substantially non-porous, smooth, non-spalling mold surface can be produced on porous molds by subjecting them to a treatment with a controlled amount of colloidal graphite suspended in a volatile carrier or vehicle followed by a drying after the treatment and finally a baking at a relatively high temperature. Mold surfaces prepared in this manner possess substantially no pores, at least those of a size which can be pene-

trated by molten metal, are dry and present an exceptionally smooth long wearing surface which does not require lubrication. Because the treated mold surface has no pores of a size which can be penetrated by molten metal it is considered to be substantially non-porous. The treatment, it is believed, introduces colloidal graphite particles into the mold pores and the subsequent baking fixes or anchors them in such a way as to prevent removal unless the mold surface itself is worn or cut away. In most cases a much better surface is developed by repeating the impregnating treatment before the baking operation. For convenience of description, the porous mold may be said to be impregnated with colloidal graphite which is subsequently fixed or stabilized in such a manner as to firmly anchor its position.

The mold or mold part to be treated must possess some degree of porosity, the pores being large enough to permit the passage therethrough of colloidal graphite particles. It is obvious, of course, that the treatment is not adapted to the treatment of molds having relatively large pores for the pores must be filled with graphite particles to the extent of providing a smooth mold surface. It has been found that molds exhibiting a pore size from about 4 to 40 microns possess a very satisfactory surface for impregnation with colloidal graphite. While it is desirable that the pores be of about the same size in a given mold or mold part and that the porosity be relatively uniformly distributed over the mold surface this is not imperative. It is essential, however, that there be enough pores of suitable size for the graphite particles to enter and become anchored therein.

The molds may be composed of any one of a number of materials depending upon the properties desired. For example, sintered metallic powders, or mixtures of metallic powders and ceramic materials, or non-metallic materials such as graphite may be employed. Molds made of any of these materials may be successfully treated with colloidal graphite according to my invention providing they possess the proper porosity. One of the materials which has been very successfully treated is that known in the trade as dense graphite. This material has a porosity of from about 20% to about 30%; i. e. 20 to 30% of the volume consists of voids, and it has a pore size of at least 4 microns. This material when in the form of molds and treated with colloidal graphite has been used to produce aluminum alloy castings having exceptionally smooth surfaces.

The colloidal graphite preparation which I employ comprises graphite particles suspended in a volatile liquid or carrier. The predominant portion of particles should be of colloidal size. Because of this fact, the preparation is herein referred to as a colloidal graphite suspension. In my preferred practice, the suspension consists of graphite particles about 1 to 8 microns in diameter. Particles of this size are generally considered to be of colloidal size. In general any graphite particles which are capable of being placed in colloidal suspension and which can enter the mold pores are considered to be satisfactory for the treatment of porous mold surfaces.

The proportion of graphite to liquid must be carefully controlled in order to secure the desired penetration of the mold. It has been found that the graphite should not exceed about 15% by weight of the liquid in which it is suspended. A greater proportion impedes the impregnating process and does not permit the establishment

of a firmly anchored coating. Smaller amounts may be employed, however, for practical purposes the quantity should not be less than about 1%.

The volatile carrier or vehicle should belong to the class of liquids which has a boiling point within the range of from about 100 to 500° F. and have a sufficiently low viscosity to permit penetration of the pores of the mold. A preferred group of liquids is that composed of a mixture of hydrocarbons in which 10% are distilled below 347° F. and not less than 95% below 464° F. Examples of such hydrocarbon mixtures are petroleum naphtha, and mineral spirits. Other organic liquids will also serve satisfactorily such as the lower alcohols. By organic liquids is meant hydrocarbons and their derivatives which are liquid at room temperature. Under some conditions water may be employed but special precautions may be necessary to insure complete evaporation.

Although the aforesaid liquids serve as suitable carriers for graphite and in most cases possess the necessary wetting power to facilitate penetration of the mold material, it may be desirable to add small amounts of other substances which will serve to keep the graphite particles in suspension or enhance the wetting power of the suspensions. Such materials as metallic salts of long chain alkyl acids, aryl substituted long chain alkyl acids, or aromatic acids are known to have this effect upon carriers of the kind herein described. Some examples of these salts are nickel, zinc or calcium naphthenates, calcium stearate, calcium phenyl stearate, wax aluminum phenate, aluminum carboxylate. The added substances do not in any way interfere with the deposition of the colloidal graphite particles nor the production of the desired quality of mold surface.

The treatment of a mold or mold part consists in contacting it with a suspension of the type defined above, subsequently permitting the volatile carrier to evaporate, and finally baking the mold. While a single treatment effects an improvement, a better and more durable surface is developed by repeating the treatment at least once, and hence this is preferred. The suspension may be applied in any conventional manner but usually immersion or spraying will be the most convenient method to use. Following contact with or exposure to the suspension the mold is dried, but in my preferred practice the contacting and drying steps are repeated at least once and often twice. By means of the multiple treatment, it has been found that the colloidal particles better penetrate the pores of the mold to a depth that permits subsequent firm anchorage in the pores. In the case of contact by immersion it is advantageous to hold the mold or mold part in the suspension for a period of time, for example, 30 minutes. This period may extend for several hours but ordinarily such long exposure does not produce corresponding improvement over a short exposure.

The drying operation may be conducted at room temperature or at somewhat higher temperatures, but below 300° F., the object being solely that of evaporating the carrier. The period required for drying will vary with the liquid employed in the suspension and the period of exposure to the suspension. It is not necessary that the drying be carried to the point of removing all traces of the liquid, but it is essential that a major portion be evaporated. A period up to 5 or 6 hours is usually sufficient.

After completion of at least one cycle of im-

pregnation and drying the article is then subjected to a baking operation at a temperature of between 500 and 800° F. for a period of at least 15 minutes. This may extend to several hours. While the baking operation serves to drive off any residual vehicle or carrier it also appears to fix or stabilize the graphite particle in the pores of the mold with the result that a firmly adherent coating is produced. Because of the firm adherence and durability of the coating obtained in the foregoing manner it may be said to be integrally bonded to the mold as compared to the superficial mold coatings of the prior art.

If upon test it is found that the mold surface is not smooth, the foregoing process may be repeated. Also, after the mold has been used and some wear may have occurred the mold may be subjected to a single contact with a colloidal suspension followed by baking.

The mold surfaces resulting from this treatment are dry and may be used with entire safety in contact with molten metal. The mold surfaces are smooth and free from pores that can be penetrated by molten metal as compared to the untreated mold surface. Furthermore, no additional lubrication is necessary. Such treated mold surfaces may be used for relatively long periods of time without renewal as compared to a surface that has not been impregnated with colloidal graphite and baked. A durable surface is of particular importance in continuous casting processes where the operation cannot be conveniently interrupted.

Although any type of metal may be cast in contact with molds treated in accordance with my invention providing the casting conditions are such as not to oxidize the coating or the mold, it has been found that aluminum and aluminum base aloy ingots having high surface quality can be cast in such molds. Other non-ferrous metals such as magnesium and copper and their alloys may likewise be cast in contact with the treated molds with resulting advantage to the surface quality of the cast product.

The invention may be illustrated in the following example. A dense graphite mold of circular shape, open at both and bottom and having a diameter of about 14 inches was treated with a colloidal graphite suspension containing about 10% by weight of graphite. The graphite mold had a porosity of about 25% and a pore size between about 4 and 40 microns. The mold was immersed in the colloidal graphite suspension in petroleum naphtha for a period of 30 minutes, withdrawn and dried in air for one hour at a temperature of 250° F. Following this it was again immersed in the suspension and again dried. The process was repeated the third time and following the drying operation, the mold was baked at 700° F. for one hour. The mold was inserted in the continuous casting apparatus for making aluminum base alloy ingots. The ingots coming from this mold had an exceptionally smooth surface and, therefore, required no subsequent surface condition treatment to prepare them for fabricating operations. The mold treated in this manner was found to retain a satisfactory surface after casting 280 ingots having a minimum length of 100 inches.

Having thus described my invention, I claim:

1. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous mold body having pores of 4 to 40 microns in size comprising contacting said mold body with a suspension of colloidal graphite in a liquid boiling between 100 and 500° F., said mold body being at a temperature below the boiling point of said liquid and the period of contact between said mold body and suspension being long enough to permit penetration of said mold body by said suspension, the proportion of said graphite to said liquid not exceeding 15% by weight of the liquid, drying said treated mold body at a temperature between room temperature and 300° F. and thereafter baking said dried mold body at 500 to 800° F. for a period of at least 15 minutes.

2. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous mold body having pores 4 to 40 microns in size, comprising immersing said mold body in a suspension of colloidal graphite in a liquid boiling between 100 and 500° F., said mold body being at a temperature below the boiling point of said liquid and the period of immersion being long enough to permit penetration of said mold body by said suspension, the proportion of said graphite to said liquid being less than 15% by weight of the liquid, drying said treated mold body at a temperature between room temperature and 300° F. and thereafter baking said dried mold body at 500 to 800° F. for a period of at least 15 minutes.

3. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous graphite mold body having a pore size of between 4 and 40 microns, said method comprising immersing said mold body in a suspension of graphite particles of 1 to 8 microns in diameter in a liquid boiling between 100 and 500° F., said mold body being at a temperature below the boiling point of said liquid and the period of immersion being long enough to permit penetration of said mold body by said suspension, the proportion of said graphite to said liquid being less than 15% by weight of the liquid, drying said mold body at a temperature between room temperature and 300° F., repeating said immersing and drying steps at least once, and thereafter baking said dried mold body at a temperature between 500 and 800° F. for a period of at least 15 minutes.

4. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous mold body having pores of 4 to 40 microns in size comprising contacting said mold body with a suspension of colloidal graphite in a liquid boiling between 100 and 500° F., said mold body being at a temperature below 100° F. and the period of contact being long enough to permit penetration of said mold body by said suspension, the proportion of said colloidal graphite to said liquid not exceeding 15% by weight of the liquid, drying said treated mold body at a temperature between room temperature and 300° F., repeating said contacting and drying steps at least once and thereafter baking said dried mold body at 500 to 800° F. for a period of at least 15 minutes.

5. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous graphite mold having a pore size between 4 and 40 microns and a porosity between 20 and 30%, said method comprising contacting said mold with a suspension of colloidal graphite in an organic liquid boiling between 100 and 500° F., said mold being at a temperature below 100° F. and the period of contact being long enough to permit penetration of said mold body by said suspension, the proportion of said graphite to

said liquid not exceeding 15% by weight of the liquid, drying said treated mold at a temperature below 300° F., repeating said contacting and drying steps at least once and thereafter baking said dried mold at a temperature between 500 and 800° F. for a period of at least 15 minutes.

6. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous graphite mold body having a pore size of between 4 and 40 microns, said method comprising immersing said mold body in a suspension of graphite particles of 1 to 8 microns in diameter in petroleum naphtha, said mold body being at a temperature below the boiling point of said naphtha and the period of immersion being long enough to permit penetration of said mold body by said suspension, the proportion of said graphite to said petroleum naphtha being less than 15% by weight of the liquid, drying said mold body at a temperature between room temperature and 300° F., repeating said immersing and drying steps at least once and baking said mold body at a temperature between 500 and 800° F. for a period of at least 15 minutes.

7. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous graphite mold body, the pores of which are large enough to permit the passage therethrough of colloidal graphite particles, said method comprising immersing said mold body in a suspension of colloidal graphite in an organic liquid boiling between 100 and 500° F., said mold body being at a temperature below 100° F. and the period of immersion being long enough to permit penetration of said mold body by said suspension, the proportion of said graphite to said liquid being less than 15% by weight of the liquid, holding said mold body in said suspension for a period of at least ½ hour, drying said mold body at a temperature between room temperature and 300° F., repeating said immersion and drying steps at least once and thereafter baking said

mold body at a temperature between 500 and 800° F. for a period of at least 15 minutes.

8. The method of providing a smooth, durable, substantially non-porous graphite surface on a porous graphite mold body, the pores of which are large enough to permit passage therethrough of colloidal graphite particles, said method comprising contacting said mold body with a suspension of colloidal graphite in a liquid boiling between 100 and 500° F., said mold body being at a temperature below 100° F. and maintained in contact with said suspension for a period of at least ½ hour, the proportion of said graphite to said liquid being less than 15% by weight of the liquid, drying said mold body at a temperature between room temperature and 300° F., repeating said contacting and drying steps at least once and thereafter baking said mold body at a temperature between 500 and 800° F. for a period of at least 15 minutes.

FREDERICK O. TRAENKNER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
928,470	Monnot	July 20, 1909
1,858,083	Goldsmith	May 10, 1932
2,241,594	Gray	May 13, 1941
2,245,747	Barr	June 17, 1941
2,246,463	Garratt	June 17, 1941
2,376,518	Spence	May 22, 1945

FOREIGN PATENTS

Number	Country	Date
2,240	Great Britain	of 1856

OTHER REFERENCES

Iron Age, February 6, 1947, pages 58 and 59.