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PRECISION CASTING MOLD AND METHODS AND MATERIALS FOR PRODUCTION AND USE

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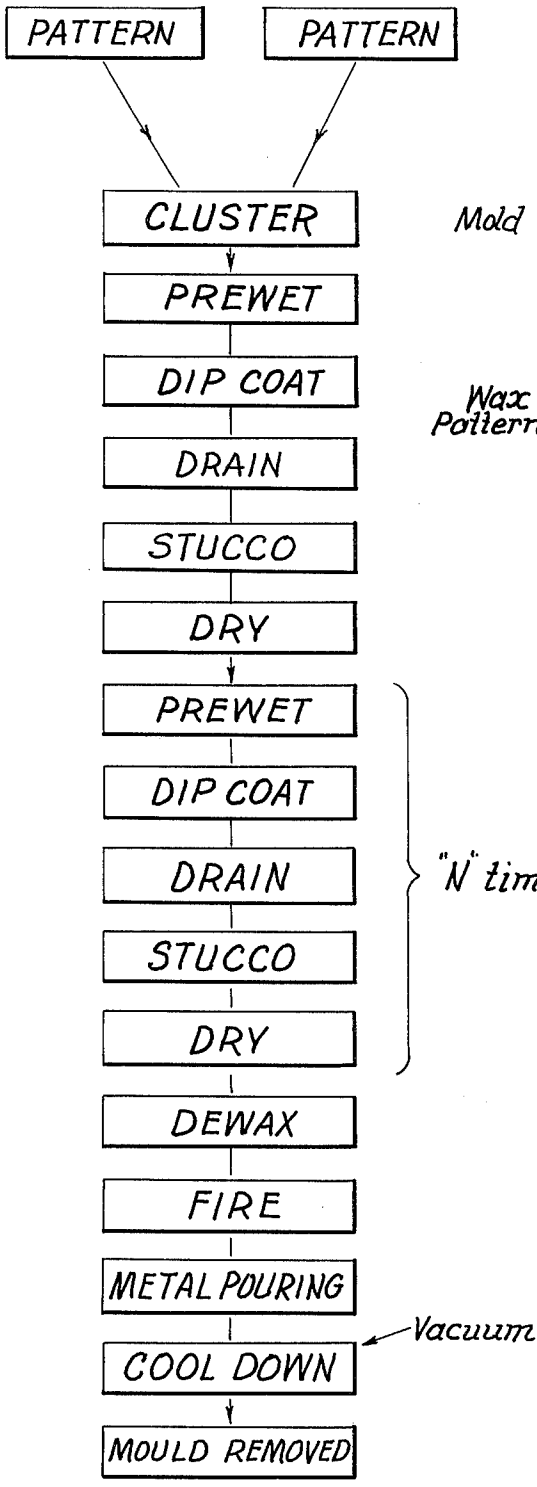


FIG. 1

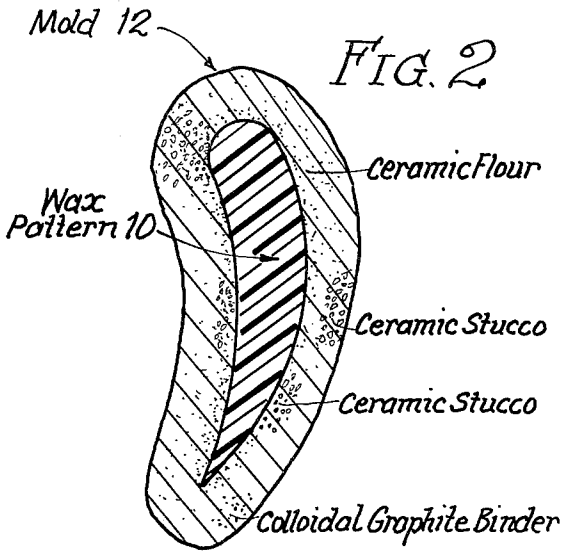


FIG. 2

INVENTOR.
Nick G. Lirones

BY Toms, McDougall & Hersh
Attys

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PRECISION CASTING MOLD AND METHODS AND MATERIALS FOR PRODUCTION AND USE

Nick G. Lirones, North Muskegon, Mich., assignor to Howe Sound Company, New York, N.Y., a corporation of Delaware

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This invention relates to the art of precision casting and to materials employed in the practice of same and it relates more particularly to a shell casting process and to compositions and methods for the preparation of the shell.

In the conventional shell molding process of the type described in the recently issued patent of Operhall et al. No. 2,961,751, description is made of a process wherein the molten metal can be poured directly into the preheated shell without the necessity for making use of the heavy investment heretofore required for support of the shell. In the described patent, use is made of a wax pattern onto which multiple applications are made of a dip coat composition for stucco coats to build up a relatively thick shell of ceramic material bonded by an inorganic binder, such as sodium silicate and the like.

Such ceramic shells, after being fired, are characterized by strengths sufficient to enable the molten metal to be poured to fill the mold without investment of the shell for support. However, such shells of ceramic material are limited to processes wherein the metal is poured in the molten state and from the standpoint of the types of metals and materials that can be molded therein.

It is an object of this invention to produce and to provide a method for producing new and improved shell molds for use in the precision casting of various materials and it is a related object to provide a new and improved shell molding process employing shell molds prepared by the practice of this invention.

More specifically, it is an object of this invention to produce a shell mold which is of sufficiently high strength and stability to enable materials to be poured directly therein for molding, and it is a related object to provide a new and improved shell moulding process which can be easily carried out for the precision casting of molten metals and in which the molded products can be easily and efficiently separated from the shell cleanly to release the molded product.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings in which—

FIG. 1 is a flow diagram of the process embodying the practice of this invention, and

FIG. 2 is a schematic sectional view through a pattern having a shell formed therein in accordance with the practice of this invention.

The invention will hereinafter be described in greater detail by reference to the preparation of a shell mold and the compositions employed therein and the procedures employed in the usage of the mold for precision casting.

In the following description, the term "pattern" will be used to refer to the individual disposable pattern formed of wax or plastic materials or combinations thereof or to a cluster formed of a multiplicity of such individual patterns in accordance with conventional investment casting techniques.

It will be understood that changes may be made in the details of formulation, materials and methods employed without departing from the spirit of the invention.

PREPARATION OF WAX PATTERN AND CLUSTER

The pattern 10 is formed of conventional materials disposable by heat or chemicals, as in the well known investment casting processes. In the illustrated modification, the pattern is molded under pressure in suitable metal molds by injection of molten wax to fill the mold and set the pattern. Instead, the pattern can be formed of a thermoplastic, synthetic resinous material or combinations of such plastics and wax.

If the shell mold is to be formed about more than one pattern, the plurality of patterns are connected by runners for communication with a pouring spout to form a completed cluster, or as described in the aforementioned issued patent of Operhall et al. No. 2,961,751. Where, as in the instant process, the cluster is to be repeatedly dipped into a slurry, identified as a dip coat composition, it is desirable to provide a hanger rod for carrying the cluster and for suspending the cluster for drying and the like.

Example 1

Dip coat composition (zirconia formulation):

11 Pounds distilled water
8.8 Pounds colloidal graphite (22% solids in water)
88 Pounds zirconia (—325 mesh)
220 cc. anionic wetting agent (1.25% solids in aqueous medium)

Example 2

Dip coat composition (alumina formulation):

26.3 Pounds distilled water
10.7 Pounds colloidal graphite (22% solids in water)
122.7 Pounds alumina (—325 mesh)
418 cc. anionic wetting agent (1.25% sodium heptadecyl sulfate in aqueous medium)

In the above formulations, the zirconia and the alumina may be of a particle size larger than —325 mesh (Tyler screen) but it is undesirable to make use of alumina or silica flour that is greater than 150 mesh.

As the colloidal graphite, use can be made solely of colloidal particles of graphite of less than 1 micron. For the purpose of reducing cost, use can be made of a combination of such colloidal graphite mixed with up to 50% by weight and preferably up to only 30% by weight of semi-colloidal graphite having a particle size of between 10–20 microns. The colloidal graphite functions in the dip coat composition as a suspension agent and is the binder component to hold the particles of the zirconia or alumina flour and the stucco until at least the time that the shell is fired at elevated temperature.

The amount of colloidal graphite in the dip coat composition may vary but it is desirable to make use of an amount greater than 0.5% by weight but less than 5% by weight and preferably an amount within the range of 1 to 3.0% by weight.

The dip coat composition of Example 1 will have a pH within the range of 8.8 to 9.4 and a viscosity measured by the cup of Patent No. 3,011,986 of between 25–35 seconds, and the dip coat composition of Example 2 will be somewhat the same.

In the dip coat compositions represented by the above formulations, the emulsifying agents and the anionic wetting agents are preferred but not essential. Instead of gum tragacanth, use can be made of other hydrophilic colloids such as the gums, gelatins, alginates and the like, wherein, when used, such emulsifying agents are employed in an amount within the range of 0.01–0.5 percent by weight. Instead of the sodium heptadecyl sulfate wetting agent, other anionic surface active agents may be employed, such as the allyl sulfates and the allyl aryl sulfonates and their salts. When employed, the amount of such surface active

agent may range from 0.01–0.5 percent by weight of the composition.

APPLICATION OF DIP COAT COMPOSITION

The wax pattern is first inspected to remove dirt, flakes and other objects which may have adhered to the surfaces of the wax pattern and which, if allowed to remain, would impair the preparation of a good mold and lead to an imperfect casting. The cleaned pattern is immersed into the dip coat composition in a manner to cover all of the surfaces with the exception of the lip of the pouring spout. To promote the elimination of air pockets, it is desirable to rotate the cluster while immersing in the dip coat composition.

Instead of immersing the pattern in the stirred slurry of the dip coat composition for coverage of the surfaces of the pattern, the dip coat composition can be applied to achieve the desired coverage by spraying the dip coat composition onto the surfaces of the pattern. By this latter spraying technique the coating weight of the dip coat composition can be increased or decreased, as desired, by comparison with the amount of coating retained on the surfaces by immersion.

When fully coated, the dipped pattern or cluster can be removed from the container and allowed to drain. During drainage, the cluster can be inspected to detect air pockets which can be eliminated by addressing a stream of air onto the uncoated portions and thereafter allowing the slurry of the dip coat composition to flow onto the uncovered areas. While the cluster is being drained, it should be held in different planes designed to achieve uniform coating on all surfaces. In general, drainage should be completed within a few minutes but, in any event, in less time than would allow the dip coat composition to gel or dry whereby the surface would not retain stucco in the desired uniform arrangement.

STUCCOING

After the cluster has been allowed to drain for a short time and while the surface is still wet with the dip coat composition, the surface is stuccoed with a composition which may be represented by the following: Alundum having a size of less than 20 mesh but greater than 150 mesh and preferably less than 50 mesh but with only 3% passing through 100 mesh and with more than 90% between 60 and 80 mesh.

APPLICATION OF STUCCO COAT

After the uniformity of coating has been achieved with the dip coat composition, the stucco is sprinkled onto the wet surface while constantly changing the position of the cluster substantially uniformly to cover the dip coating with a layer of stucco, while at the same time minimizing flow of the dip coat composition whereby non-uniformities might otherwise develop. In practice, the stucco is rained down from above through a screening member which is constantly fed from a vibratory conveyor. The screen operates to remove foreign matter from the Alundum while the particles are sprinkled over an area to give uniform and complete coverage. The stucco adheres to the wet coating and becomes partially embedded therein to become integrated with the coating formed on the cluster of wax patterns.

If the dip coat composition is adjusted to enable drying to take place within a very short period of time, the stuccoed cluster need not be set aside for drying. However, it is preferred to slow the drying of the dip coat so that sufficient leeway is available for the desired drainage and stucco application. Thus it is desirable to provide for an air dry for a time ranging from 10–25 minutes. It will be understood that the drying time may be extended indefinitely beyond the times described without harm to the structure. If desired, drying of the combined coatings can be accelerated in a humidity controlled atmosphere heated to a temperature up to about 100° F.

The first dip coat and stucco coat deposit a thin layer of the Alundum (or zircon particles when zirconia substituted for the Alundum stucco), bonded with the graphite on the surface of the pattern to form a thin shell. It is desirable to build up the thickness of the shell to provide strength and self-sufficiency to the shell when the disposable pattern is removed and to enable casting of the moldable material directly into the shell without investment. For this purpose, it is desirable to make additional coatings of the dip coat composition and stucco but between each such additional coating it is desirable, though not necessary, to prewet the surface with a composition hereinafter referred to as a prewetting composition which may merely comprise the dip coat composition diluted further with aqueous medium to reduce the solids content by about ¼ to ½ and thereby reduce the viscosity whereby the more fluid dip coat composition will more readily wet out the previously formed shell portion for better wetting by the subsequently applied dip coat composition. Thus the layers become better integrated one with the other to produce a strong and composite shell structure.

The following are representative of prewetting compositions which may be employed with dip coat compositions of Examples 1 and 2:

Example 3

Prewet for composition of Example 1:

2.2 pounds distilled water
.9 pound colloidal graphite (22% solids)
8.8 pounds zirconia (—325 mesh)
44 cc. anionic wetting agent (1.25% solids)

Example 4

Prewet for composition of Example 2:

16 pounds distilled water
4 pounds colloidal graphite (22% solids)
46 pounds alumina (—325 mesh)
44 cc. anionic wetting agent (1.25% solids)

The prewet solution should have a viscosity of from about 8–10 seconds.

Each cycle of prewet, dip coat composition and stucco should be followed by the described drying step.

ADDITIONAL DIP AND STUCCO COATS

The composition of the third and additional dip coat compositions may correspond to the compositions of Examples 1 and 2. Use is usually made of the dip coat compositions previously used to effect the first or second coatings and which probably have become contaminated by the presence of coarser particles of stucco removed from the cluster during previous dips. In commercial practice, where the dip coat composition will be consumed at a relatively rapid rate, the separation as between the first and second dip coats is not so important.

The third and additional dip coats are achieved in substantially the same manner as the first and second dip coats by immersion of the cluster with the first and second stucco coats into the dip coat composition while turning the cluster or while revolving the drum in which the dip coat composition is housed.

For the third and additional stucco coats, use is preferably made of tabular alumina in the form of coarser particles ground to pass through a 14 mesh screen and to be retained on a 20 mesh screen with less than 10% passing through a 50 mesh screen. Application is made as before onto the wet layers of the previous dip coat composition after proper drainage and distribution.

A shell **12** having a thickness of from ¼ to ½ inch is usually sufficient for the casting of products of normal weight or dimension although shells of greater thicknesses can be formed where greater strengths are desired in the molding of larger castings. The normal thickness of shell

can usually be achieved with the compositions described in from 5–10 cycles of dip coating, stuccoing and drying.

DEWAXING

After the composite shell has been produced, the disposable pattern is removed to leave a mold cavity in which the material to be molded may be cast. Pattern removal, hereinafter referred to as dewaxing, can be achieved in a number of ways:

(a) Use can be made of flash dewaxing wherein the composite is heated to an elevated temperature far above the melting point temperature of the wax or plastic. In a preferred process of flash dewaxing, the composite is heated to a temperature above 800° F. and preferably to a temperature within the range of 1800–2200° F. for a time sufficient to eliminate the wax and to fire the shell. When the shell is exposed to a temperature in excess of 800° F. during dewaxing or firing, it is desirable to enclose the shell within a reducing atmosphere, otherwise the graphite binder will be burned out.

(b) Dewaxing can be achieved by a process known as "hot sand dewaxing" wherein sand heated to a temperature of from 400–800° F. is arranged to surround the shell for intimate contact with the outer surfaces thereof whereby heat transfers rapidly from the sand into the interior to melt out the wax. Instead of hot sand, use can be made of a metal or alloy system of low melting point, such as the cerro alloys, low eutectic alloys, and the like.

(c) Dewaxing can be achieved with steam when the patterns are formed of a material having a melting point range below about 200° F. For this purpose, the shell with the pattern can be housed within a steam chamber or autoclave or else steam can be directed onto the shell while it is suspended with the spout extending downwardly for drainage of the molten wax.

(d) Dewaxing can be carried out in an oven heated to a temperature above the melting point temperature of the wax but below the oxidizing temperature of the graphite and preferably at a temperature within the range of 250–800° F. in a process referred to as "low temperature dewaxing," which does not require a reducing atmosphere.

The shell is thereafter fired by heating to a temperature above 800° F. and preferably to a temperature within the range of 800–2200° F. Firing can be achieved by exposure of the shell to firing temperature for 15 or more minutes but it is preferred to make use of a time ranging from 15–120 minutes. Firing can be combined with dewaxing in the dewaxing process (a), but otherwise the shell is intended to be fired separately. Since graphite will be consumed in an oxidizing atmosphere when heated to a temperature above 800° F., the firing step should be carried out in an inert atmosphere and preferably in a reducing atmosphere, as represented by an atmosphere of hydrogen or carbon monoxide. In the event that it is desirable to make use of a mold part from which the graphite has been removed to produce a new and novel shell mold or part composed substantially exclusively of pure almina or of zirconia or mixtures thereof, depending upon the formulation of the dip coat composition and the stucco, the shell can be fired in the manner described in air or in an oxidizing atmosphere until the graphite has been burned out.

Because of the thinness of the shell, the heat is capable of penetrating rapidly through the shell to cause portions of the heat disposable pattern immediately adjacent the inner surface of the shell to be reduced to a molten state for removal to provide space wherein the remainder of the pattern can expand, when heated to elevated temperature, thereby to avoid problems arising from destruction of the mold responsive to the expansion characteristics of the pattern.

The following portions of the description will be addressed more particularly to the uses, including the new and novel uses, which can be made of a fired shell prepared in accordance with the practice of this invention.

Molten metal can be poured directly into the mold cavity of the fired shell for the fabrication of molded products of the type generally employed in the field of precision casting. The fired shell possess strength sufficient to maintain mass integrity during pouring of the molten metal thereby to avoid the necessity for investment of the shell for support. This results in the unique advantages that are available from shell molding processes by comparison with conventional investment casting processes including reduced weight, the usage of less material, the ability more rapidly to heat up the mold, the ability to achieve more rapid cooling of the cast material, better control from the standpoint of tear strength, fuller inspection of the mold prior to metal pouring with a corresponding reduction in the amount of scrap loss and the like. The fired shell can be clamped to the furnace, with or without additional reinforcement or support, when the molten metal is poured from the furnace into the casting upon inversion of the furnace.

While preheating is not essential, it is desirable to preheat the mold prior to metal pouring. Since most precision cast metals have a melting point in excess of 800° F., it is preferred to carry out metal pouring by conventional vacuum casting techniques wherein the fired shell, with or without preheat, is housed within a vacuum chamber which communicates with a metal melting furnace, whereby a vacuum can be drawn in the chamber in which the fired shell is mounted to evacuate the chamber and the shell prior to metal pouring and thereby further to minimize the amount of oxidation or reaction which might otherwise take place. The shell and the metal cast therein should be maintained under the vacuum conditions until the metal has cooled to a solid state or the assembly has cooled to a temperature below 800° F. Thereafter, the assembly can be removed from the vacuum chamber for additional cooling.

The casting can be removed from the shell by conventional techniques such as distintegration of the shell by impact or vibration to free the cast metal products from the shell materials.

As a further concept of this invention, it has been found that removal of the shell from the cast metal product can be facilitated greatly by reason of the presence of graphite originally introduced as a binder and emulsification component from the dip coat composition. For this purpose, the shell may be allowed to cool while still at a temperature above 800° F. in an oxidizing atmosphere to consume carbon whereby the strength characteristics and self-sufficiency of the shell are materially reduced or else graphite can be burned from the shell by exposing the shell with the cast metal product therein to elevated temperatures in an oxidizing atmosphere.

It will be apparent from the foregoing that I have provided a new and improved composition for use in the preparation of shells to be employed in precision casting and it will be further apparent that the processes described result in a new and novel shell product having characteristics which can be adapted for use in the molding of shaped products from materials which have heretofore resisted fabrication by such casting techniques.

It will be understood that changes may be made in the details of formulation and methods of handling without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. A dip coat composition for use in forming a mold about a disposable pattern for use in the casting of metals, alloys and ceramics upon removal of the disposable pattern comprising an aqueous composition consisting essentially of colloidal graphite, a flour of a ceramic material and the balance water, and in which the colloidal graphite is present in an amount within the range

of 0.5 to 5 percent by weight of the dip coat composition.

2. A dip coat composition as claimed in claim 1 in which the colloidal graphite comprises a mixture of colloidal graphite of less than 1 micron and semi-colloidal graphite having a particle size within the range of 1–20 microns and in which the colloidal graphite comprises at least 50 percent of the graphite system.

3. A dip coat composition as claimed in claim 1 in which the ceramic flour has a particle size of less than 200 mesh.

4. A dip coat composition as claimed in claim 1 in which the ceramic of the flour is selected from the group consisting of silica, alumina and zircon.

5. A dip coat composition for use in forming a mold about a disposable pattern for use in the casting of metals, alloys and ceramics upon removal of the disposable pattern comprising an aqueous composition consisting essentially of colloidal graphite of less than 1 micron in diameter and present in an amount within the range of 1.5 to 5 percent by weight, a ceramic flour of less than 200 mesh and present in the ratio of 1.5 to 10 parts by weight of colloidal graphite to 98.5 to 90 parts by weight of the ceramic flour, an emulsifying agent present in an amount within the range of 0.01 to 0.5 percent by weight, and the balance water.

6. A dip coat composition for use in forming a mold about a disposable pattern for use in the casting of metals, alloys and ceramics upon removal of the disposable pattern comprising an aqueous composition colloidal graphite of less than 1 micron in diameter and present in an amount within the range of 1.5 to 5 percent by weight, a ceramic flour of less than 200 mesh and present in the ratio of 1.5 to 10 parts by weight of colloidal graphite to 98.5 to 90 parts by weight of the ceramic flour, an anionic surface active agent present in an amount within the range of 0.01 to 0.5 percent by weight and the balance water.

7. In the method of producing a mold about a disposable pattern for use in precision casting processes, the steps of wetting the surface of the pattern with an aqueous dip coat composition consisting essentially of colloidal graphite, ceramic flour and water, covering the surfaces of the pattern while wet with the dip coat composition with a ceramic stucco, repeating the cycle of wetting with the dip coat composition and stuccoing until a mold of the desired wall thickness and strength has been built up about the disposable pattern, and in which the colloidal graphite is present in the dip coat composition in an amount within the range of 1.5 to 5 percent by weight.

8. In the method of producing a mold about a disposable pattern for use in precision casting processes, the steps of wetting the surface of the pattern with an aqueous dip coat composition consisting essentially of colloidal graphite, ceramic flour and water, covering the surfaces of the pattern while wet with the dip coat composition with a ceramic stucco, repeating the cycle of wetting with the dip coat composition and stuccoing until a mold of the desired wall thickness and strength has been built up about the disposable pattern, and in which the colloidal graphite is present in combination with the ceramic flour in the ratio of 1.5 to 10 parts by weight of colloidal graphite to 98.5 to 90 parts by weight of ceramic flour.

9. The method as claimed in claim 8 which includes the step of prewetting the previously applied coatings of dip coat composition and stucco in advance of wetting with the next dip coat composition with a prewet composition which is the same as the dip coat composition but diluted with water to 25–75 percent by weight of the solids of the dip coat composition.

10. The method as claimed in claim 8 in which the pattern is a heat disposable pattern and which includes the step of removal of the pattern from the mold by heating to a temperature in excess of that for disposal.

11. The method as claimed in claim 8 which includes the step of firing the mold to a temperature within the range of 800–2200° F. in a non-oxidizing atmosphere.

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MARCUS U. LYONS, *Primary Examiner.*