

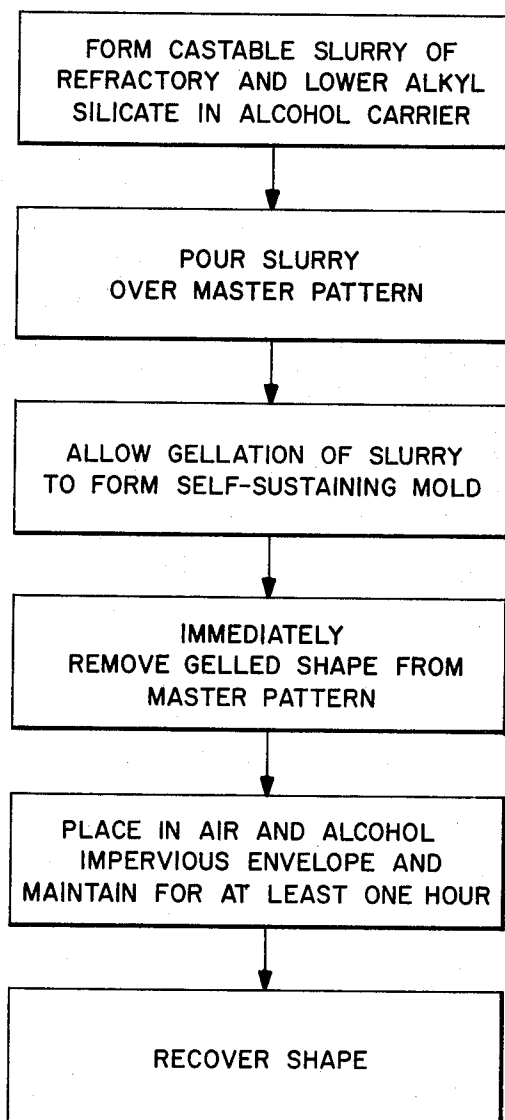
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METHOD OF TREATING AN INVESTMENT MOLD

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METHOD OF TREATING AN INVESTMENT MOLD

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In some aspects, this invention relates to an improvement in the process disclosed in copending application Serial No. 317,039, filed October 17, 1963 (now abandoned), and owned by the same assignee as the instant invention.

This invention relates to the manufacture of refractory molds of the type used for making precision metal castings. More particularly, the invention relates to a process of treating refractory patterns which are subsequently to be used for casting of molten metal.

As noted in said copending application, precision castings of molten metal and the like are used in many industries, and these castings are generally made in expendable refractory molds. There are three general classes or types of processes for making these expendable refractory molds; namely, the lost wax, the single investment, and the double investment.

The single investment casting process includes preparation of a plurality of refractory molds from the same permanent master pattern or mold. The permanent mold can be termed a positive (identical to the shape to be cast); and the refractory investment is the negative into which molten metal is cast.

The double investment casting process is quite similar to the single investment one, in that a permanent mold is repeatedly used to make refractory investments for the actual casting of molten metal. There is a difference, however, in the refractory investment. It has a backup or base portion, which can be identical to that used in the single investment mold process. However, in the double investment system, the molten metal contacting portions are coated with a layer of specially size graded refractory material to provide extremely smooth surfaces.

Both the single investment and double investment processes utilize substantially the same material (with the exception just noted). These materials include a refractory aggregate and a binder.

Most generally, the preparation of a binder is considered the most critical part of the process, since it had to be carefully and critically prepared according to a most precise recipe. One commonly used type of binder includes a mixture of alcohol (ethyl alcohol for example), an acid (such as hydrochloric acid), a small amount of water, and an organic silicate (such as ethyl silicate), sometimes with additional ingredients added.

In the above identified application, a process is taught in which specially prepared refractory grain is mixed with a prehydrolyzed binder solution, with the resulting mixture or slurry being used to cast the refractory investment which is later used for casting molten metal parts.

It is important that those portions of the investment against which molten metal is later cast be free of macro irregularities. Gas bubbles, which form on the investment surface during curing, have been one source of irregularities. The surface imperfections resulting from these bubbles, of course, result in complementary irregularities when molten metal is cast. Another distressing problem of prior methods has been the formation of hair-line cracks upon set of the investment. Some workers have termed these cracks "micro-crazing"; but this seems misdescriptive, because the cracks can be seen by the naked eye in many instances, and, of course, results in

a spiderlike network of complementary irregularities in metal cast thereagainst.

Some workers have suggested that the micro-crazing is beneficial, since it prevents gross cracking. It is accomplished by "torching" or burning the surfaces of the refractory immediately upon its reaching a self-sustaining or "set" state. I have not found micro-crazing desirable. I believe one completely free of even minute cracks is preferable.

Accordingly, it is an object of the present invention to provide an improved method of treating investment molds, to provide improved refractory investments. It is another object of the invention to provide an improved method of fabricating refractory investments according to the processes in which volatile and inflammable organic materials are used, while substantially reducing the risk of explosion or fire.

According to one aspect of this invention, I utilize a prehydrolyzed ethyl silicate solution and a pretreated refractory grain in a system of the type disclosed and claimed in copending application Serial No. 317,039, identified above. The gel formed from this system is weak, initially; but continues to develop strength when permitted to stand. However, when a mold prepared by this and prior similar systems is allowed to stand in open air too long, evaporation of alcohol from exposed surfaces produces shrinkage of such surfaces, sufficient to cause cracking or crazing before the gel is strong enough to prevent shrinkage. I have discovered that investment molds of improved strength and handleability are produced if, immediately after removal of a master pattern from the gelled investment, the exposed surfaces are covered with a thin sheet or film of substantially impervious plastic material. By "impervious," I mean the material is impervious to air and alcohol vapors. This impervious sheet retards the evaporation of alcohol, until the gel has developed sufficient strength so it may resist shrinkage cracking. Also, this encapsulation of the mold promotes an alcohol vapor-rich atmosphere which promotes uniform set.

A remarkably satisfactory and preferred impervious plastic sheet material, which can be used according to the practice of this invention, is Saran wrap, a commercially available product. This material is made from thermoplastic resins obtained by the polymerization of vinylidene chloride or co-polymerization of vinylidene chloride with lesser amounts of other unsaturated compounds. Of course, other flexible film or sheet material, which is impervious to air and alcohol fumes, and which will resist chemical reaction, i.e. inert to the organic and inorganic constituents of the gelling investment, can be used. A rigid container, if available, which can be sealed to the atmosphere, can be used, since it also will serve to enclose an alcohol-rich atmosphere about the investment.

The following detailed discussion should be understood as merely exemplary of practices according to my invention, and that the true measure of the spirit and scope is as defined in the claims.

Of course, practically any type of refractory grain, which is conventionally used for making refractory investments, can be used in the practice of this invention. Examples of satisfactory grain include alumina, calcined clay which analyzes mostly SiO₂ and Al₂O₃ on an oxide basis, mullite, silica, calcined high alumina materials such as bauxite and diaspore, fused corundum and fused mullite, sillimanite, various spinel minerals such as chrome ore, zirconia (preferably stabilized zirconia), etc.

The refractories used for making investment molds should be carefully screened so as to provide a uniform product. For example, the grains may be of a size so that 50%, by weight, is in the range -6+30 mesh, the rest mostly in the -30 mesh range. From 20 to 40%

can be smaller than 200 mesh. (All of these sizes are according to the United States Standard series of screens.) According to preferred practice, the size graded grain is treated with a solution of a volatile organic solvent and an organic base. The organic base is of the amine type, preferably having from 8 to 22 carbon atoms, and of the type of alkali metal and alkaline earth salts of chemically basic organic compounds as are discussed in the copending application above identified. The refractory grain is coated by treating them with one of the amine-type materials, just discussed, so that at least a major portion of the exposed surface area of the refractory grain of the batch (at least about 50%) is covered. The amount of the coating may run from 0.1 to about 2%, by weight, based on the weight of the refractory. The preferred range is 0.3 to 0.7%, by weight.

Coated grains are treated with a gelling binder. A preferred gelling binder is prepared from:

- (1) Ethyl silicate having 40% SiO₂, by weight,
- (2) Denatured ethyl alcohol, in a quantity sufficient to dilute the ethyl silicate to obtain a fluid mixture or solution having about 18% SiO₂, by weight and on an oxide basis,
- (3) Water, in a quantity sufficient to promote hydrolyzation of the 18% SiO₂ solution to on the order of about 60 to 80% completeness, and
- (4) Sufficient of an acid, such as hydrochloric acid, to obtain a pH of a partially hydrolyzed solution in the range from about 2 to about 4.

The resulting binder and treated refractory grain mixture, according to a preferred embodiment, is about as follows: 400 grams of a refractory consisting essentially of 20% —8 on 30 mesh calcined flint clay, the balance being —100 mesh mullite, and the mixture treated with 0.55% Duomeen C (or 0.2% diethylmethylamine—this being preferred), is mixed with 100 cc. of a binder solution containing 18% SiO₂, by weight, derived from ethyl silicate (40% SiO₂ content), water to allow 83% hydrolyzation (about 6 cc. of water), hydrochloric acid or other inorganic acid such as sulfuric or nitric acid to yield a pH of approximately 2 (about 1 cc.) and ethyl alcohol to reduce the SiO₂ content to the above mentioned to 18% (from 50 to 55 cc. of ethyl alcohol). "Duomeen C" is a coconut oil derivative of 1,3-propylenediamine. After thorough mixing, the resulting slurry is poured over a master pattern, where gelation occurs in about 3 minutes at 75° F.

While I mention prehydrolyzed ethyl silicate and alcohol as a binder solution, it is, of course, clear other lower alkyl organic silicates of the type known to the prior art for investment molding can be used. Exemplary prior art, which discloses the known character of use of lower alkyl organic silicates and alcohols for this purpose, are as follows: Prange, 1,909,008, Shaw, United States Patent No. 2,795,022.

A preferred refractory grain is the commercial product of commerce, identified by the trade name "Flintmull GG3," a product of the Harbison-Walker Refractories Company. This commercial product is a mixture of calcined flint clay and mullite. The preferred coating agent is Duomeen C, a product of the Armour Chemical Company.

In the preferred practice of the invention, the mixture of binder and coated refractory is poured into a master pattern, allowed to gel to a state sufficient to resist light finger pressure, the master pattern is stripped from the refractory, and the refractory investment is inserted in a plastic bag which is tied to close the investment off from the atmosphere. The time necessary for the refractory to remain covered by the plastic is visually determined; for example, when all surfaces are of a uniform color and no "wet" areas are obvious, the bag may be removed. I found it very satisfactory, using the preferred composition, above discussed, to remove the bag after about 1 to 2 hours, followed by air drying for a similar or longer

period. If desired, the bag may remain longer; for example, overnight (12 or so hours). If desired, after removal from the bag, the investment may be placed in an oven to ignite any residual alcohol. If desired, the investment can be heated to a temperature of on the order of 2000° F. to obtain some ceramic bonding through the refractory material to thereby obtain improved strength.

Having thus described the invention in detail, and with sufficient particularity as to enable those skilled in the art to practice it, what is desired to have protected by Letters Patent is set forth in the following claims.

I claim:

1. A method of preventing micro-crazing and cracking of gelling investment molds of the type made from a slurry of (1) a refractory, and (2) an alcohol and lower alkyl silicate bonding solution, which comprises the steps of, pouring the slurry about a master pattern, allowing the slurry to initially gel only to a self-sustaining shape about said master pattern, immediately stripping the pattern from the shape, immediately encapsulating the shape in means defining an air and alcohol vapor-impervious cavity, said means sealing said cavity from the atmosphere, said cavity being larger than the mold it encapsulates and of such size and configuration as to retard the evaporation of alcohol from the mold and to promote and allow the formation of an alcohol-rich atmosphere about exposed surfaces of the mold by evaporation of alcohol from the mold, maintaining the shape in the cavity for at least about an hour until all surfaces of the mold are substantially uniform in color and with no wet areas being obvious.

2. The method of claim 1 in which the shape is maintained in the envelope for about one to two hours.

3. The method of claim 2 in which the shape is removed from the envelope after said one to two hour period and placed in an oven to burn off residual alcohol.

4. The method of claim 3 in which the oven is heated to a temperature sufficient to fire the shape to obtain ceramic bonding.

5. A method according to claim 1 in which said refractory is selected from the group consisting of alumina, calcined clay, mullite, silica, bauxite, diaspor, fused corundum, fused mullite, sillimanite, chrome ore, and mixtures thereof.

6. A method of preventing micro-crazing and cracking of gelling investment molds of the type made from a slurry of (1) a refractory, and (2) an alcohol and lower alkyl silicate bonding solution, which comprises the steps of pouring the slurry about a master pattern, allowing the slurry to initially gel only to a self-sustaining shape about said master pattern, immediately stripping the pattern from the shape, immediately encapsulating the shape in an air and alcohol vapor-impervious plastic bag, said bag being sealed from the atmosphere and of such size and configuration as to retard the evaporation of the alcohol and to promote the formation of an alcohol-rich atmosphere about exposed surfaces of the mold by evaporation of alcohol from the mold, maintaining the shape in the bag until all surfaces of the mold are substantially uniform in color and with no wet areas being obvious.

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