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3,018,528

METHOD OF FORM REMOVAL FROM PRECISION CASTING SHELLS**Robert A. Horton, Willowick, Ohio, assignor to Precision Metalsmiths, Inc., Cleveland, Ohio, a corporation of Ohio****No Drawing. Filed Mar. 7, 1960, Ser. No. 12,899****4 Claims. (Cl. 22—195)**

This invention relates to the ceramic shell process of investment casting, and relates more specifically to the use of plastic patterns and the process of removing such a pattern from a shell coating formed thereon.

The object of this invention is to produce a ceramic casting shell from a plastic pattern.

Another object of this invention is to provide a process for removing the plastic pattern without disrupting the thin ceramic shell.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims.

In the conventional investment casting "lost wax" process, a disposable pattern, which is a replica of the part to be cast including the necessary risers and gates, is coated with a refractory slurry which hardens and forms the mold face. The bulk of the mold is formed by a refractory castable investment which is poured or vibrated around the coated pattern in a suitable container known generally as a flask, and which subsequently sets to a strong, hard mass.

The completed mold is then dried and heated to melt out the bulk of the pattern material. It is then heated still higher to burn off or volatilize the last residue of the pattern material and to prepare the mold to receive the molten metal.

The coating of the pattern is usually carried out by dipping it into a suspension of fine refractory powder in a suitable bonding liquid. The binder is one which is capable of hardening during drying at room conditions. After dipping, the excess slurry is drained off and the pattern is sprinkled or sanded with coarser refractory particles to place the coating and to facilitate bonding between the coating and the backup investment.

A growing trend within the investment casting industry is the use of thin ceramic shell molds in place of the conventional bulky investment molds. The shell molds are usually prepared by repeating the dipping and sanding operation described above until a sufficient coating thickness is obtained to resist the stresses that occur in subsequent processing. The usual thickness is from 1/8 of an inch to 1/2 of an inch, although either thinner or heavier shells may be indicated for special situations.

Some of the advantages that are frequently obtained with shell molds over conventional investment molds include:

- (1) Lighter molds, easier to handle.
- (2) Increased permeability.
- (3) Increased thermal shock resistance.
- (4) Easier knockout and cleanup after casting.
- (5) No flasks required.
- (6) Greater flexibility in processing.

A critical stage in the processing of such shells is the elimination of the pattern material. As the shell containing the pattern is heated, the usual pattern materials expand at a much higher rate than the shell, so that the resultant expansion forces tend to crack the shell. This has been overcome in the case of wax patterns by a procedure known as flash dewaxing. In this procedure the shell is placed directly into a furnace at an elevated temperature, i.e. 1600–1800° F. Under these conditions the heat transfer through the shell is so rapid that a surface skin of wax melts before the bulk of the

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wax can heat up enough to crack the shell. As the bulk of the wax does heat up, the molten surface material either flows out of the mold or soaks into the shell. This provides a space to accommodate the bulk expansion of the wax, so that it will not crack the shell.

Attempts to use plastics in place of wax patterns in shell molds have not been successful due to the fact that plastics do not respond to flash dewaxing as waxes do. The term "plastic" is used herein as it is used in the trade to denote synthetic resins. Possibly the surface skin does not soften as it should, or if it does, is not fluid enough to soak into the mold, so that the shell is still subject to large pressures. In some cases, strains in the plastic, which are set up during the injection cycle, may be released during heating, causing a distortion of the plastic which may also crack the shell. Whether these explanations are correct or not is not certain. But it is a fact that plastic patterns will cause cracking of shells which would be quite suitable for use with wax patterns. For example, a shell composition which can be used for wax patterns weighing over twelve pounds cannot be used with a plastic pattern weighing less than one-tenth of an ounce, due to cracking during burn out.

There are many instances where it is desirable to use plastic patterns. Plastic patterns can be turned out on automatic injection equipment at much higher production rates than can be attained in conventional wax injection operations. In addition, plastic patterns are not brittle, and do not crack at low temperatures or soften at high temperatures normally encountered.

The object of this invention is to provide a means of processing patterns made up in whole or in part of plastic, in the same type of shells that are now used for wax patterns. This is accomplished by soaking the shells in a solvent which is capable of diffusing through the shell and softening the plastic inside, prior to the pattern volatilization operation. The solvent soaking step is preferably carried out before the dipping process is completed, since the required soaking time is much shorter when the shell is thin. After the shell has been soaked long enough to accomplish the desired purpose, the dipping is completed and the shell is subsequently handled by any procedure which would be suitable for wax patterns.

Further, it is possible to expel the softened plastic pattern by means other than oven-heating. Dielectric heating is just one example.

This invention is not to be confused with prior known methods, wherein wax patterns were removed by solvents which fully dissolved the pattern. This invention is useful with patterns not fully soluble and further, the mere rendering of a pattern impotent with respect to its ability to resist an expansion force under later heat removal is far more efficient and less expensive.

It has been found that the diffusion of the solvent into the plastic creates a pressure of its own. This pressure is small compared to that generated during heating, but it is necessary that a minimum number of dips be applied before the soaking operation can be carried out successfully. This number varies, depending on the particular plastic-solvent-shell combination being used, and it is usually less than would be required to resist handling and casting stresses.

It is obvious that this procedure necessitates the shell being permeable to the solvent being used, but normally no special steps need to be taken to insure this, since the types of shells which have proved satisfactory in practice do have the required permeability to the common solvents.

Specific examples of the process are given below:

Complex pattern shapes of polystyrene were made.

A six-dip shell was made on such patterns using a

suspension of zircon (zirconium silicate) and fused silica in a bonding liquid consisting mainly of a colloidal silica sol, with small amounts of an organic film former, a wetting agent, and a defoaming agent. Each dip was sanded with a coarse fire-clay grog of -20+50 mesh.

Three dips were applied one hour apart. The shell was dried overnight, then soaked four hours in methyl ethyl ketone. It was removed from the methyl ethyl ketone, allowed to stand one hour, and then three more dips were applied—one hour apart. After drying at room conditions, the shell was dewaxed by placing it directly into a furnace at 1800° F. There was no cracking or other defects. A similar shell, processed in the same manner except that the solvent soaking was not used, cracked badly during dewaxing on the portion of the shell defining the plastic pattern. Furthermore, it was found that even twelve such coats did not build up a sufficient thickness to process successfully, without a solvent soaking.

A smaller plastic pattern weighing 2.5 grams was set up on a wax base. Six dips were applied as above, with a six hour soaking period in benzene after the third dip. The shell was dewaxed successfully at 1800° F. A similar shell with no solvent treatment cracked during dewaxing. Larger set ups having 25 such pieces have also been processed successfully by the solvent soaking technique.

The soaking time required depends on such factors as size and shape of the plastic piece, number of pieces on the set up, type of plastic, solvent and shell, number of dips before soaking and number of dips to be applied after dipping. A peculiar effect that has been observed is that when the soaking time is insufficient, the shells normally will not crack as untreated shells do, but the portions defining the plastic part of the pattern will blow apart. For example, test patterns were given soaking periods of zero up to five hours after the third dip. Three more dips were applied after soaking. The shell with no soaking time cracked during dewaxing in a very characteristic manner. Those soaked ½ to three hours blew apart on the plastic portion. Those soaked four hours or more were dewaxed successfully. The phenomenon has been noted on other types and sizes of set-ups as well.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

I claim:

1. The process of producing a molding shell for the casting of shapes therein, comprising the steps of providing a synthetic resin, providing an agent capable of softening said synthetic resin after it is molded and hardened, said agent being capable of producing a condition of softness wherein the softened synthetic resin has a low degree of expansion force under heat of an intensity to volatilize the synthetic resin, molding said synthetic resin into the form of a desired casting, providing a porous refractory shell coating over said synthetic resin, said shell having a strength greater than said low degree of softened synthetic resin expansion force, there-

after softening said synthetic resin by applying said softening agent through said porous shell coating, and finally heating the softened form above the heat volatilization temperature thereof until fully dispersed from the shell coating.

2. The process of producing a molding shell for the casting of shapes therein, comprising the steps of, providing a synthetic resin and an agent capable of softening said synthetic resin after it is molded and hardened to a condition of softness wherein the softened synthetic resin has a low degree of expansion force under heat of intensity to volatilize the synthetic resin, molding said synthetic resin into the form of a desired casting, providing a thin porous refractory shell coating over said synthetic resin having a strength greater than said low degree of expansion force, thereafter softening said synthetic resin by applying said softening agent through said porous shell coating, thereafter applying additional refractory shell coating over the previous coating to increase the shell strength, and finally heating the softened form above the heat volatilization temperature thereof until fully dispersed from the shell coating.

3. The process of producing a molding shell for the casting of shapes therein, comprising the steps of, providing a heat volatilizable pattern material and an agent capable of softening a pattern made therefrom to a condition of softness wherein the softened pattern has a low degree of expansion force under heat of intensity to volatilize the pattern, molding said material into the form of a desired casting, providing a refractory shell coating over said form having a strength greater than said low degree of expansion force, thereafter introducing said softening agent into the shell and thus causing the softening agent to act upon the pattern within the shell, and finally heating the softened form above the heat volatilization temperature thereof until fully dispersed from the shell coating.

4. The process of producing a molding shell for the casting of shapes therein, comprising the steps of, providing a polystyrene pattern, providing, a suspension of zirconium silicate and fused silica in a bonding agent of colloidal silica sol as a shell forming dip, dipping said pattern in said dip material and thereafter stuccoing the wet dip coat with a coarse fire clay grog, allowing said stuccoed coat to dry and thereafter repeating the dip and said stucco step until at least three coats are built up, providing a bath of methyl ethyl ketone, submersing said coated pattern in said bath until said pattern is softened, draining the excess methyl ethyl ketone and thereafter applying at least three further dip coatings, and finally placing said coated pattern into a furnace at 1800° F. until all the pattern is evaporated from the shell.

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

January 30, 1962

Patent No. 3,018,528

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 32, for "dipping" read -- soaking --.

Signed and sealed this 26th day of June 1962.

(SEAL)

Attest:

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