

UNITED STATES PATENT OFFICE

2,683,296

METHOD OF PREPARING SHELL MOLDS AND
COMPOSITION THEREFOR

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No Drawing. Application November 17, 1951,
Serial No. 256,959

9 Claims. (Cl. 22—193)

1

This invention relates to shell molds for preparing metal castings. More particularly, the invention pertains to sand-binder compositions adapted for preparing shell molds.

Shell molds are used in the foundry industry for the casting of molten metals. The molds may have a wall thickness varying from 0.05 to 1.5 inches or more in thickness. The molds are prepared by bringing a mixture of sand and a binder into contact with a heated pattern at a temperature sufficiently high to fuse the binder and for a time long enough to build up the desired shell thickness. An excess of sand-binder mixture is used and the unused excess is separated from the shell mold for use in preparing other molds. The shells are then heated at an elevated temperature until the binder sets.

As originally described, foundry sand was mixed with a thermosetting resin. A heated pattern was placed in a box or other container and the sand-resin mixture poured over the pattern in the container. The heat from the pattern rendered the thermosetting resin tacky enough to bind the sand particles. After a short dwell in the container, the excess sand-resin mixture was removed by simply overturning the container leaving a thin-walled shell lightly adherent to the pattern. The duration of the dwell determined the extent of penetration of the heat from the pattern through the sand-binder mixture and consequently determined the thickness of the shell. The shell and pattern were then heated to set the resin, after which the shell was removed from the pattern and then used as a mold for casting molten metal without further treatment. In most cases, it was necessary to prepare the molds in two parts which were fastened together for the casting operation.

The shell molds are so thin and fragile that they usually must be backed up in the casting process to prevent their losing their shape. Steel shot packed around the shell mold is a convenient method for this purpose.

This process is an efficient method for making molds for the precision casting of many molten metals. However, it has been found that the shell loses strength too rapidly and frequently crumbles before the casting is complete, thus spoiling the casting. This crumbling effect is particularly noticeable at the high temperatures needed for casting some of the more temperature-resistant stainless steels.

One object of this invention is to provide a new sand-binder mixture for preparing shell molds.

A further object is to provide shell molds which

2

will not crumble at the temperatures of the molten metal cast therein.

These and other objects are attained by preparing a sand-binder composition comprising foundry sand, a thermosetting resin and cryolite, cryolithionite, pachnolite, or mixtures thereof, and preparing shell molds from the composition.

The following examples are given in illustration and are not intended as limitations on the scope of this invention. Where parts are mentioned, they are parts by weight.

Example I

Mix together 100 parts of foundry sand, 6 parts of a pulverulent fusible phenol-formaldehyde condensation product and 5 parts of pulverulent cryolite. Preheat a suitable metal pattern such as a pattern for a gate valve plug at about 275° F. Pour a large excess of the homogeneous mixture over the pattern. After about 10 seconds, invert the pattern to remove excess mixture. A shell about 0.25 inch thick remains on the pattern. Heat the shell and pattern to 500° F. to set the resin. Remove the shell from the pattern and then heat the shell to about 1600° F. For a gate valve plug, the mold must be made up of two half-shells which are fastened together to form the final mold. After the two shells are made, fasten them together and place the mold in a casting box. Fill the void spaces in the box with steel shot to back up the mold and then heat the mold to about 1500° F. Cast molten steel into the mold at 1500° F. and cool the casting. The product obtained is a smooth, substantially perfect plug for a gate valve requiring little or no finishing.

Similar results are obtained if a urea-aldehyde, melamine-aldehyde, alkyd or other thermosetting resin is substituted for all or part of the phenol-formaldehyde resin of Example I.

Example II

Mix together 100 parts of foundry sand, 1.5 parts of a fusible pulverulent melamine-aldehyde resin and 0.5 part of cryolite. Pour an excess of the mixture over a pattern preheated to 350° F. After about 10 seconds, remove the excess mixture and heat the shell and pattern at 600° F. for about 2 minutes. Remove the shell from the pattern and heat the shell at 1800° F. for 10 minutes. Cool the shell to a temperature at which it can be easily handled in the casting process.

Example III

Mix together 100 parts of foundry sand, 6 parts of a pulverulent fusible phenol-formaldehyde

resin, 6 parts of a pulverulent fusible melamine-formaldehyde resin and 6 parts of cryolite. Prepare a shell as shown in Example I. The shell will be about 1.0 inch thick. Due to the extra thickness of the shell, the setting of the resins will take about 5 minutes.

The "sands" used to make the shells may be any particulate inorganic materials which do not fuse at temperatures below 2500° F. Typical foundry sands are siliceous in character. They are at least as fine as 75 on the American Foundrymen's Society fineness scale. Generally, they should be washed to remove organic impurities. For shell molds, it is frequently desirable to use a material of quite small particle size to replace all or part of the foundry sand. Among such materials are silica flour, zirconite flour, fly ash, coke breeze, powdered alumina, etc.

Example IV

Mix together 80 parts of foundry sand, 20 parts of zirconite flour, 5 parts of a pulverulent fusible urea-formaldehyde resin, 1.0 part of pulverulent polymerized styrene having a molecular weight of about 60,000, and 6 parts of cryolite. Prepare a shell as shown in Example I. The shell will be about 0.25 inch thick.

Any organic thermosetting resin may be used as one binder for the sand. For ease of handling, the resin should be in the solid form. However, liquid resins or solutions of the resins may be used provided the resins are solidified in the mixing operation either by advancing the resin to the solid state by the heat developed in the mixer or by drawing off the solvent during the mixing process. The amount of dry fusible resin added to the sand may vary between about 1.0 to about 15 parts per 100 parts of sand.

In addition to the alkyd resins and the phenol, urea or melamine aldehyde resins referred to in Example I, other thermosetting resins may be used such as furfural resins, lignin, etc. Mixtures of two or more resins may be used. In some cases, it is desirable to mix the thermosetting resin with a minor amount, less than 50%, of a thermoplastic material such as a vinyl or vinylidene polymer or copolymer, a cellulose derivative, polyamides, etc. The thermoplastic resins serve the purpose of speeding the preparation of the initial shell. Hydrocarbon polymers such as polystyrene and polyethylene are particularly suitable for admixture with the thermosetting resin.

Cryolite is the preferred second component of the binder but it may be replaced in part or entirely by cryolithionite or pachnolite. The cryolite should be pulverized to at least about the same fineness as the foundry sand used. An effective bond is obtained when from 0.1 to 20 parts of cryolite is used for 100 parts of sand.

To prepare the shell molds of this invention, the following steps are necessary:

(1) Mix the sand and two binders together in the dry state until the binders are thoroughly intermingled with the sand. This is conveniently carried out in a standard muller. No water, starch, flour or other ingredient which imparts green strength to the mixture should be used. Alternatively, the mineral binder may be incorporated in the resin during the process of preparing the resin or it may be blended with a powdered resin before being mixed with the sand.

(2) The sand-binder mixture is poured over a heated pattern and maintained in contact with the pattern until a shell is formed. Convenient-

ly, this is done by placing the pattern on a match plate in an open-topped container, heating the pattern through the match plate, and then pouring an excess of the sand-binder mixture onto the pattern. The resinous binder closest to the pattern fuses quickly to bind the sand into a thin shell. The thickness of the shell is governed by the temperature of the pattern, the length of dwell of the sand-binder mixture against the pattern, and the amount of resinous binder in the mixture. The temperature of the pattern may be varied between 275° F. and 750° F., and the dwell against the heated pattern may vary from 6 to 60 seconds. At the end of the desired dwell, the container is inverted to pour off the unbound sand-binder mixture.

(3) The shell is heated at 200–750° F. to set the resinous binder and firmly bond the sand and cryolite. This setting is generally complete in from 2 to 5 minutes although at 200° F., setting is slow and will not be completed in much less than 60 minutes. The shell may be heated in this step alone but it is preferred to heat shell and pattern together.

(4) The shell is then further heated out of contact with the pattern at from 1000° F. to 2500° F. The dwell at the high temperature may vary from 5 minutes to several hours depending on the temperature used, the amount of binder, and the thickness of the shell.

(5) The shell is then cooled to a safe handling temperature. Ordinarily, this will be room temperature but under some conditions, it may be desirable to remove the shell from the high temperature apparatus before it cools to room temperature.

The shell molds thus produced are used for casting metals which in the molten condition are at a temperature of 700–4000° F. The molds are positioned in a mold box and generally backed up with pressure-resistant materials such as steel shot to prevent distortion of the mold under pressure of the molten metal. For some castings, the molds are strong enough so that they resist the pressure of the cast metal without the use of a backing.

A particular advantage of the shells of this invention is that molds prepared therewith may be heated to an elevated temperature without warping or otherwise changing shape. As a result molten metal may be cast into hot molds which helps to control the shrinkage of the casting, eliminates porosity, and improves the finish of the casting. The only restriction on the preheating of the mold is that, in general, the preheat temperature should be at least 100° F. less than the highest temperature used in forming the shells.

The thickness of the shell molds may be varied between 0.05 and 1.5 inches. For small castings, a thinner wall is satisfactory whereas for large castings a thicker wall will be advantageous in resisting the pressure of the molten metal. For particularly large castings, it may be desirable to prepare shells which are thicker than 1.5 inches.

If desired, small amounts of liquids may be added to the sand-binder mixture to minimize the dusting and segregation of the dry mix. These liquids should be volatile at temperatures below 500° F., should have little or no solvent power for the resin binders and should not impart green strength to the sand-binder mixture. An example of an effective anti-dusting agent is tetraethyl silicate.

5

6

It should be emphasized that the sand-binder mixture should have little or no green strength. The efficacy of the process depends on the free-flowing qualities of the sand-binder mixtures so that the mixtures may be poured onto the heated pattern and then poured away from it quickly when desired.

The sand-binder mixture may advantageously contain minor amounts of a mold release agent such as naphthenic acids, fatty acids, fluid and powdered silicones, etc. The nature and quantity of the mold release agent should be controlled to prevent the development of green strength in the sand-binder mixtures. In some cases, it is preferred to coat the pattern with the mold release agent.

The shell molds made by this process do not crack or crumble during the casting process. Ordinarily, they are used for a single casting but for simple shapes it is sometimes possible to use the same mold for several castings. After they are no longer usable for casting purposes, the shell molds are easily pulverized and the powder used to prepare additional molds.

It is obvious that variations may be made in the products and processes of this invention without departing from the spirit and scope thereof as defined in the appended claims.

What is claimed is:

1. A process for preparing shell molds which comprises mixing together 100 parts of a particulate inorganic material having a fusing temperature above 2500° F., from 0.1 to 15 parts of a pulverulent, fusible thermosetting resin and from 0.1 to 20 parts of a pulverulent mineral taken from the group consisting of cryolite, cryolithionite, pachnolite and mixtures thereof, until an intimate mixture is obtained, pouring an excess of the mixture onto a pattern preheated to from 200° F. to 750° F. and maintaining the mixture in contact with the heated pattern until a shell is formed, removing excess mixture, heating the shell and pattern to from 200° F. to 750° F. to set the thermosetting resin, separating the shell from the pattern and then heating the shell from 700° F. to 4000° F.

2. A process as in claim 1 wherein the thermosetting resin is a phenol-formaldehyde resin.

3. A process as in claim 1 wherein the mineral is cryolite.

4. A shell mold prepared by the process of claim 1.

5. A composition suitable for the preparation of shell molds for casting molten metals, said composition consisting essentially of 100 parts of a particulate inorganic material having a fusing temperature above 2500° C., from 1 to 15 parts of a fusible, pulverulent thermosetting resin and from 0.1 to 20 parts of a pulverulent mineral taken from the group consisting of cryolite, cryolithionite, pachnolite and mixtures thereof, said compositions having substantially no green strength.

6. A composition as in claim 5 wherein the thermosetting resin is a phenol-formaldehyde resin.

7. A composition as in claim 5 wherein the thermosetting resin is a melamine-aldehyde resin.

8. A composition suitable for the preparation of shell molds consisting essentially of 100 parts of foundry sand, 6 parts of a fusible, pulverulent phenol-formaldehyde resin and 5 parts of cryolite, said composition having substantially no green strength.

9. A composition suitable for the preparation of shell molds consisting essentially of 100 parts of foundry sand, from 0.1 to 20 parts of a pulverulent mineral taken from the group consisting of cryolite, cryolithionite and pachnolite, and mixtures thereof, and from 1.0 to 15 parts of a pulverulent mixture consisting of from 50 to 100% of a fusible thermosetting resin and up to 50% of a thermoplastic organic material, said compositions having substantially no green strength.

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