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SELF-LUBRICATING SHELL MOLDS

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This invention relates to shell molding and particularly to a shell mold and method of forming the same from a self-lubricating molding mixture which prevents the mold from adhering to the hot patterns on which it is formed.

Recently developed techniques in foundry practice incorporate the use of thin-walled dispensable molds and cores composed of sand and thermosetting binders. These procedures, frequently generally referred to as "shell molding" processes, are particularly suitable for the production of precision castings in a wide variety of metals.

In shell molding, the advantages obtained by the use of thin-walled sand-resin molds and cores in casting metal parts to close dimensional tolerances result principally from the fact that these castings have very smooth as-cast surfaces. Accordingly, it is imperative in the formation of the molds that there is a clean separation of the sand from the surfaces of the metal pattern. In the past, some difficulty had been encountered from stripping the mold from the pattern because of the inadequacy of the parting material used, thereby frequently resulting in the partial breaking or tearing of the mold edges and the destruction of mold details.

Mold release agents, usually in liquid form, heretofore have been applied directly to the hot pattern surfaces. However, the spraying of mold release agents or lubricating materials on the surfaces of the metal pattern results in an uneven distribution of the lubricating material on the pattern because the recesses formed therein tend to accumulate this material while the vertical surfaces tend to be inadequately lubricated. This uneven distribution, in turn, results in an excessive lubricant build-up on the patterns, thereby interfering with the precise and accurate formation of molds. Moreover, spraying of a mold release agent on a pattern before it is used is a relatively expensive procedure, particularly inasmuch as a considerable proportion of the sprayed lubricant is usually lost to the atmosphere.

The above conditions are aggravated by the fact that such mold release agents generally must be applied to the pattern surfaces each time the pattern is used, the lubricating properties of these agents not being satisfactorily retained while on the pattern for more than one molding cycle.

Accordingly, a principal object of the present invention is to provide a shell molding mixture which does not adhere to the pattern to which it is applied and which does not require the application of an external mold release agent to the pattern. A further object of this invention is to form a self-lubricating shell mold from a molding mixture containing a mold release agent which prevents the molding mix from adhering to the pattern. A still further object of the invention is to provide a method of forming shell molds which eliminates the necessity of spraying a lubricant on the pattern and at the same time provides a more even distribution of the lubricating material on the pattern surfaces, thereby substantially reducing the amount of residue build-up.

These and other objects and advantages are attained in

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accordance with my invention by the use of a shell molding mixture which contains a small but effective amount of an internal lubricant or mold release agent. Such a molding mixture, in which carnauba or other suitable waxes are preferably included as the release agent, may be easily and inexpensively prepared. The use of such an internal lubricant in the mold permits accurate reproduction of pattern details and eliminates the danger of any measurable proportion of the sand mold adhering to the pattern. Furthermore, the presence of wax does not materially decrease the strength of the formed mold. Such a molding mixture having an internal mold release agent functions equally well when applied to cast iron, aluminum and other pattern and core box materials.

It will be understood that the term "mold," as used herein, is generally applied in its generic sense to mean a casting form which includes both molds and cores, this invention in no manner being limited to the former. Similarly, unless indicated otherwise, the word "pattern" is used herein as including both mold patterns and core boxes.

Essentially, the shell molding process consists of using a thermosetting plastic or resin as a binder for the grains of sand or other suitable refractory material to form rigid molds having high gas permeability, good surface smoothness and dimensional stability. The molding material, which is generally a dry mixture of a major proportion of silica sand and a minor proportion of a plastic binder, is used in powdered form with no water being added. This sand-resin mix normally contains between 3% and 15% by weight of binder, phenol formaldehyde and melamine formaldehyde resins being typical examples of the type of thermosetting binders preferably used. It is desirable that the sand employed is free of metal oxides, clay, moisture and organic matter. Silica flour or other finely comminuted refractory facing materials may also be included in the molding mix to provide the mold with an exceptionally smooth surface.

These sand-resin molds are prepared by allowing the dry mixture of sand and resin powder to come into contact with a hot pattern for a short period of time. A layer of the mix adheres to the pattern surfaces due to the heating of the resin which entraps the sand with which it is intimately mixed, thereby accurately reproducing pattern details. The half patterns, gates and runners are usually all permanently fixed on metal plates. Metal patterns normally must be used because they are subjected to elevated temperatures. Pattern temperatures in the range between 250° F. and 350° F. are typical, but temperatures up to 600° F. may be advantageously employed under particular conditions. The pattern temperatures and the length of time the molding material is allowed to remain in contact with the hot pattern surfaces determine the resulting thickness of the mold. Mold build-up times ranging from a few seconds to approximately one minute are appropriate for various applications.

After this short time interval the excess dry sand and resin are removed, and the closely adhering sand-resin layer is preferably cured while in contact with the pattern by baking in an oven having a temperature within the range of approximately 300° F. to 1500° F. The baking time is relatively short, usually from a few seconds to five minutes. This baking operation results in the conversion of the resinous material to a hard insoluble binder which securely bonds the sand grains together. The formed molds are, in effect, thin shells which have sufficient strength and stiffness to make them suitable for many casting operations.

Upon removal of the pattern and mold from the curing oven, the mold is stripped from the pattern. As

hereinbefore explained, in the past partial breaking or tearing of the mold edges has been often experienced in this stripping operation because of the unavailability of shell molding materials or mixture having surfaces possessing satisfactory parting or mold-releasing properties.

In accordance with my invention, however, I have found that a shell molding mixture which contains a mold release agent evenly distributed throughout the mix is of great utility in preventing the adhesion of the resultant molds to pattern surfaces. This mold release agent or lubricant is preferably added to the sand-resin mixture in the form of a fine solid or powder with no liquid vehicle being necessary. High melting point natural waxes, such as carnauba wax, provide optimum results with a minimum of expense. Such a finely powdered wax may be distributed in the mixture by means of a mixer used for blending the sand and resin materials. Any conventional commercial mixer or muller may be used for this purpose. Upon placing the resultant mix into contact with the hot metallic pattern during the mold forming operation, the lubricating constituent melts and flows to the pattern surface, thus preventing the resin from adhering to the pattern.

When carnauba wax is to be used as the internal mold release agent in accordance with the preferred embodiment of my invention, it is first changed from the flake form in which it is normally received to a finely powdered form. In order to provide most thorough distribution of this wax powder in the molding mix, it is desirable that this powder be finer than 200 mesh. A wax powder having such a fineness may be obtained by melting the wax and spraying it under air pressure into a large closed drum. On coming into contact with the cool air the mist of molten wax solidifies, and very fine solid wax particles are deposited on the bottom of the drum. This wax dust or powder may then be collected and added to the sand and resin mixture. One thousand cc. of the powder formed by spraying by this method weighs approximately 470 grams, and hence it is necessary to mix only a small amount of wax with a relatively large quantity of the sand and binder.

The amount of wax which should be employed may be as small as approximately 0.02% of the total weight of the molding mixture for some applications, but generally it is desirable that at least 0.05% by weight of wax be present in order to completely eliminate adhesion of the mixture to the pattern. Only a small amount of wax is necessary because heating of the molding mix melts the wax and normally causes the mold to have its greatest concentration of wax adjacent its molding surface. The wax content of the molding mix will vary with the type of pattern being used, of course, as well as with the type of sand employed and quantity of resin in the mixture. Normally the maximum amount of wax which should be used is approximately 1% since a wax content in excess of 1% weakens the resultant mold shell to too great an extent. This weakening effect is due to the fact that the wax will soften and melt at approximately 190° F., while the resin binders will normally retain their rigidity at about 450° F. or higher. Although the resin binders begin to decompose at this latter temperature, the softening of the wax at substantially lower temperatures, if it is present in excessive amounts, will lower the overall strength of the mold. Moreover, it becomes uneconomical to use amounts of wax greater than 1%, and in most instances amounts appreciably less than this provide optimum results. In view of the above considerations, therefore, it is normally preferable to use a sand-resin molding mix containing 0.1% to 0.3% wax, although generally a wax content between approximately 0.1% and 0.5% is completely satisfactory.

For some applications the wax may be sprayed into the sand-resin mixture in a liquid form, the mixture then being thoroughly mulled before application to the hot pattern. However, the lubricating effects of a wax when

used in liquid form, either as molten wax or as an emulsion, are inferior to those provided by the use of a powdered wax. Moreover, a higher wax content generally is necessary if the wax is used in the liquid form, although the wax content would still be within the aforementioned range. If the wax is to be sprayed into the mixture, a carrier is usually neither necessary nor desirable, hot unrefined wax alone being preferably used. Any spray temperature above the melting point of the wax is satisfactory, but it is desirable to use a temperature above approximately 200° F.

Under particular circumstances where the wax can be effectively introduced into the molding mixture as a hot liquid, it may be first mixed with an emulsifier or wetting agent, if it is desired to add the latter to the sand-resin mixture. Such carriers should be thoroughly mixed with the wax and the mixture sprayed into the sand molding mix at a temperature of at least approximately 200° F., as indicated above. However, this spraying procedure is disadvantageous if the wetting agent used is a thermosetting material since it will tend to partially set up in the hot lubricating mixture. Moreover, spraying is less satisfactory and less economical than using the wax in powdered form in that some of the wax is inevitably lost to the atmosphere and deposited on surrounding parts.

As hereinbefore noted, when mixing the wax powder with the other constituents of the shell molding mix any conventional mulling equipment may be used. It is desirable to first intimately mix the sand and wetting agent, if the latter is to be used, the resin subsequently being added and thoroughly mixed with the sand and wetting agent. Optimum results have been provided if the wax is added last, after the other constituents have been mixed, and the mixing action continued for 10 or 15 minutes to thoroughly mix the wax with the remainder of the batch.

In the above-described molding mixture the basic and preferred constituent which effects the release of the shell mold from the pattern is carnauba wax, a hard natural wax having a high melting point. Such a wax is not easily vaporized upon contact with metallic patterns which are kept at proper temperatures, thus permitting the formation of a substantially unbroken film of wax on the hot pattern surface. Highly satisfactory results have also been obtained wherein less expensive candleilla wax, another hard natural wax, and/or paraffin is substituted for a portion of carnauba wax in the aforementioned parting mixtures. Where these various waxes are used together, it is preferable to maintain the percentage of the carnauba wax in the total wax content to at least 25% by weight; and for optimum results the release agent in the mold should contain at least 50% by weight of carnauba wax.

Sand-resin molds may be easily and completely removed from the most intricate pattern equipment when the above-described molding mixture is employed. Furthermore, inasmuch as the use of a molding mix containing an internal lubricant in accordance with my invention causes a negligible amount of residue build-up on the pattern equipment, there results no deviation from desired dimensions in the cured mold as would otherwise be the case. Since excessive residue build-up also increases the sticking tendency of the mold on the pattern, the subject shell mold composition is particularly advantageous. After use of a pattern for a considerable period of time, if the residue build-up should ever become greater than would normally be desirable for precision casting operations, the residue resulting from the formation of these shell molds is of such a nature as to be easily, quickly and completely burned off by merely heating the pattern to a temperature above that initially used in forming the molds.

Before commencing the first mold-forming cycle after burning any such residue off the pattern, it is beneficial

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to condition the pattern by applying an external mold release agent to its molding surfaces. It is preferable to rub on the parting agent, such as an aqueous carnauba wax emulsion, rather than merely to spray it onto the pattern. This conditioning treatment, which serves to close the pores in the pattern surface, may also be advantageously employed when a new pattern is first placed in use.

Upon pouring the molten metal into a shell which is formed in the above-described manner, the hot metal, on coming into contact with the mold, burns the plastic binder to essentially carbon. The gases which are generated readily escape through the highly permeable sand-resin shell. As a result of this plastic breakdown, the shake-out is easily accomplished.

Among the numerous advantages of this process is the fact that the molds and cores so produced offer very little resistance to the expansion and contraction of the molten metal subsequent to pouring, thus minimizing the danger of the formation of cracks or hot tears. This process and the molds formed in accordance therewith can be used to provide castings of extremely thin section because of the unusual smoothness and high gas permeability of the molding material. Such molds permit the production of sound castings in a variety of metals and alloys over a wide range of casting temperatures. Moreover, the molds and cores can be produced and processed without objectionable dust formation; and the cured cores and molds have no affinity for water, are completely stable under atmospheric conditions and may be stored indefinitely.

The use of a shell molding mixture in accordance with my invention further increases the value of this process for precision casting operations by providing molds which faithfully produce pattern details, maintain good dimensional tolerance and possess excellent surface qualities. Accordingly, the resulting castings have unusually smooth and clean surfaces, true dimensions and a minimum of fin at the parting line. The surfaces of these castings are free of residual mold material, thereby eliminating the necessity of shot blasting.

It is to be understood that, while my invention has been described by means of certain specific examples, the scope of my invention is not to be limited thereby except as defined in the following claims.

I claim:

1. In a molding composition for forming shell molds consisting essentially of a major proportion of sand and a minor proportion of thermosetting binder, the improvement which consists of including therewith approximately 0.02% to 1% by weight of carnauba wax as a mold release agent.

2. In a molding mix for application to a heated metallic pattern to form shell molds, said molding mix consisting essentially of a major proportion of sand and a minor proportion of thermosetting binder, the improvement which consists in including therewith powdered carnauba wax in a quantity sufficient to constitute between approximately 0.05% and 1% of the total weight of the molding mix.

3. A dry molding mixture to be placed in contact with a heated pattern to form a thin-walled sand-resin mold, said molding mixture comprising, by weight, approximately 3% to 15% thermosetting resin binder, 0.1% to 0.5% finely powdered carnauba wax, and the balance substantially all sand.

4. A molding mixture to be placed in contact with a

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heated pattern to form shell molds, said molding mixture consisting essentially of a major proportion of sand, a minor proportion of thermosetting resin binder, and 0.05% to 1% by weight of a mixture of carnauba wax and at least one member selected from the group consisting of candelilla wax and paraffin, the amount of carnauba wax constituting at least 25% by weight of the total wax content in the molding mixture.

5. A shell mold which is readily released from a hot pattern on which it is formed, said mold consisting essentially of a major proportion of sand, a minor proportion of thermosetting binder, and at least 0.02% by weight of at least one wax selected from the group consisting of carnauba wax, candelilla wax and paraffin, said mold having its greatest concentration of wax adjacent its molding surface.

6. In the process of forming a shell mold by mixing a major proportion of sand with a minor proportion of a thermosetting binder and thereafter placing said mixture in contact with a heated pattern for a period of time sufficient to bond a substantial portion of the sand particles together, the improvement which consists in adding carnauba wax as a mold release agent to the molding mixture prior to contact of the mixture with the pattern, said carnauba wax being added in an amount constituting between approximately 0.05% and 1% of the total weight of the mixture.

7. The process of forming a thin-walled sand-resin mold by the shell molding process which comprises thoroughly mixing 3% to 15% by weight of thermosetting resin binder, 0.05% to 1% by weight of a finely powdered mold release agent having a carnauba wax content of at least 25% by weight, and the balance substantially all sand, placing the molding material so formed into contact with a heated metallic pattern for an interval at least sufficient to bind together a substantial proportion of the sand particles and to melt the powdered wax adjacent the heated pattern, removing any excess molding material, subsequently curing the resultant mold layer by baking while in contact with the pattern, and thereafter stripping the formed mold shell from said pattern.

8. A dry molding mixture for application to a heated metallic pattern to form shell molds, said molding mixture consisting essentially of 3% to 15% by weight of a thermosetting resin binder, a small but effective amount of a set-accelerator for the binder, 0.05% to 1% by weight of a finely powdered mold release agent having a carnauba wax content of at least 25% by weight, and the balance substantially all sand.

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