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COATING FOUNDRY MOLD SURFACES

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The present invention relates to foundry molds and cores which are employed in the casting of metal, and more particularly to the use of a new type of material for coating such molds and cores.

Metal castings prepared by pouring molten metal into sand molds are in large measure dependent for their properties and quality on the character of the mold and core surfaces against which the molten metal flows and sets. The smoothness of the sand surfaces, the ability of the sand and sand surfaces to conduct heat and gases and their reaction to the heat of the metal are factors which have an important bearing on the quality of the castings.

Foundry sand practice properly embraces the treatment of molds and cores with coatings to improve the quality of castings made in such molds. The general methods of special treatment of mold and core surfaces include (1) preparation of a special facing sand, (2) coating the sand surfaces with a prepared suspension of refractory material, (3) dusting on finely divided refractory powders, and (4) spraying the surfaces with adhesive liquids, which are usually solutions of adhesive materials.

The preparation of a special facing sand involves the mixing of a fine clean sand with water and binders which provide the necessary strength and working properties or moldability to the sand. This sand is mixed separately from the main bulk of the sand, and often in mixing equipment set aside for the purpose. This sand is applied to the pattern or core box first, against which it forms a thin layer, which becomes the face of the mold or core and against which the molten metal directly contacts, if no coating is subsequently applied to the facing. Facing sand is carefully prepared and closely controlled to provide the best possible mold and core surfaces.

Instead of a specially prepared facing sand, the mold or core surface may be one of a refractory material applied as a coating to an ordinary sand surface, or this coating may be applied to a special facing sand, thus combining the advantages of both methods of providing a satisfactory sand surface. These coatings in the foundry art are suspensions of fine silica, mica, graphite, zircon, clays or other refractory material, applied in liquid form by brushing, spraying or dipping the molds and cores. Upon drying they provide a smooth and heat resistant coating which largely prevents the burning of sand onto metal.

On occasion, the dispersing of the refractory material into liquid form is dispensed with and dry powdered refractory material is dusted onto the damp sand surfaces. Thus silica flour or graphite might be dusted onto parts of molds or cores which require some protection because of severe action of the flowing metal, as for instance near the gate or point of entry of the molten metal to the mold, or around bends in the design which are subjected to severe erosion as the mold fills. Though less commonly employed, this is one method of improving core and mold surfaces.

Another method directed at the same objective involves coating, usually by spraying, of the sand surfaces with adhesive liquids. These are usually solutions of materials which are adhesive in nature, or become so on drying. The application of a spray imparts extra strength and a "crust" or "skin" to the sand on drying. Usually water soluble materials are employed, such as molasses, sulfite waste liquor, dextrine, sodium silicate solution, etc., but sometimes oils are applied or sprayed on. These same solutions at times serve as the medium for suspending finely divided refractory material to prepare coatings of the second class described above.

The demands of the production schedule or of the casting design will dictate which of the methods described is to be used in any one foundry for any certain job, but they all have the common purpose of improving the quality of the casting.

The facing sand, coating or spray must meet certain demands of performance to be acceptable by the foundry industry. The most important requirement is that of providing a sand surface which is stronger or smoother, or both stronger and smoother, than the main body of the sand. The practice of specially treating the sand surface by coating or spraying makes possible the formation of cores having shell structure, that is a structure of relatively hard and firm exterior with relatively soft interior. Cores of such structure can be made sufficiently strong and hard for handling and to withstand pressure of the molten metal, and yet because they are only superficially of a high degree of strength and hardness they yield to shrinkage of the casting and are readily removed from the cooled casting. This feature of core shell structure attainable by application of the present invention to the art of making cores is one of the primary objectives here sought.

There are other more obvious requirements of a good facing material or coating. If the ma-

terial is in the liquid form it should preferably be of high stability, not changing in storage or handling, as by separating or fermenting. In many types of foundry sand work the production schedule will not permit of the application of any material not conveniently applied. A coating or spray must therefore be of such a nature that it can be applied rapidly and uniformly to either wet or dry sand surfaces without damaging, tearing or rolling up the sand. The material must preferably penetrate quickly into the sand to prevent running and to insure uniformity of strength, hardness and thickness over the entire surface of the mold or core. Strength is developed by drying or hardening, and this drying or hardening must take place within a reasonable period of time.

A further requirement of a good facing or coating material is that, when dry, it should withstand moisture of the air; that is, should resist the harmful effect of moisture of the atmosphere of either the foundry or the closed mold. Oils are preferred for dry sand work because the oil coatings withstand damp air. The compositions utilized in the present invention also withstand the effects of moisture and provide moisture-resistant molds and cores.

This invention is based upon the discovery that thermosetting phenol-formaldehyde resin condensed to stages where the resin is still soluble in water proves to be a mold and core coating material possessing the necessary qualities discussed above and in addition exhibits advantages over materials heretofore used for the purpose.

The dry mold or core surface bonded or coated with a water solution of thermosetting phenol-formaldehyde resin differs from cores and molds bonded or coated with straight core oil in being highly collapsible by heat and therefore yielding readily to the pressure exerted by the cooling and shrinking casting. This feature of high collapsibility contributes to casting quality in reducing the amount of burned-on sand and the cracks which might form in the section of the casting as it shrinks. High collapsibility also means easy removal of burned sand from the casting. The feature of high collapsibility of core or mold is especially advantageous in the pouring of lead, aluminum or magnesium alloy castings where the metal heat is relatively low; but is also of advantage in the pouring of other metals where shrinkage percentages are high, as with certain steels, and where the design of the casting is such that shrinkage cracks are likely to occur because of unequal shrinkage in different parts of the casting.

When sprayed onto the sand surfaces of cores and molds, a liquid composition made according to this invention penetrates rapidly but not deeply. Comparative measurements have been made of the depth of penetration of a spray according to the present invention and of core oils conventionally used. In one test the two types of spray were applied by spray gun to green sand core test bars in amounts so that equal increase in weight of the sprayed core on the solids basis resulted. Upon visual examination the depth of penetration was found to have been as follows:

	mm.
Phenol-formaldehyde resin solution in water--	2
Core oil A-----	8
Core oil B-----	8

Shallow penetration results in concentration of the spray material at or near the surface of

the core or mold, thus providing a two-fold advantage, viz. (1) increased strength and hardness at the surface and (2) shell structure to the core or mold. The increased strength and hardness at the surface of the sand is added protection against breakage in handling, and secondly, increased surface hardness promotes chilling of the hot metal. Shell structure in cores in varying degree depending upon design of casting is desirable, for a soft-centered core is more readily collapsible and more friable, thus more readily removed from the casting, than a solid core.

Another characteristic of a spray according to the present invention, and which present core oils do not possess, is its ability to dry in the air at room temperature. Green cores, when sprayed according to the present invention, acquire a "skin" within a few minutes by virtue of the rapid drying of the spray coating. This "skin" possesses strength and serves as protection against dropping or distortion while the sand is in the green stage. Such a core or mold stands up better under the jarring and vibration incident to conveying to the core oven and therefore provides cores of the more intricate designs with dimensions within minimum tolerances.

A further characteristic of a spray according to the present invention, and which core oils do not possess, is its strength in hot cores. The synthetic resin is not a thermoplastic material and therefore is not soft at the temperatures usually prevailing in the core oven. On the contrary, the sprayed cores are substantially as hard when as hot as core oven temperatures of about 400° F., as at room temperature. Therefore the hardness of surface of the core is maintained all through the oven cycle and during handling of the hot cores.

The phenol-formaldehyde resin best suitable for this purpose is one condensed to a stage where the product is still soluble in water, for the advantages in the use of this type of coating described above accrue mainly by virtue of the fact that the composition is aqueous, and the desirable effects which water has on foundry core and molding sands are provided. Furthermore, with water as the vehicle the cost of the coating is reduced as compared to solutions in which organic solvents serve as vehicle.

The degree of condensation of the resin need not be narrowly defined for the resin to be useful for the purpose of this invention, so long as the reaction product of the ingredients is carried in solution in water. In fact the ingredients may be present in the initial stages of condensation, that is, in the so-called "phenol alcohol" stage. It is possible to obtain satisfactorily hard and strong cores from a resin in the lowest stage of condensation because the procedure of baking or drying at elevated temperatures is a part of the core making process and is accomplished under conditions which readily convert the resin from its initial stage of condensation to the fully cured insoluble and infusible stage.

The proportion of ingredients in making the resin may vary within the range of one mol of phenol to from one to three mols of formaldehyde. When the lower proportions of formaldehyde are used, the product will be free from the objectionable sharp odor of this chemical and will, furthermore, be more stable on dilution with water, allowing a weak solution to be used. In fact if the resin is made on the formula of one mol of phenol to one mol of formaldehyde and the reaction carried on at 90° C. for 30 minutes

or until the solids content of the solution has increased to about 50% dry basis, the product will be completely miscible in water in all proportions, when freshly made. In storage at normal room temperature these water solutions of phenol-formaldehyde resin gradually thicken and lose stability against dilution with water. Nevertheless the resin solution prepared as described above will be dilutable with several times its volume of water for as long as three months after preparation.

We may, in fact, apply as a coating a mere mixture of phenol and formaldehyde relying upon the heat applied to the core to condense the ingredients to the resinous stage. However, the precondensed resin is to be preferred over a mixture of the ingredients. We refer to phenol as one of the primary ingredients of this resin and do so without intention of restricting the preparation of it to phenol (C_6H_5OH) only. Pure or commercial grades of cresol or of xylenol may be substituted for the phenol, as is well known in the art of making "phenolic" resins. Phenol yields a resin solution more soluble in water than are the resins made from commercial cresol or xylenol. I may however, substitute either of these in part or in whole for the phenol as a means of reducing cost of the product.

Condensation of the ingredients to form the resin may be carried out under either mildly alkaline or mildly acid conditions. Condensation under mildly alkaline conditions is to be preferred, however, as the degree of condensation is more readily controlled and the product more stable than when carried out under acid conditions.

As an example of a resin solution suitable for the purpose of this invention, react 10 pounds of pure phenol with 10 pounds of 37% formaldehyde (commercial formalin) by heating the mixture at 90° C. under atmospheric pressure in the presence of 2 ounces of caustic soda flakes and for a period of 30 minutes. The resulting solution will contain approximately 50% of resin solids.

As an illustration of the practical use of the resin solution prepared as described above, small oil-bound sand cores weighing 200 grams in the green condition were sprayed on all surfaces except the plate side with the resin solution, after this had been diluted with water to a 25% resin solids content. The spraying was done from a foundrymen's mouth sprayer into which air was led through the mouthpiece from a compressed air line, and was continued until the cores had gained in weight by 5 grams. During a period of one hour in the open air these cores acquired a "skin," that is because superficially firm, whereas a core which was not so sprayed did not harden in the air. The sprayed cores were dried in an oven at 450° F. for a period of two hours. Upon removal from the oven and cooling, these cores were observed to have "shell structure," that is they were extremely hard and possessed sharp edges, but about 2 mm. back of the surface the sand was soft and friable. The extreme contrast between core surface and core interior as to hardness observed in these cores could not have resulted from the drying of uncoated cores of any sand formula in practical use.

For purposes of describing the coating material used in the present invention, we have discussed its use as a spray. The manner of its application is not limited, however, to spraying. Occasionally the core or mold or part thereof may

best be treated by brushing or swabbing on the liquid, and where particularly heavy coatings are desired this may be done with the concentrated fluid, without dilution. Although the full advantages of its properties are evident when cores are treated before baking or drying, the application may be made to cores after baking, either while they are still hot or after they have cooled. In the latter procedure a short secondary drying of the coated core will be necessary.

The application of the resin solutions used in the present invention, and described above, is sufficient protection for cores and molds for many types of castings. However, where extra resistance to heat of the metal is required, the solution is made to serve as a binder for the finely divided refractory materials commonly used in foundries, such as silica, mica, graphite, zircon, clays, etc., which are mixed into the solution by simple stirring and the mixture then reduced with water to the required consistency. Such refractory materials are available in a wide variety of types and grades, and when used in admixture with a phenol-formaldehyde resin solution the latter becomes the vehicle and the binder for the refractory material. These refractory materials are relatively inert chemically and do not destroy the technological properties of the resin solution as to collapsibility, penetration, drying and strength described above.

The advantages to be gained by applying resin solutions to cores as herein described are not wholly lost if the solution be diluted with water solutions of certain materials instead of with water only. For instance, mixtures of resin solution and molasses or of resin solutions and water solutions of sulfite waste liquor (commercial lignin) can be employed which will be less expensive than if the resin solution is applied straight. Other water soluble materials might be employed as extenders or fillers, such as sugars, dextrines and water-soluble gums. Casein solutions may be admixed with the resin solution in small amounts, in proportions which will not thicken the liquid beyond spraying consistency.

As an aid in absorption of the liquid by the sand we have added wetting agents to the resin solution and cite as an example the agent known as Tergitol. A phenol resin solution containing 1.5%, for example, of Tergitol has been observed to soak into the sand more quickly than in the absence of the wetting agent and the depth of penetration is somewhat increased. The primary purpose of the wetting agent, however, is to cause rapid soaking in of liquid and the increased depth of penetration is moderate and not more than one mm. in the example given above.

For the sake of brevity, the expression "mold surface" in the appended claims is used to designate a part or the parts of a foundry sand mold and the cores inserted or to be inserted therein, if any, with which the molten metal comes in direct contact during the pouring or casting operations; the said expression "mold surface" is therefore used in the appended claims as applying to cores as well as to the sand mold itself.

In our copending case Serial No. 405,718 filed August 6, 1941, of which the present application is in part a continuation, we claim the coating of mold surfaces with emulsions, e. g., of an oil (or oily material) and a water soluble resin. In the present case we do not claim emulsions but aqueous solutions. These are applied, as in the parent case, to surfaces of the sand or sand mixtures, and are not mixed with the bulk of

sand, from which the molds and/or cores are subsequently made. These aqueous solutions are not deeply absorbed by the sand of the molds or cores, but remain on and in the surfaces, leaving the sand remote from such surfaces substantially unimpregnated and hence substantially free of resin.

We claim:

1. A foundry sand mold, a part at least of the surface of which is coated with a coating composition containing an aqueous solution of a condensation product of a phenolic body with formaldehyde.

2. A foundry sand mold, at least a part of the surface of which is coated with an aqueous solution of phenol-formaldehyde resin condensate.

3. A foundry sand mold, at least a part of the surface of which is coated with an aqueous solution of cresol-formaldehyde resin condensate.

4. A foundry sand mold, at least a part of the surface of which is coated with an aqueous solution of xlenol-formaldehyde resin condensate.

5. A foundry sand mold, at least a part of the surface of which comprises a completely resinified body selected from the group consisting of phenol-formaldehyde, cresol-formaldehyde and xlenol-formaldehyde reaction products, said mold surface being characterized by a substan-

tially higher degree of hardness than possessed by the underlying layers of sand, by a high resistance to moisture and by a high rate of collapsibility when exposed to the temperatures of molten metal.

6. In the art of producing castings of metals with sand molds, the process which comprises coating at least a part of the mold surface of a sand mold with an aqueous solution of a resinous reaction product of a phenolic body with formaldehyde.

7. In the art of producing castings of metals with sand molds, the process which comprises coating at least a part of the mold surface of a sand mold with an aqueous solution of phenol-formaldehyde resin condensate.

8. In the art of producing castings of metals with a sand mold, the process which comprises coating at least a part of the mold surface of sand molds with an aqueous solution of cresol-formaldehyde resin condensate.

9. In the art of producing castings of metals with a sand mold, the process which comprises coating at least a part of the mold surface of sand molds with an aqueous solution of xlenol-formaldehyde.

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