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METHOD OF IMPROVING FOUNDRY MOLDS
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This invention relates to the improvement of molding sands and core sands used in the manufacture of castings, and more particularly to the use of certain ingredients in these sands and the improvement of metal castings produced in molds made with these sands. During the solidification of a casting in a mold, heat is lost from the molten metal in the mold cavity by transfer to the mold material from which it is gradually dissipated. The rate of extraction of heat from the mold cavity will greatly determine the exact density, structure and physical characteristics of the solidified metal casting.

As foundry sand is a relatively poor conductor, the rate of cooling of molten metal in a sand mold is relatively slow, and this slow cooling quite often leads to an excessively coarse grained structure in the casting. In cast iron, for example, slow cooling in the mold results in a coarser graphite flake.

Moreover, certain areas in castings (particularly cored cavities where the core is surrounded by metal on all sides) cool excessively slowly, because the core becomes greatly overheated and is incapable of conducting away this heat. In a casting such an area is likely to be completely different from other areas in the casting where the cooling has been more normal.

Many notable advances have been made in controlling the rate of cooling in a sand mold in order to produce specific results in a casting. The most common of these is to use a metal chill in certain areas of the mold, thereby avoiding direct contact between the molten metal and the mold itself. This chill, being metallic, will conduct heat away rapidly, thereby producing more rapid solidification in that area. By controlling the rate of heat extraction in relation to the effect desired and the composition of the metal, it is possible to produce many unusual effects by this more rapid cooling in given areas of a casting. For example, in cast iron thousands of tons of chilled castings are made every day. In these chill castings the rate of heat extraction is either severe enough to produce a white iron in any particular area of the casting, or else it is sufficient to greatly densify the iron in this area of the casting. In either case, the more rapid heat extraction produces a casting of unusual quality.

Attempts have also been made to produce special effects in certain casting areas by the use of washes on the mold or core in these areas. For example, in cast iron, tellurium has been proposed and used as a mold wash. Tellurium dissolving in the molten metal in the vicinity of the area containing the special wash causes it to be whitened and densified by the fact that less graphite is formed in this area. This is a chemical effect produced by the solution of tellurium in the molten metal.

The use of chills and the use of special washes all have serious practical drawbacks. In the case of metallic chills, these are costly to prepare and are subject to severe erosion and deterioration by the molten metal. This means they only can be used a limited number of times. In the case of special washes these tend to dissolve prematurely in the molten metal and migrate to areas where their effect is not desired.

Various other methods used for the removal of heat from molds consist of embedded pipes, allowing air or coolant liquid circulation; projecting metallic chillers which dissolve in the molten metal, thereby lowering the temperature in that area; and even metallic sprayed coat-

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ings on the mold or core, which both dissolve in the metal and also extract some heat by conduction.

All of these methods quoted have various limitations, but the number of methods highlights the very serious problem that exists in the manufacture of castings, and that is, the controlled removal or dissipation of heat from the mold.

An object of this invention therefore is to provide a molding mix which will rapidly remove heat from molten metal, thereby increasing the rate of solidification of the metal and giving an improved metallurgical structure.

Another object of this invention is to provide a molding mix which will give a greatly improved surface finish and dimensional accuracy to the casting produced therein.

A further object of this invention is to provide an improved molding mix which will hold its shape and be capable of easy handling during the normal casting procedures. Other objectives and advantages of the present invention will be apparent to those skilled in the art from the following description:

The present invention is based on the discovery that certain additives to molding sands will extract heat by an endothermic chemical reaction which takes place within the sand itself. Reactions which produce heat in a molding sand, namely, exothermic reactions, are quite well known and consist of using additives such as aluminum powder and metallic oxides or sodium nitrate and carbon. Up to the time of this invention, however, no method has been successfully proposed for producing a chemical reaction in the sand which will extract heat units.

It is well known that chemical reactions involving the formation of gaseous materials such as the dissociation of water to produce steam, will result in the absorption of heat units. Most of these reactions leading to gaseous products are strongly endothermic in nature; however, their controlled use in molding sands is not very practical, because gases can produce defects such as blows, and they can also lead to gas holes in the molten metal itself. It is well known, for example, that a high moisture content in the sand will produce more chilling or more rapid cooling of a casting than a low moisture content in the sand will.

Apart from the harmful effects of steam, it is not practical to make certain areas of a mold with a higher moisture content than others in an effort to produce faster solidification in these high moisture areas. Furthermore, the effect of moisture is rather rapid and is soon lost as this moisture is converted into steam. Also, where the steam is not removed from its point of formation it often provides an insulating effect. In the practice of this invention I utilize the endothermic effect of certain chemical reactions. There are many such reactions, but in addition to removing heat from the molten metal, these reactions must not produce harmful effects. As a particular example, I prefer to use zinc oxide in combination with silica. This zinc oxide will combine with silica to produce zinc silicate. This chemical reaction is endothermic and will remove heat. Various other oxides such as tin and cadmium oxide also seem to work, but for reasons of economy and availability I prefer to use zinc oxide.

The process of this invention is best illustrated by a series of examples.

In the first example two molds were made—one was made with a sand consisting of silica sand plus 4% of sodium silicate as a binder, and the second mold was made with the same silica sand plus 4% sodium silicate as a binder plus 10% of zinc oxide. These molds were rammed and were gassed with carbon dioxide gas for hardening purposes. The zinc oxide produces improved reaction between the carbon dioxide gas and the sodium

silicate binder and also aids the subsequent shakeout of cores and molds from the casting.

The molds consisted of wedge test pieces having approximately a 28° angle between the sides of the wedge and a 1" back connecting the sides of the wedge at one end thereof. These wedge test pieces are commonly used in the iron foundry practice to measure chill. Molten gray cast iron was poured into the two test molds. These two molds were poured—one immediately after the other, so that the pouring temperature was essentially the same. The wedge pieces, when cold, were fractured and examined. In the case of the wedge test piece poured in the mold made from silica sand and sodium silicate only, the chill value was $\frac{1}{2}$ nds in the zone of demarcation between the gray fracture and the white fracture. This means that the distance between the two sides of the wedge was $\frac{1}{2}$ " at the zone of demarcation between the gray and the white. In the case of the wedge poured in the mold which contained zinc oxide as an extra additive, the chill value was $\frac{7}{8}$ nds at said line of demarcation, and in addition to this the corners at the back of the wedge were also white and chilled. This test illustrates very clearly that zinc oxide, when used as an additive in this mold, produces a cooling or chilling effect. This is not a chemical effect in the metal, because no trace of zinc itself could be found in the casting, and no effect was observed in the test castings other than that which would be caused by more rapid solidification.

I have found that this endothermic action of zinc oxide can be intensified by using molding materials having a higher conductivity than ordinary molding sand. I refer particularly to materials such as zirconite and silicon carbide. To a lesser degree materials such as forsterite, olivine, magnesite and dolomite may also be used. The zinc oxide reaction may also be accentuated by incorporating silica flour or powdered silica in the mixture. The amount used is usually from 2 to 12%.

As an example of the use of such molding materials, a series of wedge test pieces were cast from the same base metal. The molds were made with several mixtures, tabulated in Table 1.

Table 1

Mix No.:	Percent
(A) Silica sand.....	96
Sodium silicate.....	4
(B) Silica sand.....	86
Zinc oxide.....	10
Sodium silicate.....	4
(C) Silica sand.....	83
Zinc oxide.....	10
Silica flour.....	3
Sodium silicate.....	4
(D) Zirconite sand.....	86
Zinc oxide.....	10
Sodium silicate.....	4
(E) Zirconite sand.....	84
Zinc oxide.....	10
Silica flour.....	2
Sodium silicate.....	4
(F) 100-mesh silicon carbide.....	86
Zinc oxide.....	10
Sodium silicate.....	4
(G) Silica sand.....	85
Zinc oxide.....	10
Western bentonite.....	5
(H) Silica sand.....	85
Tin oxide.....	10
Western bentonite.....	5
(I) Silica sand.....	85
Cadmium oxide.....	10
Western bentonite.....	5

The test wedges were fractured after casting and the degree of chill was measured in 32nds across the line of

demarcation between the gray fracture and the white fracture. The results obtained are tabulated in Table 2.

Table 2

Mix No.:	Chill value obtained
A.....	$\frac{3}{32}$
B.....	$\frac{6}{32}$
C.....	$\frac{8}{32}$
D.....	$\frac{10}{32}$
E.....	$\frac{11}{32}$
F.....	$\frac{14}{32}$
G.....	$\frac{5}{32}$
H.....	$\frac{9}{32}$
I.....	$\frac{5}{32}$

These results indicate very clearly the chilling effect due to increased solidification rate caused by the molding materials of this invention. It was also observed during the casting of these test pieces that those cast in the cores made from the endothermic materials solidified in a much shorter time than that which was cast in the conventional core represented by Mixture A.

I have found that the amount of endothermic oxide such as zinc oxide used in the mix may be varied to decrease or increase the chilling effect. In general I prefer to use from 5 to 25% of oxide in the mix, and usually 10 to 15% will give the desired effect.

Many binders may be used for providing strength in these mixes. Thus core oils, sugar, resins, pitch compounds and the like may be used. I prefer to use sodium silicate, because it has unusually high hot strength, it supplies silica for the endothermic reaction, and it is non-carbonaceous. In general I have found that carbon tends to decrease the intensity of the endothermic effect, although it does not seem to prevent it from taking place.

The particular advantage of sodium silicate is that it may be hardened by the use of carbon dioxide, as is well known to those skilled in the art. Where preferred, it may also be hardened by baking in an oven in the conventional manner. The preferred mixture containing sodium silicate has a high degree of heat stability, preventing premature breakdown of the mold or core under the action of heat. This is particularly true where zirconite sand or silicon carbide is used as the molding material.

I have found that this chilling effect may be produced by the materials of this invention, whether the molds are used in the dry or baked condition or whether they are used in the green or unbaked condition. When moisture is present, as in the unbaked condition, it is important to provide permeability in the mix so that steam may escape. If it does not escape freely, it may produce a heat insulating effect.

I have also found that the molding materials of this mix, particularly those containing zirconite and silicon carbide, produce a casting surface of excellent finish and high degree of accuracy, when the mesh size of the mixture is kept at the value usual for molding mixtures. This accuracy and finish results from rapid setting of the casting surface and the very high stability of the mold materials under the action of heat.

By using the mixture of this invention I have been able to improve the quality of castings by eliminating such costly defects as porous areas, cracked castings and soft castings.

Although this 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 details may be resorted to without departing from the spirit and scope of the invention hereinafter claimed.

What is claimed is:

1. The method of accelerating the solidification rate of molten metal by casting said metal in a molding mixture forming at least a portion of a mold cavity, said

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molding mixture consisting of a high conductivity substance selected from the group consisting of silicon carbide and zirconite and containing a first additive of sodium silicate in the amount of from 2% to 12% and a second additive selected from the group consisting of zinc, cadmium, and tin oxide in the amount of from 5% to 25%, said additives improving the heat extraction ability of said molding mixture by an endothermic reaction.

2. A molding mixture for producing shapes for receiving molten metal, said molding mixture consisting of a high conductivity substance selected from the group consisting of silicon carbide and zirconite and containing a first additive of sodium silicate in the amount of from 2% to 12% and a second additive selected from the group consisting of zinc, cadmium, and tin oxide in the amount of from 5% to 25%, said additives being adapted to improve the heat extraction ability of said molding mixture by an endothermic reaction.

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3. A molding mixture for producing shapes for receiving molten metal, said molding mixture consisting of a high conductivity molding material containing a first additive of sodium silicate in the amount of from 2% to 12% and a second additive selected from the group consisting of zinc, cadmium and tin oxide in the amount of from 5% to 25%, said additives being adapted to improve the heat extraction ability of said molding mixture by an endothermic reaction.

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