United States Patent Office 3,453,229
Patented July 1, 1969

3,453,229

MATERIAL FOR MAKING SHELL MOLDS

Alfred B. Steck, Elm Grove, Wis., assignor to Sivyer Steel Casting Company, Milwaukee, Wis., a corporation of Wisconsin

No Drawing. Filed Feb. 28, 1967, Ser. No. 619,197
Int. Cl. B22c 1/04, 1/20
U.S. Cl. 260—38
5 Claims

ABSTRACT OF THE DISCLOSURE

A small amount of a mineral which produces an endothermic reaction when subjected to heat, is added to the resin coated silica sand of which shell molds are formed, to delay and offset the exothermic reaction which accompanies the thermal decomposition of the resin as the hot molten metal is poured into the mold.

This invention relates to shell molding and has as its purpose and object to overcome the one problem that steel founders consider the major objection—if not the only one—to the use of this molding technique.

Shell molds are formed of a mixture of refractory material, usually silica sand, and a thermosetting phenolic resin. Release agents such as calcium stearate may be and generally are added to the mixture to keep the formed mold or core from sticking to the hot pattern or core box used in its formation.

Identification of the resins used and an explanation of the manner in which they are mixed with the sand will be found in Patent No. 2,991,267, issued July 4, 1961. As described in that patent, the preferred method of mixing the resin with the sand results in a lacquer-like coating of resin on each particle of sand. Hence, when the heat from the hot pattern or core box used to form the mold or core fuses and sets the resin, the sand particles are securely bonded to one another.

As is well known to the art, shell molding is especially suitable for the production of castings which require dynamic balancing and which have intricate and fine surface details. Heretofore, however, when low carbon and low alloy steels and occasionally also martensitic and ferritic stainless steel, aluminum-bronze alloys and metals with high nickel content were cast in shell molds, the results left much to be desired. Pock-marking of the casting surface was a common defect. This defect, which in steel foundries is known as "orange peel" or "alligator skin," according to P. J. Neff, a recognized authority on shell molding, is the major deterent to use of this technique in the steel casting industry. He makes this statement in an article entitled Some Notes on Shell Molding, which was published in the September 1965 issue of Steel Foundry Facts. In that article he also remarks that "this defect has been studied intensively, but is still something of a mystery."

The article discusses the various theories that have been advanced to explain the cause of the surface defects that are encountered when low carbon steels and low alloy steels are cast in shell molds, and goes on to explain the many efforts that have been made to correct or overcome the problem. The addition of manganese dioxide (MnO_2) and calcium carbonate ($CaCO_3$) to the sand-resin mix is mentioned as having shown some promise, but as the article points out, the use of such chemical additives did not solve the problem.

It is known that better results can be obtained if olivine sand is used instead of silica sand, but for economic reasons the industry is practically constrained to the use of silica sand. Olivine sand not only costs considerably more

than silica sand, but its use demands a greater percentage of resin to achieve the needed bond strength.

Attempts have also been made to solve the problem by coating the mold cavity with certain solutions generally referred to as "washes." The 1963 Neff et al. Patent No. 3,113,360, and the 1964 Neff Patent No. 3,121,269, are examples of this latter approach to the problem.

However, as is evident from the aforesaid Neff publication, the problem was not solved by any of these various prior expedients, and the reason it was not solved lies in the fact that the cause of the difficulty was not understood. I believe that I have discovered the key to the problem, at least my experiments and the results obtained in actual production strongly indicate that the correct solution has been found.

Undoubtedly, the objectionable surface defects were caused by a reaction within the mold or core material set off by the heat of the molten metal as it filled the mold cavity. Since the mold cavity is not devoid of air and the walls of the mold are sufficiently porous to permit air to pass through them, the resin in the mold or core material is ignited by the hot metal coming in contact therewith; and since the resin is a material which produces an exothermic reaction upon ignition, the ignition of the resin results in an exceedingly high temperature at the mold-metal interface. The exact mechanism by which this high temperature brings about the defects in the casting surface is not too clear, but whatever the explanation might be, I have found that the defects will be prevented and that cracking of molds and cores will be greatly minimized if the ignition of the resin and the consequent exothermic reaction is delayed until after the surface of the molten metal has frozen. By this I mean that the peak in the exothermic reaction resulting from the combustion of the resin should ke kept from occurring until the casting surface is solid enough to resist whatever occurs at the metal-mold interface as a result of the thermal decomposition of the resin.

Although ignition of the resin begins to take place at some temperature above its curing point, which is normally 250° C., the attendant exothermic reaction flashes or peaks at some temperature substantially above that—probably in the range of 600° to 1000° C. Therefore, if the material of which the mold is made would contain an additive that produces an endothermic reaction in time to delay or offset the exothermic reaction of the resin, or in other words, precedes it, the objectionable consequences of the combustion of the resin would be overcome. I have found that there are several materials which exhibit the proper endothermic reaction for this purpose. These materials can be grouped according to the phenomena which produces the reaction, and—more specifically—they are all minerals in which the endothermic reaction is the result of emission of water of crystallization. Minerals which possess the needed attributes, and which, when added to the sand-resin admixture, will satisfactorily delay and offset the exothermic reaction resulting from thermal decomposition of the thermosetting resin are:

Mineral	Chemical composition	Temperature at which endothermic reaction peaks (° C.)
Kaolinite	$(OH)_8Si_4Al_4O_{10}$	500–650
Dickite	$Al_4(OH)_8Si_4O_{10}$	500–750
Talc	$Mg_3(OH)_2Si_4O_{10}$	880–1,050
Brucite	$Mg(OH)_2$	390–550
Boehmite	$AlO(OH)$	450–600
Diaspore	$AlO(OH)$	500–650

The best results have been obtained with hydrated kaolin clay, i.e. kaolinite, in the 1 to 5 micron size. This material has the economic advantage of low cost and of

being completely compatible with silica sand and the resin employed as a bonding agent. The endothermic reaction which occurs when this clay, in the 1 to 5 micron size, undergoes chemical change in the presence of heat, peaks at about 600° C. The amount of this additive, kaolin clay, that is used should be in the range of one-quarter of one percent to three percent of the amount of sand, on a weight basis.

Kaolin clay is obtained primarily from the State of Georgia, and is a very fine grained substance. It is completely compatible with silica sand and the bonding resin is easily incorporated in the sand-resin admixture. Preferably the kaolin additive is added to the silica sand, or other refractory base sand used, in the dry state, and then the admixture of sand and clay has the resin added thereto. The dry mixing of the clay and sand can be effected in any suitable wap, as long as thorough admixture is achieved. The addition of the resin may likewise be effected in the dry mixing manner, but preferably the resin is added to the sand-kaolin admixture in the form of either a liquid or a solution. In the former case the resin is suspended in water and in the latter it is dissolved in a suitable organic solvent, as for instance, a lower aliphatic alcohol.

The resins employed are customarily thermosetting phenolic resins.

A typical formula for the entire mix is as follows:

	Lbs.
Silica sand	100
Thermosetting resin	4
Hydrated kaolin clay	2

While the amount of hydrated kaolin clay used can be increased when the castings being made have exceptionally large sections, or decreased for smaller castings, the proportions given in the foregoing formula will cover most situations.

Any of the other minerals listed hereinbefore can be substituted for the hydrated clay, and in the same proportion.

Shell molds and cores made with the described sand-resin-clay mix are being used in actual commercial production, with results far more gratifying than expected. Not only are the casting surfaces free from "orange peel" or "alligator skin," but the instances of molds being cracked as a result of thermal shock has been greatly reduced.

This invention thus has fully met its object of eliminating the only remaining deterent to the use of the shell molding process in steel foundries; and it should be understood that while a specific embodiment of this invention has been described, the scope of the invention is not to be restricted to that particular way of practicing the invention, but on the contrary, all modifications thereof which come within the scope of the appended claims are encompassed.

It should also be understood that whenever the term "shell mold" is used herein, it includes cores formed of the sand, resin and endothermic additive.

What is claimed as my invention is:

1. In the art of shell molding low carbon, low alloy steel castings wherein the molds and cores if any are formed of silica sand bonded together by thermosetting resin, the improvement which comprises:

eliminating the surface defects characteristic of conventional shell molded low carbon, low alloy steel castings by incorporating in the silica sand-resin mix a mineral additive chosen from the group consisting of kaolinite, dicktite, talc, brucite, boehmite and diaspore, and in an amount sufficient to produce an endothermic reaction as a result of emission of water of crystallization when heated to a temperature above that at which the resin cures and in time to precede the exothermic reaction which occurs during combustion of the resin.

2. In the art of shell molding, the improvement set forth in claim 1,

wherein the mineral additive is hydrated kaolin clay.

3. In the art of shell molding, the improvement set forth in claim 2,

wherein the amount of kaolin clay incorporated in the silica sand-resin mix is between one-quarter of one percent and three percent of the amount of sand, by weight.

4. A material for producing shell molds and cores consisting essentially of silica sand and a thermosetting resin binder, and characterized by:

the incorporation therein of a mineral additive chosen from the group consisting of kaolinite, dicktite, talc, brucite, boehmite and diaspore,

the additive constituting between one-quarter of one percent and three percent of the amount of silica sand, on a weight basis.

5. The material of claim 4, wherein the mineral additive is hydrated kaolin clay.

References Cited

UNITED STATES PATENTS

3,002,948	10/1961	Lawther et al.
2,988,525	6/1961	Clem.
2,817,127	12/1957	Wickett.
2,763,626	9/1956	Salzberg.

ALLAN LIEBERMAN, *Primary Examiner.*

R. BARON, *Assistant Examiner.*

U.S. Cl. X.R.

106—288