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METHOD OF CASTING MAGNESIUM

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The present invention relates to a method of casting magnesium and alloys thereof. One object of my invention is to permit casting such metals in water-bound or "green" sand molds and the like, whereby the metal is protected from attack by air or by the moisture in the mold. Other objects and advantages will appear as the description proceeds.

For convenience the term "magnesium" is used herein and in the appended claims to mean not only magnesium but also alloys thereof in which the magnesium predominates.

The production of commercially acceptable castings of magnesium presents a problem which is unique in foundry practice due to the affinity for both oxygen and nitrogen which this metal possesses, especially at elevated temperatures. In the molten state, at temperatures employed in casting, the metal is capable of combining spontaneously with oxygen, which may be derived either from the air or from substances containing free or combined oxygen that are in contact with the metal, such as water or steam or other compounds in the molding material. The burning or oxidation of molten magnesium in an atmosphere of steam or in contact with water may be at times so violent as to approach explosiveness. Thus it is practically impossible to make a sound casting of magnesium in a simple water-bound mold of conventional type, such as is used for casting other metals.

Various methods have been proposed by which it is sought to overcome the tendency for water or other oxygen compounds in a mold to attack magnesium when cast therein. Heretofore, for example, it has been suggested to incorporate sulphur or boric acid in water-bound sand molds for casting magnesium to overcome the harmful effects of air or water vapor on the metal. However, these substances have proved to be not wholly satisfactory, inasmuch as when a sufficient amount of either sulphur or boric acid is added to the molding sand to prevent oxidation of a casting of relatively heavy section, the thin sections are liable to be pitted. On the other hand, if the amount of agent is reduced to a point where pitting of thin sections is reduced, heavier sections may be insufficiently protected from oxidation. Other types of protective agents, namely, ammonium fluoride and ammonium silicofluoride, have been proposed in United States Patent No. 1,825,242 to prevent the burning of magnesium when cast in water-bound molds, and at the same time to produce a corrosion-resistant film upon the surface of the casting. However, these substances are not wholly desirable, since, as the aforesaid patent disclosure shows, ammonium fluoride reacts with water in the molding sand and gives off ammonia, thus impoverishing the sand with respect to the agent and necessitating frequent readditions thereof to the sand. Furthermore, ammonium fluoride, and ammonium silicofluoride, as well, are stated to react with the sand, causing it to swell. It thus becomes necessary to replenish the sand with the protective agent or to provide with these agents other materials which will overcome the loss of ammonia and the swelling of the sand with the resulting distortion of the molds. Accordingly, the aforementioned patent proposes to reduce swelling and loss of ammonia by adding hydrofluoric acid or oxalic acid to the molding sand in addition to ammonium fluoride or silicofluoride. These materials, however, are undesirable inasmuch as hydrogen fluoride is especially corrosive, while oxalic acid is toxic.

Briefly stated, the problem encountered in satisfactorily casting magnesium in temporary water-bound molds involves overcoming the detrimental effect of one or more of the following factors:—(1) oxidation, which may be due to attack by air, water vapor, or other oxygen compounds, or even by the sand itself; (2) the formation of pits and blowholes due to gas evolution when the molten metal is poured into the mold; (3) the formation of superficial coatings or films of a non-metallic nature on the surface of the castings which give them an unattractive appearance.

I have discovered that certain new and improved agents, when mixed with water-tempered foundry sand or the like, are more stable and permanent therewith, especially under the effects of the heat of casting in molds made from such mixtures, than agents heretofore employed and do not possess their undesirable properties. My new agents do not cause swelling of foundry sand and, due to their stability, the sand mixtures containing them may be used repeatedly without replenishing the agent therein. Magnesium castings made by proper procedure in temporary molds treated with my new agents are free from pits, blowholes or similar defects, are substantially free from oxidized areas and are of commercially acceptable appearance. The principle of my invention consists in including in the mold material, at least for the parts adjacent to the metal cast therein, a sufficient quantity of one of my new agents to provide protection from oxidation or burning.

To the accomplishment of the foregoing and related ends, the invention, then, consists of the method hereinafter more fully described and particularly pointed out in the claims, the following description setting forth in detail several forms of molds and modes of carrying out the invention, such disclosed molds and modes illustrating, however, but several of the various ways in which the principle of the invention may be used.

My invention is based upon the discovery that the fluophosphoric acids and their volatile salts, such as the ammonium salts thereof, when mixed with moist foundry sand, not only overcome the tendency for oxidation or burning of magnesium when cast therein but also permit making castings of either relatively heavy or light section substantially without pitting, blowholes or similar flaws, and of commercially acceptable appearance. The agents which I have found to be suitable for the purpose are:—hexafluophosphoric acid, HPF_6; ammonium hexafluophosphate, NH_4PF_6; difluophosphoric acid, HPO_2F_2; ammonium difluophosphate, $NH_4PO_2F_2$; monofluophosphoric acid, H_2PO_3F; ammonium monofluophosphate, $(NH_4)_2PO_3F$. These new agents are apparently less volatile under casting conditions than those hereinbefore mentioned, so that their effectiveness is not lost after repeated use of the sand, while they do not have a detrimental effect on the molding quality of foundry sands. The treated sand may be used repeatedly to produce castings of good appearance and free from the usual defects without replenishing the agent.

The amount of such agents or mixtures thereof which may be employed varies with the size and type of castings to be made as well as with the nature of the molding material. In making large castings a greater proportion of the agent may be required than when relatively small castings are made. Normally the foundry molding material may be intimately mixed with from 0.5 to 10 per cent by weight of any one of the compounds aforementioned, although usually about 3 to 6 per cent is satisfactory. Mixtures of two or more of these substances may be employed, the sum of which preferably does not exceed about 10 per cent. For castings having relatively thin sections from 2 to 5 per cent of the agent may be sufficient, while for the average run of castings approximately 4 per cent of same may be used. It is understood, however, that the quantity of one or more of such agents employed in a given case is a matter of judgment, governed more or less by the size and character of the casting.

Naturally the effectiveness of any agent for use as hereinbefore described varies with the permeability of the molding material, it being somewhat greater with sand of high permeability than with those of relatively low permeability. The molding material should, therefore, be sufficiently open or permeable to permit the free escape out of the mold of gases which are formed by contact with the hot metal as it is poured. In general, I have found that a permeability factor of 30 or more gives satisfactory results, although in many cases good results may be obtained with sands of somewhat lower permeability. The definition of the term "permeability" as used herein and the method of measuring its numerical value are described in the bulletin "Testing and Grading Foundry Sand" published by The American Foundryman's Association, March 1931.

By way of illustrating a preferred mode of carrying out my invention, I made an intimate mixture of water-tempered foundry sand having a permeability factor of about 25 and about 3 per cent of ammonium hexafluophosphate, and formed the mixture into a mold. Then I poured into the mold a magnesium alloy consisting of approximately 4 per cent of aluminum, 0.3 per cent of manganese, the balance being magnesium, at a temperature between 1300° and 1400° F. The surface of the resulting casting was smooth, free from pits, blowholes, and oxidized areas. No further superficial treatment, such as sandblasting, was required to render the casting suitable for use.

In similar manner I made a mold from water-tempered foundry sand containing about 4 per cent of a mixture of 50 per cent of ammonium monofluophosphate and 50 per cent of ammonium difluophosphate, and poured therein a magnesium alloy. The resulting casting was substantially free from oxidized areas and pitting and of commercially acceptable appearance. When I employed a relatively small proportion of hexafluophosphoric acid in the molding material in similar manner in making a magnesium alloy casting, the surface thereof was free from oxide and of commercially acceptable appearance.

While I have described my invention more particularly in terms of a water-tempered molding sand having in admixture therewith one or more of the agents above specified, my invention is not necessarily limited thereto inasmuch as these agents are effective to prevent oxidation or other defects in casting magnesium when used in mold facings or in solution sprayed upon the inner surface of the mold. For example mold facings may be made from foundry sand with which is mixed one or more of my new agents, and the mixture applied to the pattern in the usual manner. A suitable method of coating the mold cavity or core pieces is to form a solution or suspension of one or more of my new agents, preferably in a non-aqueous liquid such as carbon tetrachloride, and then spray or otherwise apply the mixture to the mold parts which come into contact with the metal. The use of my new agents, furthermore, is not necessarily limited to molds made from sand since other moldable materials, such as graphite, pulverized carbon, coke, cinders, or the like, may be substituted for the sand.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. The method of casting magnesium and alloys thereof in temporary molds which comprises incorporating in water-tempered molding material an agent selected from the group consisting of hexafluophosphoric acid, monofluophosphoric acid, difluophosphoric acid, ammonium hexafluophosphate, ammonium monofluophosphate, ammonium difluophosphate, forming a mold of the mixture and casting the metal in the mold.

2. The method of casting magnesium and alloys thereof which comprises incorporating ammonium hexafluophosphate in water-tempered foundry sand, forming a mold of the mixture and casting the metal in the mold.

3. The method of casting magnesium and alloys thereof which comprises incorporating am-

monium monofluophosphate in water-tempered foundry sand, forming a mold of the mixture and casting the metal in the mold.

4. The method of casting magnesium and alloys thereof which comprises incorporating ammonium difluophosphate in water-tempered foundry sand, forming a mold of the mixture and casting the metal in the mold.

5. In casting magnesium and alloys thereof, the step which consists in casting the metal in a sand mold in which is incorporated, at least for the parts adjacent to the metal cast therein, an agent selected from the group consisting of the fluophosphoric acids and their ammonium salts.

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