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METHOD OF MAKING AND TREATING MAGNESIUM CASTINGS

Robert Thomas Wood, Cleveland, Ohio, assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates to methods of casting "magnesium," a term which is used herein and in the appended claims to include the metal magnesium and alloys containing about 70 per cent or more by weight of magnesium.

One common method of casting metals into desired shapes is known as sand casting. This widely employed method involves the use of a mold formed from non-metallic aggregate such as foundry sand. The mold is shaped from the aggregate, molten metal is cast therein and after solidification thereof the casting is removed from the mold. During such removal the mold is wholly or partially destroyed and the aggregate recovered to be again used in subsequent formation of other molds. Such aggregate-bodied molds are somewhat lacking in chilling effect on the solidifying metal and it is often desirable or necessary to increase the rate of solidification in localized areas where the mass of solidifying metal is great or where a greater rate of solidification is necessary to insure that solidification proceeds, at the desired time, at the desired place in the casting. To this end it is customary to insert in the body of the mold, near or on the face of the mold cavity, one or more pieces of metal. Such metallic pieces are commonly known as chills and are conventionally made of copper or cast iron. These chills, having greater chilling power than the aggregate from which the mold is formed, increase the rate of solidification of the molten metal and thus forms in the chilled regions of the casting smaller grains than would have been formed if chills had not been used. This method of casting metal into aggregate-bodied molds in which are incorporated metallic chilling bodies is used in the casting of most metals and is widely used in the casting of magnesium.

It has been observed that when magnesium castings, made by the above described method, are heat treated to improve their characteristics such as, for instance, their strength or hardness, areas of large grain may develop in the chilled regions of the casting. In these areas the grain has grown relatively large as compared to the normal grain size of the casting established during the casting process. Such localized grain growth during heat treatment is, I believe, more prevalent in magnesium castings than in castings of other commercial metals. The development of these excessively large grains in the otherwise comparatively small grain casting unfavorably affects the useful properties of the metal, such as its strength, ductility and machinability.

The present invention is predicated upon the use, in the aggregate-bodied mold, of chills of certain thermal conductivity. I have found that if the metallic body used as a chill is composed of a metal or alloy having a thermal conductivity substantially less than that of cast iron, i. e. a thermal conductivity not greater than about 80 per cent of that of cast iron, the metallic bodies will fulfill their chilling function, but that the casting produced in such a mold will not have the same tendency to form large grains on heat treatment. It is understood, of course, that the mass of the metal chill used is sufficient to perform the chilling function and that the present invention is concerned with the thermal conductivity rather than the mass (thermal capacity) of the chill.

I have further found that the tendency to the formation of large grains on heat treatment is almost, if not entirely, suppressed if the chills employed have a thermal conductivity that does not exceed about 65 per cent of that of cast iron, and I accordingly prefer to employ chills having such conductivity. Any metal or alloy, stable at the temperatures employed, which fulfills the conductivity requirements outlined above may be employed in the practice of the invention, and such metals and alloys may be easily selected either by reference to standard data on the thermal conductivity of metals and alloys or by determination of that conductivity by well known standard methods. It is, of course, desirable that the metal or alloy selected as a chill body have a melting point sufficiently high to withstand the temperatures developed in the mold when magnesium is cast therein. These temperatures may be as high as 820° C. or even higher. However, the location of the chill in the mold and also the quantity of metal cast in the mold are compensating factors, allowing in some instances the use of metallic bodies which would ordinarily melt if exposed for a long time to such temperatures. The choice of a metal or alloy of proper melting point may be readily made from available melting point data or by simple trial in a representative casting operation.

Convenient alloys may be selected from the copper-zinc-nickel alloy series and from the copper-nickel-manganese alloy series, but I prefer the use of the copper-nickel alloy and have found that an alloy containing 60 per cent copper and 40 per cent nickel is particularly suitable for the practice of the invention. The melting point of this alloy is sufficiently high and at room temperature its thermal conductivity measures to be about 50 per cent of that of cast iron. Chills

made of it produce excellent results. For example, castings of an alloy containing about 10 per cent by weight of aluminum and about 0.2 per cent by weight of manganese, the balance being magnesium, when made in sand molds containing conventional cast iron chills and then heat treated for 40 hours at 810° F. develop areas of large grain. Alloys of the same composition similarly cast in a sand mold containing similarly located chills of the same shape and size, said chills being formed of an alloy composition of 60 per cent by weight of copper and 40 per cent by weight of nickel, produced a casting which when similarly heat treated did not develop large grain areas. The practice of the invention is not, however, limited to chills made of copper-nickel alloys and, as above stated, contemplates the use of any metal which has a conductivity not greater than about 80 per cent of the thermal conductivity of cast iron.

Listed below are a number of alloys selected at random from standard tables showing the normal thermal conductivity of various materials. The conductivity values are expressed in terms of c. g. s. units (i. e., calories per second per square centimeter per degree centigrade where the distance between the opposed surfaces of the body being measured is one centimeter). The conductivity of cast iron is between 0.1 and about 0.115. The values expressed in the following tabulation will, of course, vary slightly with the condition of the metal (i. e., cast, wrought, etc.) and with the temperature at which the measurement is made.

Composition	Thermal conductivity
21–23% Ni, 7–10% Cr, 1–1.5% Cu, 0.6–0.9% Mn, 1.25–1.5% Si, 0.25% max. C., balance Fe	0.066
17–19% Cr, 7–9% Ni, 0.6% max. Mn, 0.75% max. Si, 0.08–0.20% C, balance Fe	0.039
24–26% Cr, 19–21% Ni, 0.5–0.7% Mn, 0.7–1.5% Si, 0.25% max. C, balance Fe	About 0.05
12–15% Cr, 0.4% Mo, 0.35% S, 0.45% Mn, 0.25% Si, 0.12% max. C, balance Fe	0.046
60% Cu, 40% Ni	0.054
20% Cu, 80% Ni	0.073
Chromium steel (10% Cr)	0.052
80% Cu, 20% Mn	0.041
Chromium steel (15% Cr)	0.044
63% Cu, 15% Ni, 22% Zn	0.059
Nickel steel—30.4% Ni, 0.14% Si, 0.84% Mn, 0.26% C, balance Fe	0.031
84% Cu, 4% Ni, 12% Mn	0.053
22–28% Cr, 12–16% Ni, 0.25% max. C, balance Fe	0.04
6–18% Cr, 0.10% max. C, balance Fe	0.07
25–30% Cr, 0.10% max. C, balance Fe	0.06

The heat treatments of magnesium castings above referred to are the normal thermal processes to which many magnesium castings are subjected and which usually involve heating the casting to temperatures above about 200° F. but below those temperatures at which incipient melting would take place in the magnesium casting under treatment. The development of large grains which the practice of this invention wholly or partially overcomes is usually encountered in those magnesium castings, produced in aggregate-bodied molds containing chills, which have been so treated at temperatures over about 730° F., and it is in connection with the manufacture of castings which are to be heat treated in this higher range that the practice of my invention is particularly useful. However, beneficial results will be obtained by the practice of this invention whenever the heat treatment tends to develop in the magnesium casting areas of grain which are larger than the normal size of the grain established in the casting by the solidification of the metal in the mold.

I claim:

1. In that method of making and treating magnesium castings which comprises casting and solidifying molten magnesium in a sand mold containing one or more chilling bodies and thereafter subjecting the casting thus produced to heat treatment at temperatures below the incipient melting point of the casting and above about 730° F., the step of minimizing the inducement of grain growth by said heat treatment which consists in providing as chilling bodies metallic bodies having a thermal conductivity which is not more than about 80 per cent of the thermal conductivity of cast iron.

2. In that method of making and treating magnesium castings which comprises casting and solidifying molten magnesium in a sand mold containing one or more chilling bodies and thereafter subjecting the casting thus produced to heat treatment at temperatures below the incipient melting point of the casting and above about 730° F., the step of minimizing the inducement of grain growth by said heat treatment which consists in providing as chilling bodies metallic bodies having a thermal conductivity which is not more than about 65 per cent of the thermal conductivity of cast iron.

3. In that method of making and treating magnesium castings which comprises casting and solidifying molten magnesium in a mold composed of a non-metallic aggregate body containing one or more chilling bodies and thereafter subjecting the casting thus produced to heat treatment, the step of minimizing grain growth induced by said heat treatment which consists in providing as chilling bodies metallic bodies composed of an alloy consisting of about 60 per cent nickel and balance copper.

4. In that method of making and treating magnesium castings which comprises casting and solidifying molten magnesium in a mold composed of a non-metallic aggregate body containing one or more chilling bodies and thereafter subjecting the casting thus produced to heat treatment, the step of minimizing grain growth induced by said heat treatment which consists in providing as chilling bodies metallic bodies having a thermal conductivity at least 20 per cent less than that of cast iron.

5. In that method of making and treating magnesium castings which comprises casting and solidifying molten magnesium in a mold composed of a non-metallic aggregate body containing one or more chilling bodies and thereafter subjecting the casting thus produced to heat treatment, the step of minimizing grain growth induced by said heat treatment which consists in providing as chilling bodies metallic bodies having a thermal conductivity which is not more than about 65 per cent of the thermal conductivity of cast iron.

ROBERT THOMAS WOOD.