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METHOD OF IMPROVING MAGNESIUM ALLOYS

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This invention relates to improvements of certain physical properties of high percentage magnesium alloys and methods for producing same.

An object of the present invention is to produce a finely crystalline structure of said alloys by a heat treatment of the metal in the molten state, whereby certain mechanical properties, particularly the tensile strength, are considerably improved. Although these improvements are particularly conspicuous in the metal as cast, the invention is not limited to castings but may be also applied advantageously when a further mechanical working up of the cast metal is contemplated.

I have observed that one and the same alloy of magnesium, for example a magnesium alloy containing a certain percentage of aluminium, when treated in the molten state with fluxes mainly consisting of chlorides and containing a thickening medium (for example by the processes described in U. S. Patents 1,576,080 and 1,661,526) for purposes of purification, and cast, yields products having different mechanical strength. A closer investigation of this phenomenon has made it appear that the most valuable mechanical properties with respect to tensile strength, elongation, elastic limit, etc., are obtained in the metal when the latter is subjected, during the melting process, to an overheating above at least 800° C., i. e. about 200° C. or more above the melting point, for some time. The duration of overheating which is necessary to produce the desired effect is shorter when a comparatively higher temperature is maintained during the overheating stage, and vice versa. The minimum temperature of overheating, however, varies somewhat according to the particular composition of the alloy to be treated and must be ascertained by experiment. The effect is already apparent after a single overheating, but is further enhanced when overheating is repeated. The improvement of the mechanical properties thus produced is otherwise practically independent of the casting temperature selected, at least within the limits coming into consideration for all practical purposes. The effect remains the same whether the melt is cooled down to the usual temperature of casting after the overheating stage or whether the overheated melt as such is immediately cast.

The improvements obtained in the mechanical properties of the metal are probably due to the formation of a considerably more finely grained crystalline structure in the solidified metal by virtue of the described heat treatment in the molten state. It is well known that a finely grained structure is generally accompanied by superior mechanical properties.

The following examples will serve to show various preferable modes of carrying out my present invention and the effect produced on the structure and properties of the solidified metal as compared with those of the untreated alloys of identical composition.

Example 1

Magnesium-aluminium alloy: 3 percent Al, balance magnesium (melting point about 630° C.).

(*a*) The alloy was heated in an iron crucible to about 770° C.) i. e. 140° C. above the melting point). The pot was then immediately removed from the furnace and the metal cast at 750° C.: Coarsely grained structure. Mechanical properties of the solidified alloy at about 20° C.:

Tensile strength	16.5 kg/mm²
Elongation	8%
Elastic limit	2.7 kg/mm²
Yield limit	5.0 kg/mm²
Compressive limit	4.9 kg/mm²

(*b*) The same alloy was heated in an iron crucible with the same flux to 900° C. (270°

C. above the melting point) and maintained at this temperature for 15 minutes, then allowed to cool down to 750° C. and cast: Finely grained structure.

The following mechanical properties of the alloy at 20° C. were ascertained:

Tensile strength	18.9 kg/mm²
Elongation	10.2%
Elastic limit	3.4 kg/mm²
Yield limit	6.7 kg/mm²
Compressive limit	6.7 kg/mm²

Example 2

Magnesium-aluminium alloy: 6 percent Al, balance magnesium (melting point about 610° C.).

(*a*) The alloy was heated to 780° C. (about 170° C. above the melting point) and immediately cast: Coarsely grained structure.

Mechanical properties:

Tensile strength	17.5 kg/mm²
Elongation	6%
Yield limit	7.5 kg/mm²

(*b*) The alloy was overheated to 800° C. (190° C. above the melting point) and maintained at this temperature for 30 minutes. Casting temperature 780° C., finely grained structure.

(*c*) The alloy was heated to 850° C. (240° C. above the melting point), then slowly cooled down to 780° C. (casting temperature): Finely grained structure.

Mechanical properties:

Tensile strength	20.0 kg/mm²
Elongation	8%
Yield limit	9.0 kg/mm²

Example 3

Magnesium-aluminium alloy: 10 percent Al, balance magnesium (melting point about 580° C.).

(*a*) Heated to about 760° C. (180° C. above the melting point) and immediately cast: Coarsely grained structure.

(*b*) Heated to 800° C. (220° C. above the melting point), then cooled down to 740° C. and cast: Finely grained structure.

Example 4

Ternary alloy magnesium-aluminium-zinc: 4 percent Al, 3 percent Zn, balance magnesium.

(*a*) Heated to 790° C., cast at 740° C.: Coarsely grained structure.

Mechanical properties:

Tensile strength	18.7 kg/mm²
Elongation	6%

(*b*) Heated to 850° C., cast at 740° C.: Moderately finely grained structure.

Mechanical properties:

Tensile strength	19.0 kg/mm²
Elongation	7%

(*c*) Heated to 900 C°. and maintained at this temperature during 1 hour. Cast at 740 C.: Finely grained structure.

Mechanical properties:

Tensile strength	21.0 kg/mm²
Elongation	9%

With alloys having comparatively low contents in alloying metals it is generally advantageous to apply higher overheating temperatures and a longer duration of overheating than with alloys containing larger amounts of foreign metals, so as to obtain improved physical properties.

The process as described may be also applied with the same effect to magnesium alloys in which the usual small percentages of manganese (up to about 0.4 percent) have been incorporated so as to improve their resistance to corrosion.

I claim:

1. The method of refining the crystalline structure of magnesium alloys which comprises melting the alloys and temporarily subjecting the molten alloys to temperatures of about 200° C. and more above their melting point.

2. A process for improving certain physical properties of high percentage magnesium alloys which comprises temporarily subjecting the molten alloys to temperatures of about 200° C. and more above their melting point.

3. A process for improving certain physical properties of high percentage magnesium alloys which comprises subjecting the molten alloys to temperatures of about 200° C. and more above their melting point for a period of time necessary to cause the formation of a finely grained crystalline structure in the solidified alloy.

4. A process for improving certain physical properties of high percentage magnesium alloys which comprises repeatedly subjecting the molten alloys to temperatures of about 200° C. and more above their melting point.

5. A process for improving certain physical properties of high percentage magnesium alloys including aluminium as an alloying metal which comprises subjecting the molten metal to temperatures of about 200° C. and more above their melting point for a period of time necessary to cause the formation of a finely grained crystalline structure in the solidified alloy.

6. A process for improving certain physical properties of high percentage magnesium alloys, including aluminium as an alloying metal, which comprises subjecting the molten metal to a temperature between about 850 and 900° C. for at least about 10 minutes.

7. A process for improving certain physical properties of high percentage magnesium alloys, including aluminium as an alloying metal, which comprises repeatedly subjecting the molten metal to temperatures of about 200° C. and more above their melting point for a period of time necessary to cause the formation of a finely grained crystalline structure in the solidified alloy.

8. The process of producing castings of high percentage magnesium alloys which comprises melting the alloy with a flux, heating the molten metal to a least 800° C. while protecting the surface of the metal from oxidation by a layer of said flux, maintaining said temperature for at least about 10 minutes, and casting the metal.

9. The process of producing castings of high percentage magnesium alloys which comprises melting the alloy with a flux, heating the molten metal to at least 800° C. while protecting the surface of the metal from oxidation by a layer of said flux, maintaining said temperature for at least 10 minutes, cooling the alloy to the desired temperature of casting, and casting said alloy.

10. A process for improving the mechanical properties of magnesium alloys containing a high percentage of magnesium, which process comprises superheating the alloys to at least 800° C. for a period of time which varies inversely with the content of the alloying ingredient of the alloy and with the superheating temperature employed.

11. A process for improving the mechanical properties of magnesium alloys containing a high percentage of magnesium, which process comprises repeatedly superheating the alloys to at least 800° C. for a period of time which varies inversely with the content of the alloying ingredient of the alloy and with the superheating temperature employed.

12. A process of improving the mechanical properties of magnesium alloys having a content of magnesium ranging from 97 to 90 percent which comprises superheating the alloy to temperatures ranging from 900 to 800° C. for a period of time necessary to cause the formation of a finely-grained crystalline structure, the temperature decreasing over this range as the content of magnesium decreases, the time of treating remaining constant.

In testimony whereof I have hereunto set my hand.

HEINZ MENKING.