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MAGNESIUM BASE ALLOYS

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This invention relates to magnesium base alloys. It has been proposed in the specification of British Patent No. 532,143 to provide magnesium base alloys containing cerium from 0.1% to 2%, zinc between 1.1% and 12% with or without manganese between 0.3% and 0.8%, aluminium not exceeding 1%, and iron at least 0.05%. These alloys have, however, up to the present time not been developed to the point of commercial utilisation, in spite of the fact that they offer excellent mechanical properties. In the continued investigation of these alloys, it has been found that mechanical properties of castings produced therefrom are variable over wide limits. We have now found that one reason for this difficulty can be attributed to the variation in nucleation effects. In order to overcome this difficulty, we have found that it is desirable to control the method of introduction of the iron into the alloy.

According to one feature of the present invention, iron is introduced into magnesium alloys of this kind by means of a pre-alloy of iron with one or more of the following metals, viz. zinc and rare earth metals. We have found that if iron is introduced by means of such a pre-alloy or hardener into the molten magnesium alloy and the latter is then cast in the usual way, the castings have a consistently fine grain size associated with excellent mechanical properties. The alloy has a much finer grain size than an alloy of the same composition produced without the aid of this hardener and retains its fine grain on remelting and recasting.

In carrying the invention into effect, we may proceed as follows. We make a melt of zinc and bring this to a temperature of 750–800° C. whereupon 5–10% of mild steel turnings are added. Since the zinc tends to volatilise at these temperatures, it is preferable to cover its surface with a suitable flux. The melt is maintained at this temperature for about half an hour with occasional stirring, whereupon it is cast into blocks of suitable size. The hardener thus produced is found to contain 5–7% iron by weight of the pre-alloy. We then make a magnesium base alloy containing the required quantity of manganese and heat this alloy to a temperature of about 750° C. The required quantity of rare earth metal, together with a sufficient quantity of the hardener, is then introduced into the melt in a perforated basket. The temperature of the melt is increased to about 800° C. and after stirring for a few minutes is cast. It is found that the final alloy contains about 0.05% iron.

The pre-alloy of zinc and iron preferably contains 1 to 10% iron but can be used successfully when containing even higher quantities of iron. The pre-alloy of rare earth metals and iron may contain 50% or more of iron.

The addition of iron as above described is essential

to ensure consistently fine grain size and good mechanical properties, but has the disadvantage that it tends to lower the resistance of the alloy to corrosion. This tendency may however be reduced by an addition of beryllium. The most usual way of adding beryllium to magnesium base alloys is by means of a beryllium-aluminium hardener. However, our investigations have shown that the presence of aluminium greatly enhances the difficulty of consistently achieving a fine grain size. According to a further feature of the present invention, therefore, beryllium is added to the alloy in the absence of more than 0.1% aluminium by weight of the finished alloy. The beryllium may be added in the form of a hardener or pre-alloy consisting of an alloy of beryllium with one or more of the following metals, viz. zinc and rare earth metals. It may also be added in the form of a reducible halide. If desired, the beryllium may be included in the iron containing hardener.

We have found it further to be desirable to avoid contamination of the alloy by silicon.

The alloys of the present invention preferably have a composition within the following limits:

- Zinc 2 to 8% preferably 4 to 7%.
- Rare earth metals 0.3 to 2.0% preferably 0.4 to 1.25%.
- Manganese 0.1 to 2.0% preferably 0.3 to 0.8%.
- Beryllium 0.001 up to 0.05%.
- Aluminium from nil to 0.1% preferably less than 0.03%.
- Iron 0.01 to 0.1% preferably 0.03 to 0.07%.

It is preferable that alloys with zinc contents lying towards the higher limit should also have a rare earth metals content lying towards the higher limit and alloys with lower zinc contents should also have lower contents of rare earth metals.

The alloys of the present invention will normally be used in the form of sand or die castings in the fully heat treated condition, i. e. being subjected to a solution heat treatment followed by a precipitation heat treatment. The heat treatment may be carried out substantially as carried out in the aforesaid specification of British Patent No. 532,143. We prefer however to quench the castings after the solution or soaking heat treatment prior to the precipitation heat treatment. For example, with an alloy containing 6% zinc, 0.7% rare earth metal and 0.5% manganese, we have satisfactorily effected solution heat treatment at a temperature of 440–450° C. for 16 hours followed by a water quench, after which the castings were subjected to a precipitation heat treatment at 150° C. for 50 hours.

Test bars made in this alloy to the requirements of specification No. B. S. L101, paragraph 9.2, heat treated as described, gave the following typical mechanical properties:

| 0.1% proof stress, tons per sq. inch | Ultimate tensile stress, tons per sq. inch | Elongation percent on two inches |
|--------------------------------------|--------------------------------------------|----------------------------------|
| 11.....                              | 18                                         | 6.5                              |

The following minimum properties can be confidently expected:

| 0.1% proof stress, tons per sq. inch | Ultimate tensile stress, tons per sq. inch | Elongation percent on two inches |
|--------------------------------------|--------------------------------------------|----------------------------------|
| 10.....                              | 17                                         | 4                                |

It has also been found that with a heat treatment as described test bars cut from material of thick section

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retain high proof stress values. For example, bars cut from a casting of 3½ inch square section gave an average 0.1% proof stress value of 11 tons per square inch.

The alloys may contain up to 2% cadmium and the following elements each in amounts not exceeding about 0.5% thorium, lead, silver, mercury, tin.

The alloys of the present invention may also be used in the wrought condition.

"Rare earth metals" means the group of elements consisting of cerium, lanthanum, samarium, praseodymium, neodymium, europium, gadolinium, terbium, holmium, dysprosium, erbium, thulium, and ytterbium.

We claim:

1. A magnesium base alloy having a consistent and fine grain structure made of the following composition:

|                        | Percent       |
|------------------------|---------------|
| Zinc-----              | 2 to 8        |
| Rare earth metals----- | 0.3 to 2.0    |
| Manganese-----         | 0.1 to 2.0    |
| Iron-----              | 0.01 to 0.1   |
| Aluminum-----          | Nil to 0.1    |
| Beryllium-----         | 0.001 to 0.05 |
| Magnesium-----         | Balance       |

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2. A magnesium base alloy having a consistent and fine grain structure made of the following composition:

|                        | Percent       |
|------------------------|---------------|
| Zinc-----              | 4 to 7        |
| Rare earth metals----- | 0.4 to 1.25   |
| Manganese-----         | 0.3 to 0.8    |
| Iron-----              | 0.03 to 0.07  |
| Aluminum-----          | Nil to 0.03   |
| Beryllium-----         | 0.001 to 0.05 |
| Magnesium-----         | Balance       |

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