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ALUMINUM BASE ALLOYS

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My invention relates to alloys, and more particularly to aluminum base alloys having a low thermal expansion.

Aluminum and aluminum alloys are very desirable in many applications, such as pistons, cylinder heads and similar cast articles utilized in motor constructions because of their low specific gravity, high thermal conductivity and good frictional performance. Aluminum and aluminum alloys, in general, however, have a high thermal expansion and since operation of the motor at an elevated temperature causes the parts of the motor to expand, it is desirable to provide an aluminum base alloy having a comparatively low thermal expansion for the construction of castings for motor parts, in which aluminum is a constituent.

It is, therefore, an object of my invention to provide an aluminum-base alloy having a comparatively low thermal expansion, combined with good mechanical and physical properties.

Another object of my invention is to provide an aluminum base alloy having a comparatively low thermal expansion, fine grain structure, and which is capable of being subjected to elevated temperatures without causing grain growth or loss of strength.

A further object of my invention is to provide a readily machinable aluminum-base alloy that may be cast in the usual types of molds and which has low thermal expansion, a fine, homogeneous grain structure, combined with excellent physical properties, and which may be subjected to elevated temperatures without losing its strength.

It is now well known in the art that silicon reduces the thermal expansion of aluminum. The coefficient of expansion of aluminum-silicon alloys, however, is still high as compared with other metals, such as cast iron and steel, with which they are frequently associated in internal combustion engines, and they do not possess the other mechanical properties, such as hardness and machinability which are required in producing pistons and other motor parts.

Magnesium, when added to aluminum-silicon alloys, increases their hardness and improves their machinability, but does not lower the thermal expansion of the alloy.

I have made the discovery that if manganese in certain well defined proportions is added to aluminum-base alloys containing silicon, or aluminum-base alloys containing silicon and magnesium, the thermal expansion of the alloy will be substantially lowered. Manganese also prevents grain growth at elevated temperatures, which makes the alloy especially adaptable for use in the production of pistons, or other motor parts, which are subjected to such temperatures. Furthermore, manganese increases the hardness of the alloy and improve its machinability. Castings, such as pistons or other motor parts, may therefore be produced when only aluminum, silicon and manganese, or aluminum, silicon, manganese and magnesium are present.

In preparing my improved alloy, silicon is utilized as the predominating alloying ingredient and may be present in amounts ranging from 7% to 20%. As larger proportions of silicon are more effective in reducing the thermal expansion of the alloy, I generally utilize at least 12%. However, when large proportions of silicon are employed, some of the silicon has the tendency to segregate out in large crystals unless the casting is chilled very rapidly.

In order to improve the physical properties of the alloy when heat treated, approximately .2% to 6% of magnesium may be added. The magnesium acts as an accelerator in increasing the hardness of the alloy when it is subjected to heat treatment and enables the production of a hard, machinable alloy. As large amounts of magnesium, however, render the alloy brittle, I prefer to maintain the amount of magnesium added to proportions ranging from .5% to 2%.

I have found that if manganese in certain well defined proportions is added to an aluminum-silicon or an aluminum-silicon-magnesium alloy, an alloy may be produced that not only has good casting properties but one which has a lower coefficient of thermal expansion than any previously known aluminum base alloy. Furthermore, the manganese prevents grain growth at elevated temperatures, which makes my improved alloy especially adaptable for use in the production of castings for pistons or other motor parts, which are subjected to heat for comparatively long periods of time. The manganese should be present in effective amounts but not exceeding 5%. Amounts ranging from .1% to 5% may be utilized, although I prefer to maintain the proportions within amounts ranging from .5% to 2%.

The amount of manganese that is utilized will depend to a certain extent upon the shape of the casting that is to be produced, and the amount of silicon which is present. If large amounts of silicon are present, as a rule, the amount of manganese should be kept low; otherwise a brittle alloy will be produced. Manganese in large amounts also has the tendency to make the alloy

sluggish, which renders the making of castings more difficult, especially if the shape of the casting is complicated.

Boron or titanium may also be present in the alloy in effective amounts ranging from more than incidental impurities up to .3%, although I prefer to employ amounts ranging from .0005% to .1% of either or both. When silicon is present in hypereutectic amounts, one or both of these elements is desirable because in such cases some of the silicon has the tendency to separate out in large crystals and the addition of boron or titanium aids materially in preventing such segregations. When the silicon is present in approximately eutectic proportions, however, it does not segregate and the benefits derived from the addition of boron or titanium are not so pronounced.

Small amounts of other ingredients may also be added to the alloy or be present in the alloy. Iron may be present in amounts ranging from more than incidental impurities up to a maximum of approximately 1.5%. The iron appears to have an effect somewhat similar to manganese, or acts to intensify the effect of manganese. If iron is present without manganese, however, the full beneficial effects produced by the manganese will not be obtained.

Copper may be present in the alloy in small amounts, but is not an essential ingredient of the alloy. When present the copper does not affect the thermal expansion of the alloy, and therefore it is not necessary in making the alloy to entirely exclude base metal containing small amounts of copper as impurities. However, when an alloy having a high resistance to corrosion and low specific gravity is desired, the amount of copper should be very low.

It is often desirable, however, to provide an alloy which will have approximately the same or a less specific gravity than aluminum so that it may be utilized in motor parts where low specific gravity is required. In such cases, the presence of heavy metals which do not lower the thermal expansion should be either omitted or limited to comparatively small amounts.

As an illustration of my improved alloys, the following specific examples are given. An alloy containing 19% silicon, 2% magnesium, 1% manganese, and the balance aluminum and minor impurities, was chill cast and, upon being tested, was found to have a thermal expansion of 15.4×10^{-6} per degree centigrade between a temperature range of 33° and 100° C. This alloy has a lower coefficient of thermal expansion than any previously known aluminum base alloy.

An alloy containing 15% silicon, 2% magnesium, 1% manganese and .1% titanium and the balance aluminum and minor impurities, was also prepared in a manner similar to the alloy specified, and its thermal expansion tested, both as cast, and after being heat treated. It was found that the alloy had a thermal expansion of 16.3×10^{-6} per degree centigrade between a temperature range of 20° and 100° C. as cast.

It will be understood that the strength of my improved alloy may be increased by suitable heat treatment. For example, an alloy containing 15.5% silicon, 1% magnesium, .5% manganese and small amounts of copper and impurities was chill cast, heated for four hours at a temperature of 520° C., quenched in hot water, and aged for two hours at 195° C. It was found that the alloy, as cast, had a thermal expansion of 18×10^{-6} per degree centigrade and a thermal expansion after heat treatment of 16.9×10^{-6} per degree centigrade between a temperature range of 20° and 100° C. After the heat treatment mentioned the alloy had a tensile strength of approximately 45,000 pounds per square inch, an elongation of 1%, and a Brinell hardness of approximately 135.

In view of the foregoing specification, it will be apparent that I have produced an improved alloy that has a lower thermal expansion than the aluminum copper alloys which have heretofore been utilized and is, therefore, desirable for use in pistons, cylinder heads or other motor parts. It is also more resistant to corrosion than aluminum-copper alloys and is, therefore, desirable for use in outboard motor parts.

In view of the fact that my improved allow has a low thermal expansion, it may also be utilized in machines which are subject to a wide range of temperature changes, such, for example, as aeroplanes and the like, as the stresses which are created are much less than when metals having a higher coefficient of expansion are employed.

It will also be seen that the addition of manganese to aluminum-silicon alloys, or aluminum-silicon-magnesium alloys, in certain well-defined proportions not only lowers the thermal expansion of the alloy but prevents grain growth when the casting is subjected to heat.

It will also be apparent that because manganese in comparatively small proportions increases the hardness and improves the mechinability of the alloy, an alloy may be produced which has approximately the same, or a lower specific gravity, than aluminum, and this is especially true when magnesium is present because it has a lower specific gravity than aluminum.

Furthermore, it will be understood that the present invention is not limited to the specific details set forth in the foregoing examples, which should be construed as illustrative and not by way of limitation, and in view of the numerous modifications which may be effected therein without departing from the spirit and scope of this invention, it is desired that only such limitations be imposed as are indicated in the appended claims.

What I claim is:

1. An aluminum base alloy having a low thermal coefficient of expansion comprising a predominant amount of aluminum 7% to 20% silicon, .2% to 6% magnesium, and from .1% to 5% manganese, said alloy being comparatively free from other elements having a higher specific gravity than aluminum.

2. A machinable aluminum base alloy having a low coefficient of thermal expansion comprising a predominant amount of aluminum 12% to 20% silicon, .5% to 2% manganese, and .5% to 2% magnesium.

3. An aluminum base alloy having a low thermal coefficient of expansion comprising a predominant amount of aluminum 12% to 20% silicon, .5% to 2% manganese and an ingredient selected from a group comprising boron and titanium in proportions ranging from effective amounts up to .3%.

4. An aluminum base alloy having a low thermal coefficient of expansion and consisting essentially of 12% to 20% silicon, .5% to 2% manganese, .5% to 2% magnesium, and the remainder aluminum and minor impurities.

5. An aluminum base alloy having a low thermal coefficient of expansion and consisting essentially of 12% to 20% silicon, .5% to 2% manganese, .5% to 2% magnesium, .0005% to .1% of of an element selected from a group consisting of

boron and titanium and the remainder aluminum and minor impurities.

6. A casting for use in motor construction formed from an aluminum base alloy consisting essentially of 12% to 20% silicon, .5% to 2% manganese, .5% to 2% magnesium, and the remainder aluminum and minor impurities.

7. A piston formed from an aluminum base alloy consisting essentially of 12% to 20% silicon, from .1% to 5% manganese, from .0005% to .3% of an element selected from a group consisting of boron and titanium, and the remainder aluminum and minor impurities.

8. A piston formed from an aluminum base alloy consisting essentially of 12% to 20% silicon, .5% to 2% manganese, .5% to 2% magnesium, and the remainder aluminum and minor impurities.

9. An aluminum base alloy having a low thermal coefficient of expansion, comprising a predominant amount of aluminum, 12% to 20% silicon, .5% to 2% magnesium, and .5% to 2% of manganese, said alloy having a coefficient of thermal expansion as cast of approximately 18×10^{-6}, or less, per degree centigrade between a temperature range of 20° and 100° C. and being substantially free from other ingredients in an amount which would increase the thermal coefficient of expansion of the alloy beyond that amount.

10. An aluminum base alloy having a low thermal coefficient of expansion, comprising a predominant amount of aluminum, 12% to 20% silicon, .1% to 5% manganese, and .2% to 6% magnesium, said alloy having a coefficient of thermal expansion as cast of approximately 18×10^{-6}, or less, per degree centigrade between a temperature range of 20° and 100° C., and being substantially free from other ingredients in an amount which would increase the thermal coefficient of expansion of the alloy beyond the amount stated.

11. An aluminum base alloy having a low thermal coefficient of expansion, comprising a predominant amount of aluminum, 7% to 20% silicon, .1% to 5% manganese, .2% to 6% of magnesium, and an element selected from a group comprising boron and titanium in amounts ranging from .0005% to .3%, said alloy being substantially free from other ingredients in an amount which would increase the thermal coefficient of expansion of the alloy.

12. An aluminum base alloy having a low thermal coefficient of expansion, comprising a predominant amount of aluminum, 7% to 20% silicon, .1% to 5% manganese and an ingredient selected from a group comprising boron and titanium in proportions ranging from .0005% up to .1%.

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