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FREE CUTTING ALLOYS

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The invention relates to aluminum base alloys and is particularly concerned with aluminum base alloys containing magnesium and silicon.

Aluminum base alloys containing from about 0.1 per cent to 1.0 per cent of magnesium, and from about 0.5 per cent to about 2.5 per cent of silicon have heretofore been used. They are usually in the wrought condition since they are readily susceptible to mechanical deformation such as rolling, forging, or extrusion. It is possible, by appropriate thermal treatments to very substantially improve their physical properties. After a high temperature solution treatment they do not age-harden to any great extent at room temperature but may be artificially aged by temperatures somewhat in excess of room temperature as is well known in the art. For this reason these alloys may be wrought to substantially final form, then subjected to a high temperature solution treatment, and while in a relatively soft condition they may be given certain final working steps at low temperature. Since they do not materially age at room temperature these finishing steps may be performed at any convenient time. They may ultimately be artificially aged if the maximum tensile strength, yield strength, and hardness are desired.

Since all commercial aluminum base alloys contain some silicon as an impurity, usually less than, or not greatly in excess of 0.5 per cent, it is to be understood that the amount of silicon discussed herein, and hereinafter claimed, represents the total quantity of silicon present, and that the silicon content of the aluminum used should be known in order to provide a basis for determining the eventual composition of the aluminum-magnesium-silicon alloy.

There are, however, some applications wherein aluminum-magnesium-silicon alloys as hereinabove disclosed might be conveniently and profitably used except for an inherent disadvantage which militates against their use in the production of certain articles requiring exacting machining operations. Mechanical cutting operations such as drilling, shaping, or lathe-cutting are successfully carried out only by using certain precautions which increase the cost of production and perhaps favor the choice of another metal or alloy which can be machined more readily but which is not so desirable in other respects, as for example, in physical properties. When alloys are difficult to machine this disadvantage becomes evident, in many cases, through rapid wear of the cutting tool edge, so that frequent tool re-sharpening is required.

Despite continual lubrication the machined surface is rough and irregular, and the chip has a tendency to form a continuous curl or spiral which often fouls the tool or the moving parts of the machine. It is immediately apparent that there is need for an alloy of good working characteristics and satisfactory physical properties, yet possessing such favorable machining properties that the complete machining operations may be performed economically and successfully, and may be productive of a pleasing surface appearance.

Accordingly an object of our invention is the provision of an aluminum base alloy containing from about 0.1 to about 1.5 per cent of magnesium and from about 0.5 to 2.5 per cent of silicon, which may be readily and economically machined.

Our invention resides in the discovery that the foregoing object is effected by adding at least one of the elements lead and tin to the aluminum-magnesium-silicon alloy. When these elements are added, in the proportions specified below, the alloys are known as free cutting or free machining alloys because they can be machined more rapidly than similar alloys without the lead or tin, and yet have as good or a better finished surface. After an extended series of investigations we have discovered that the elements lead and tin belong to a class of alloying elements which has a favorable effect upon the machining properties of aluminum-magnesium-silicon alloys. In recognition of this effect we term lead and tin "free machining" elements. We have further discovered that the simultaneous presence of both of these elements is productive of an improvement in free machining characteristics which is considerably greater than that caused by the presence of the same total amount of either one alone. For example, the addition of 0.5 per cent of lead and 0.5 per cent of tin to an aluminum base alloy containing about 0.6 per cent of magnesium and 1.0 per cent of silicon effects a greater improvement in machining quality than does the addition of 1.0 per cent of either lead or tin singly.

Since these two elements have such a favorable effect on the machining characteristics of aluminum-magnesium-silicon alloys, it is fortunate that they are also of relatively low melting point, a fact which makes possible their addition to molten aluminum in the pure state, without the intervention of so-called "rich alloys". It is also a fact that the elements lead and tin form with aluminum a series of alloys

of limited liquid solubility. Within the range disclosed and claimed however these free machining elements may be added without unusual difficulty. We suspect that this characteristic feature of the elements lead and tin may be one of the significant factors which contribute to their free machining effect. We believe that this effect is further strengthened by distributing the free machining constituent relatively homogeneously throughout the solid matrix, since lead and tin are also practically insoluble in the solid aluminum-magnesium-silicon base alloy.

The lead or tin, if used alone, may be added in amounts between about 0.05 per cent and 6.0 per cent. If used together the total amount of free machining constituent should not be less than 0.05 per cent, and need not exceed 6.0 per cent. We have determined that the maximum limit of 6.0 per cent of free machining metal is sufficient for satisfactory commercial results, since although the free machining effect persists beyond this amount, certain of the other physical properties may be unfavorably affected.

Aluminum-magnesium-silicon alloys containing one or both of the free machining elements lead or tin may be machined more rapidly, with less tool wear, less tool sharpening, better quality of chip and better machined surface than the same base alloys without the free machining additions and as previously indicated the simultaneous presence of tin and lead is considerably more helpful to the machining quality of the alloy than an equivalent total amount of either lead or tin alone.

As a preferred alloy within the range of the respective elements disclosed hereinabove we suggest an alloy containing about 0.6 per cent of magnesium, 1.0 per cent of silicon and a total of 3 per cent of lead and tin, the balance being aluminum. For some applications which do not require a high degree of free machining quality a lesser amount of the free machining metal may be added to the alloy base, for instance 0.5 per cent of lead or 0.5 per cent of tin, or 0.75 per cent total of lead and tin.

For certain purposes, notably the improvement of tensile strength, hardness and grain structure, the alloys as hereinabove disclosed may be improved by the addition of one or more of the group of elements composed of molybdenum, vanadium, titanium, tungsten, zirconium and chromium. From 0.05 to 1 per cent of any one of these elements may be used alone, but if more than one is employed the total amount should not exceed about 2 per cent.

The free machining alloys which have been described hereinabove may be subjected to the thermal treatments well known in the art to improve their strength and hardness. We have found that a solution heat treatment and subsequent aging does not impair the free machining quality of the alloys and in many instances the treatment even tends to improve this property. For many purposes a relatively high strength and hardness are necessary to the successful performance of the machined article and hence the alloy must be heat treated. This treatment is generally applied prior to the machining operation.

As hereinabove indicated the free machining elements, by reason of their low melting point, may be added to the molten aluminum in pure metallic form. However, since some difficulty may be encountered in introducing them in the higher percentages of our disclosed range we prefer to use the method which is more fully described in U. S. Patent No. 1,959,029, issued March 15, 1934. Briefly it involves heating the melt to a somewhat higher temperature than is customary, and vigorously stirring it in excess of a critical period of time.

The term "aluminum" as used herein and in the appended claims embraces the usual impurities found in aluminum ingot of commercial grade or picked up in the course of the ordinary handling operations incident to melting practice.

We claim:

1. A free cutting aluminum base alloy containing from 0.1 to 1.5 per cent magnesium, from 0.5 to 2.5 per cent silicon, and a total of from 0.05 to 6 per cent of one of the group of free machining elements composed of lead and tin, the balance being substantially aluminum.

2. An aluminum base alloy containing from 0.1 to 1.5 per cent magnesium, from 0.5 to 2.5 per cent silicon, and from 0.05 to 6 per cent of lead, the balance being aluminum.

3. An aluminum base alloy containing from 0.1 to 1.5 per cent magnesium, from 0.5 to 2.5 per cent silicon, and from 0.5 to 6 per cent of tin, the balance being aluminum.

4. An aluminum base alloy containing from 0.1 to 1.5 per cent magnesium, from 0.5 to 2.5 per cent silicon, from 0.05 to 6 per cent of one of the group of free machining elements composed of lead and tin, and from 0.05 to 2 per cent of hardening metal from the group composed of molybdenum, vanadium, titanium, tungsten, zirconium and chromium, the balance being aluminum.

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