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FREE CUTTING ALLOY

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This invention relates to aluminum base alloys and it is especially concerned with improved alloys of this nature containing magnesium and silicon as the principal alloy components.

Aluminum-magnesium-silicon alloys of the type described in U. S. Patent 1,472,739 to Jeffries and Archer have been widely used because of their excellent hot and cold working characteristics combined with satisfactory strength and ductility. The alloys referred to contain between about 0.5 and 4 per cent each of magnesium and silicon and are generally heat-treated in the manner described in the aforesaid patent to develop the maximum strength. Alloys containing as little as 0.1 per cent each of these two elements have also been used successfully for certain purposes, notably, electrical equipment. Wrought or extruded articles made from these alloys often require some machining operation such as boring, drilling, planing, shaping, and the like, to complete them for their intended use. This type of alloy has a somewhat better machining quality than other aluminum base alloys and for this reason aluminum-magnesium-silicon alloys of the kind described have been often selected where this property is of importance. In spite of this relative superiority, however, these alloys do not have the degree of machinability desired for large scale or automatic machine production. For purposes of this nature the alloy should be "free cutting" or "free machining", that is, the chips should flow freely from the article being cut, they should also be short and breakable to prevent fouling of the cutting tool or operating parts of the machine. A bright, smooth, evenly cut surface should be left on the machined article. The cutting speed should also be greater than for ordinary aluminum alloys in order to promote more rapid and economical production of machined articles. These ends should be accomplished without undue wear on the cutting tool which would necessitate frequent resharpening or replacement. Aluminum-magnesium-silicon alloys of the class disclosed in the above referred to patent do not possess a machinability of this order with a consequent limitation in the field of their utility.

It is an object of our invention to improve the machining quality of the above-mentioned alloys by rendering them free machining. Another object is to accomplish the foregoing purpose without substantially affecting the physical properties of the alloy.

Our invention is predicated upon the discovery that the addition of small amounts of cadmium and tin to the herein described alloys produces a marked and favorable effect upon the machining quality of the same. These elements may be used in the alloys in the proportion of from about 0.05 to 6 per cent, the amount to be employed in a particular case being dependent on the properties desired and the severity of the cutting operation. For the purpose of our invention the elements cadmium and tin are substantially equivalent and are considered to constitute a class of substances because of their similarity in behavior in the alloys herein disclosed in respect to the machining quality of said alloys. These elements are referred to, therefore, as free machining elements or constituents.

The amount of cadmium and/or tin that may be needed in a particular aluminum-magnesium-silicon alloy is determined by the nature of the fabricating operations required to produce the desired article and the conditions of service to which the article is ultimately subjected. From about 0.1 to 6 per cent of cadmium and/or tin imparts the desired property of improved machinability without substantial detriment to the physical properties of the alloy. For many applications we prefer to use between about 1 and 4 per cent of these free machining elements. Aluminum-magnesium-silicon alloys containing from about 0.5 to 2 per cent of magnesium and 0.75 to 2 per cent of silicon have been extensively used where strong light aluminum alloys are required and the addition of cadmium and/or tin within the limits above named has been very effective in improving their cutting quality. An alloy of the type above described containing about 0.6 per cent of magnesium and 1 per cent of silicon has found wide favor because of the exceptionally good combination of working and physical properties. The addition of about 2 per cent of cadmium reduces the size of the chip and causes the alloy to be cut more readily, while the addition of about 4 per cent of this element serves to further improve these machining characteristics. A smooth evenly cut surface of pleasing appearance is also obtained in both cases.

While we have found that the addition of cadmium and/or tin to alloys of the kind herein disclosed favorably affects their machining quality without diminishing their physical properties, it is necessary to exercise care in hot working of the alloys containing these free machining elements. Alloys containing less than about 1 per cent cadmium or 0.5 per cent tin can be handled in the usual manner in hot working operations such as forging, but if these amounts are exceeded we prefer to extrude the alloy to avoid cracking of the metal. These alloys may be thermally treated in the customary manner, however, without injurious effect.

The addition of cadmium or tin is not only effective in improving the machinability of aluminum-magnesium-silicon alloys when used separately in said alloys, but they may also be advantageously employed in combination. It has been ascertained that in some cases a superior machining quality is obtained in a given alloy through the simultaneous presence of cadmium and tin than when an equivalent amount of either element alone is used. For example, an alloy containing about 0.6 per cent magnesium, 1 per cent of silicon, 1 per cent of cadmium, and 1 per cent of tin machined more easily with shorter chip and better surface than the same base alloy containing about 2 per cent of cadmium or tin. The total amount of free machining constituents should not exceed about 6 per cent and preferably less than about 4 per cent and more than 1 per cent is to be employed. The relative proportions of the free machining elements may be varied but we have found that satisfactory results are obtained by using them in substantially equal proportions. By virtue of this discovery regarding the joint beneficial action of cadmium and tin, it is possible to employ a smaller amount of added constituents to obtain a desired degree of machinability than if only one element is used. This feature is desirable where it is necessary to limit the amount of added elements that can be present in addition to the essential alloy components.

For certain purposes it has been found desirable to add other elements to the base aluminum alloy than the cadmium and tin as hereinabove described. Such elements as lead, bismuth and/or thallium have a similar effect in improving the machining quality of aluminum-magnesium-silicon alloys, and may be used in conjunction with cadmium or tin. An alloy, for example, containing about 0.6 per cent of magnesium, 1 per cent of silicon, 1.5 per cent of lead, and 1 per cent of cadmium has satisfactory characteristics. In using lead, bismuth or thallium, the proportions employed may vary between about 0.05 and 6 per cent for each element or for all of this group, although it is preferred to use between about 1 and 4 per cent of the elements separately or in combination.

The tensile properties of the alloys are not substantially affected by the presence of the free machining elements in amounts of less than about 4 per cent. There is a tendency for a slight decrease in strength if more than 4 per cent of these elements are employed, but the machining quality is somewhat better when the larger quantity is present. A suitable adjustment of proportions may soon be established for any alloy under set conditions of fabrication and service.

The cadmium and/or tin may be most conveniently added to the molten aluminum-magnesium-silicon alloy in solid metallic form since the melting points of these elements are considerably below that of the aluminum alloy and the temperatures commonly used in melting the same. When so added to the molten alloy, the mass should be vigorously stirred to avoid segregation and assure a uniform mixture. In case cadmium is added, the temperature of the molten alloys should not exceed about 1400° F. in order to prevent excessive loss of the element through volatilization.

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

We claim:

1. An aluminum base alloy containing from about 0.5 to 4 per cent of magnesium, from about 0.5 to 4 per cent of silicon, and both of the elements cadmium and tin, each of the elements cadmium and tin being present in amount of at least 0.1 per cent and both of these elements being present in total amount between about 1 per cent and 4 per cent, the balance being aluminum.

2. An aluminum base alloy containing about 0.6 per cent of magnesium, about 1 per cent of silicon, and both of the elements cadmium and tin, the elements cadmium and tin each being present in amount of at least 0.1 per cent and both elements being present in total amount between about 1 per cent and 4 per cent, the balance being aluminum.

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