Patented July 14, 1936 2,047,873

UNITED STATES PATENT OFFICE

2,047,873

FREE CUTTING ALLOYS

Louis W. Kempf and Walter A. Dean, Cleveland, Ohio, assignors to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

No Drawing. Application December 3, 1935, Serial No. 52,667

5 Claims. (Cl. 75—139)

This invention relates to aluminum base alloys and is particularly concerned with alloys of this nature containing substantial amounts of copper.

Despite the manifold advantages connected with the use of aluminum and its alloys in commercial fields, there is an inherent drawback which somewhat curtails their use in certain potential adaptations. Aluminum alloys, for instance, containing from about 4 per cent to about 12 per cent of copper have a wide range of usefulness because of their favorable mechanical properties and their susceptibility to improvement by suitable thermal treatments. Mechanical cutting operations, however, such as boring, drilling, planing, or lathe-cutting are successfully carried out only by using certain precautions which increase the expense of the operation and which occasionally necessitate the substitution of another alloy which may be machined more readily but is otherwise not so desirable from the standpoint of physical properties. When alloys are difficult to machine this disadvantage becomes evident, in many cases, through rapid wear of the cutting tool edge which necessitates frequent resharpening. In such cases where machining is difficult, continual lubrication is required, the machined surface is rough and irregular, and the chip has a tendency to form continuous curls or spirals that may foul the tool or the operating parts of the machine. These drawbacks retard production and increase the cost of operation. Many articles require a variety of machining operations before being applied to their final purpose and it is particularly desirable that these articles be finished economically and satisfactorily.

An object of this invention is to provide an aluminum base alloy containing substantial amounts of copper, that can be readily machined. Another object is to provide an aluminum base alloy that can have its physical properties improved by suitable thermal treatments and yet retain its good machining quality. Still another object is to provide a free cutting aluminum base alloy containing from 4 to 12 per cent copper, whose fundamental physical properties are not substantialy impaired by the addition of elements designed to improve the machinability.

We have discovered that the addition of lead and bismuth to an aluminum base alloy containing from 4 to 12 per cent copper, greatly improves the machining quality of the base alloy without detracting from its other properties. Additions of from about 0.05 to 10 per cent of lead and 0.05 to 1.5 per cent of bismuth accomplish this purpose. The total amount of the two elements may vary between about 0.1 and 10 per cent. The amount of lead and bismuth to be employed in a particular case is to be determined by the properties desired in the alloy. Where strength is an important consideration, the amount of these two elements should be kept relatively low. Where other properties are of greater importance a larger proportion of lead may be used with a resultant decrease in the strength. The basic nature of the alloy is not changed, however, by the presence of a large amount of lead, and the alloy is still readily machinable. In the making of wrought alloys we prefer to employ from about 4 to 6 per cent copper, from about 0.2 to 1.5 per cent lead and from about 0.2 to 1.5 per cent bismuth, with a total of lead and bismuth varying between about 0.5 to 3.0 per cent.

Certain aluminum base alloys, such as one composed of aluminum, 8 per cent copper and 5 per cent tin, have been made heretofore which are readily machinable but this property has been obtained, we have observed, at the expense of other properties such as strength, workability and ductility. We have determined that these disadvantages may be overcome by combining copper, bismuth and lead with aluminum in suitable proportions. Although we have found that the addition of bismuth or lead alone to aluminum-copper alloys greatly improves their machining quality, we have now discovered that an even better machinability is obtained by using both lead and bismuth. This improvement is gained by a co-action between the two elements which has not as yet been explained. The combined effect of the two elements is, however, quite pronounced and unexpected in view of the behavior of each one alone in aluminum-copper alloys.

We have furthermore found a readily machinable alloy that can be improved by the heat treating and aging process, well known in the aluminum alloy art. The well known heat treated aluminum base alloys heretofore employed usually possess a sufficient degree of machinability for ordinary machining operations, but they are not so well adapted to the manufacture of screw machine products with respect to their free cutting quality. Such alloys do, however, possess an adequate strength for screw machine parts which is quite essential in view of the small dimensions of these parts and the magnitude of the stresses to which they are often subjected in service. An alloy has long been sought which would combine the high

strength of the well known heat treated alloys and the degree of machinability found in free cutting brass alloys. We have discovered that these apparently divergent properties are combined in our improved alloy. More particularly, we have found that the addition of lead and bismuth to an aluminum-copper alloy does not destroy the response of said alloy to solution heat treatment and aging, nor do these additions substantially alter the fundamental characteristics of the base alloy.

Although our alloy in the un-heat treated condition has a better machining quality than a binary aluminum-copper alloy having the same copper content, the advantageous properties of our composition are most apparent when the alloy is heat treated. For some applications it is sufficient to simply heat treat and quench the alloy, while for other types of service a stronger material is needed and consequently the alloy should be aged after quenching. The heat treatment to be employed is of the well known type, namely, heating at a temperature above about 850° F. for a sufficient length of time to obtain a substantial degree of solution of the soluble constituents. Upon obtaining this condition the alloy is then quickly cooled to a much lower temperature, usually room temperature, by quenching in water or some other liquid medium. The alloy may then be aged, if desired, by reheating to between 200° and 350° F. for several hours or longer, depending on the degree of strength desired.

The improvement in physical properties mentioned hereinabove is exemplified in an alloy composed of 6.0 per cent copper, 0.5 per cent lead and 0.5 per cent bismuth, the balance being aluminum. This alloy was cast in ingot form and rolled to ¾ inch rod. Sections of the rod were then heat treated at 960° F. and quenched in water. In this condition the alloy had a tensile strength of 44,800 pounds per square inch, a yield strength of 16,700 pounds per square inch, and an elongation of 24.5 per cent in 2 inches. When aged at 310° F. after quenching, the alloy developed a tensile strength of 56,400 pounds per square inch, a yield strength of 31,700 pounds per square inch, and an elongation of 22 per cent in 2 inches. These figures compare favorably with a wrought alloy composed of aluminum and 6 per cent copper, which when heat treated and aged, possessed an average tensile strength of 58,000 pounds per square inch, a yield strength of 30,000 pounds per square inch, and an elongation of 24 per cent in 2 inches.

When the foregoing improved alloy is machined on an ordinary lathe or on an automatic screw machine, small, easily breakable chips are produced which fall away from the cutting tool as rapidly as they are formed. Furthermore, a smooth pleasing surface is left on the machined article which enhances its appearance and obviates the necessity of a subsequent finishing operation. On the other hand under the same conditions of machining, aluminum base alloys which are not free cutting will produce relatively long, tough chips, often in the form of spirals, which tend to accumulate around the cutting tool and unless removed by the operator, they may foul the tool and mar the surface of the piece being machined. The surface of the machined product is also not as satisfactory as that where our improved alloy is employed.

In the production of certain articles it sometimes becomes desirable to increase the strength, hardness or control the grain size of the alloy beyond that which is ordinarily obtainable. We have discovered that the addition of one or more of the group of elements composed of molybdenum, vanadium, titanium, tungsten, zirconium, manganese, and chromium act as hardeners without changing the fundamental characteristics of the alloy. From about 0.05 to 1 per cent of any one of these elements may be used alone, but where more than one is employed the total amount should not exceed about 2 per cent.

The lead and bismuth may be added directly to the molten aluminum base alloy in solid metallic form, since these elements melt at a temperature considerably below that of aluminum. However, since there is a great difference between the specific gravity of aluminum and that of lead and bismuth, and in view of the limited solid solubility of these elements in aluminum, the molten alloy containing lead and bismuth must be vigorously stirred to obtain a uniform distribution of these elements throughout the mass. A satisfactory method of adding such elements to aluminum is more fully described in U. S. Patent No. 1,959,029, issued March 15, 1934.

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 usual handling operations incident to ordinary melting practice.

We claim:

1. An aluminum base alloy consisting of from about 4 to 12 per cent copper, from about 0.05 to 10 per cent lead, and 0.05 to 1.5 per cent bismuth, the balance being aluminum.

2. An aluminum base alloy consisting of from about 4 to 6 per cent copper, from about 0.2 to 1.5 per cent lead, and 0.2 to 1.5 per cent bismuth, the balance being aluminum.

3. An aluminum base alloy consisting of about 6 per cent copper, 0.5 per cent lead, and 0.5 per cent bismuth, the balance being aluminum.

4. An aluminum base alloy consisting of from about 4 to 12 per cent copper, from about 0.05 to 10 per cent lead, from about 0.05 to 1.5 per cent bismuth, and from about 0.05 to 1 per cent of at least one of the elements of the group composed of titanium, vanadium, molybdenum, tungsten, zirconium, manganese and chromium, the total amount of said hardening elements not exceeding about 2 per cent, the balance of the alloy being aluminum.

5. An aluminum base alloy consisting of from about 4 to 6 per cent copper, from about 0.2 to 1.5 per cent lead, and 0.2 to 1.5 per cent bismuth, and from about 0.05 to 1 per cent of at least one of the elements of the group composed of titanium, vanadium, molybdenum, tungsten, zirconium, manganese and chromium, the total amount of said hardening elements not exceeding about 2 per cent, the balance of the alloy being aluminum.

LOUIS W. KEMPF.
WALTER A. DEAN.