United States Patent Office

2,994,947

Patented Aug. 8, 1961

1

2,994,947

ALUMINUM BASE ALLOY POWDER PRODUCT

Raymond J. Towner and John P. Lyle, Jr., New Kensington, Pa., assignors to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

No Drawing. Filed Nov. 12, 1958, Ser. No. 773,153
3 Claims. (Cl. 29—182)

This invention relates to articles made from aluminum base alloy powders and it is more particularly concerned with those products resulting from heating and working a compacted mass of atomized particles of an aluminum-beryllium base alloy.

Heretofore, compressed and sintered bodies of oxide-coated aluminum flake powders have been produced which possess unique strength properties at elevated temperatures. The particles of oxide distributed throughout the body appear to impart the unusual strength at elevated temperatures. The production of the oxide-coated flakes is time consuming and consequently expensive. It has now been found, contrary to previous belief, that useful articles can be made from certain types of atomized aluminum alloy powders. As is well known, the atomization process involves disintegrating a stream of molten metal with a jet of gas, such as compressed air or by mechanical means. Very finely divided particles can be produced by this process that will pass through a standard Tyler 100 mesh screen.

It is an object of this invention to provide articles having a high strength at elevated temperatures which are made from atomized particles of an aluminum base alloy containing beryllium as the principal added alloy component.

Another object is to provide such articles which do not require any preliminary thermal treatment to place them in condition for service at elevated temperatures.

Still another object is to provide an article made from atomized aluminum-beryllium alloy powder that does not depend upon the presence of oxide particles to impart strength at elevated temperatures.

These and other objects are achieved by atomizing a substantially iron-free aluminum base alloy containing not less than 50% aluminum and from 4 to 40% by weight of beryllium as the principal added alloy component, and subsequently consolidating and working a mass of such atomized particles under the influence of heat and pressure. The resultant articles have a density closely approximating that of the alloy if cast; and in the hot worked condition, they have a tensile strength of not less than 8,000 p.s.i. and a minimum yield strength of 7,000 p.s.i. at 600° F. after a 100-hour exposure. These tensile and yield strength values are to be compared with those of some conventional wrought heat treated aluminum base alloys that have been previously recommended for service at elevated temperatures. For example, a wrought aluminum base alloy nominally composed of aluminum, 12.2% silicon, 1.1% magnesium, 0.9% nickel and 0.9% copper has in the solution heat treated and age hardened condition a tensile strength of only 5,000 p.s.i. and a yield strength of 3,000 p.s.i. after exposure at 600° F. for 100 hours. Under the same exposure conditions a second well-known wrought aluminum base alloy nominally consisting of aluminum,

2

2.5% copper and 0.3% magnesium when worked, solution heat treated and age hardened, has a tensile strength of 5,500 p.s.i. and a yield strength of 4,500 p.s.i. The aluminum-beryllium powder products can be readily worked under the usual hot working conditions of temperature and pressure employed in fabricating conventional aluminum and aluminum base alloy articles. Furthermore, the hot worked product can be cold worked to a limited extent, if desired. The fabricated aluminum alloy products can be placed in service without any preliminary thermal treatment. The strength of the wrought powder products at elevated temperatures is not influenced to any significant extent by the oxide film which coats the atomized particles.

The atomized alloy particles are preferably prepared by melting the alloy of the desired composition and projecting it through a suitably designed nozzle with the aid of a compressed gas. The atomizing conditions should be so adjusted that none or only a small proportion of the particles are larger than 100 mesh (145 microns opening) and that the majority of the particles will pass through a 200 mesh screen (74 microns opening). The particles produced in this manner generally have an irregular shape but for the most part are substantially equiaxed in dimensions and have as-cast structure. The aluminum-beryllium constituent in the alloy is very finely divided as a result of the drastic chill associated with the atomization process. The surface of the particles are, of course, oxidized if the atomization has occurred in air or in some other oxidizing atmosphere, however, the oxide skin is very thin and the amount of oxide introduced into the final product is too small to affect the properties thereof to any significant extent.

The beryllium content of the alloy should be between 4 and 40% by weight, as mentioned above, and preferably within the range of 10 to 30% to obtain the highest strength at elevated temperatures. If less than 4% is employed, the minimum strength is not achieved and if more than 40% is present, the worked article has insufficient ductility and may fracture under applied stresses. Beryllium is substantially insoluble in aluminum and whatever small proportion may be dissolved is too small to have any significant effect upon the properties of the atomized particles. It will therefore be appreciated that the matrix of the atomized particles consists of aluminum with a dispersion of finely divided aluminum-beryllium constituent distributed throughout the particle. The high strength at elevated temperatures appears to be controlled by the amount of the aluminum-beryllium constituent and the fineness of the dispersion.

The alloy may contain the usual impurities associated with aluminum, for example, silicon and iron. Generally, the silicon impurity should not exceed 0.8% and the iron content should not be more than about 1%. Other impurities, such as copper, should not exceed 0.5%. In view of the relatively small amount of iron impurity permitted in the alloy, the composition is referred to herein as being substantially iron-free.

For some purposes, it may be desirable to add one or more elements selected from the group composed of nickel, cobalt, manganese, titanium, vanadium, zirconium, chromium, and tungsten in amounts of 0.1 to 10% each, the total not exceeding 10%. These elements act as hardeners and, like beryllium, are substantially insoluble in the aluminum matrix. To attain the properties attributable to the aluminum-beryllium constituent, the beryllium content of the alloy should exceed the total amount of any added hardener elements.

To make the wrought article from the atomized powder, the powder may be initially formed into a compact that is subsequently worked or it may be charged directly to a compression chamber such as an extrusion press cylinder and be extruded therefrom after initial consolidation of the mass. The initial compact may be made by heating the powder to a temperature between 700 and 900° F. and applying a sufficient pressure thereto for a long enough period of time to cause at least some consolidation and welding of the atomized particles. Pressures of 200 to 150,000 p.s.i. are satisfactory which are applied for varying periods of time from a minute or less to a few hours. Generally, a longer time is required where low pressures are employed. The compact may be left in the press cylinder and then extruded, or it may be ejected, cooled, scalped, reheated to the hot working temperature and hot worked. In some cases it may be desirable to reheat the compact to temperatures as high as 1150° F. before hot working in order to obtain adequate workability. Where the powder is charged to a compression chamber, it may be initially heated to a temperature between 700 and 900° F. and introduced to the chamber or it may be charged cold and heated within the chamber. Alternatively, it may be heated to an intermediate temperature, then charged to the chamber and brought to the desired temperature. When the powder is to be compacted and immediately extruded, it is generally convenient to compress the powdered mass against a blind die in a press cylinder and then substitute an extrusion die for it to produce the desired extruded shape. Although reference has been made to the extrusion of the powder mass, it is to be understood that it can be subjected to other types of hot working operations, such as rolling, forging or pressing, providing a suitable compact is initially produced. The hot working is preferably performed within the temperature range of 700 to 900° F.

Our invention is illustrated by the following example wherein an aluminum-4.0% beryllium atomized powder was consolidated and the product hot worked. The powder was of a fineness such that approximately 85% passed through a 200 mesh screen and substantially all of the remainder passed through a 100 mesh screen.

The alloy powder was charged to an extrusion press cylinder preheated to 800° F. and compressed against a blind die under a pressure of 100,000 p.s.i. for a period of approximately one minute. In the course of charging and compressing the powder, the temperature of the compact reached 700° F. After the compact was formed it was ejected from the cylinder, cooled to room temperature, scalped, reheated to 850° F., inserted in an extrusion press and extruded into ¾" diameter rod. Tensile specimens were cut from the extruded rod and tested without any preliminary thermal treatment, some at room temperature and others at 600° F. after a 100-hour exposure at that temperature. The tensile properties at both room temperature and at 600° F. are given in Table I below.

TABLE I

Tensile properties of extruded Al—Be powder product

At Room Temperature			At 600° F.		
Tensile Strength, p.s.i.	Yield Strength, p.s.i.	Percent Elong.	Tensile Strength, p.s.i.	Yield Strength, p.s.i.	Percent Elong.
27,600	15,400	24	8,200	7,200	42

It is apparent from the foregoing that the tensile and yield strengths of the alloy were higher at 600° F. than those of the two commercial wrought heat treated alloys mentioned above. It is also noteworthy that the properties reported are those obtained without any preliminary thermal treatment of the worked powder article such as a solution heat treatment, which is an economic advantage.

Having thus described our invention and certain embodiments thereof, we claim:

1. A hot worked aluminum base alloy powder article free from aluminum oxide except as an incidental impurity and having a maximum iron content of 1%, said hot worked alloy powder article being formed from atomized powder of an aluminum base alloy containing at least 50% by weight of aluminum and from 4 to 40% by weight of beryllium as the essential component, the amount of said component exceeding the total quantity of any hardening elements present in the alloy, said alloy being substantially free from elements which form a solid solution with aluminum, except as they occur as impurities, said hot worked article being characterized in the as-worked condition by a tensile strength at 600° F. after a 100-hour exposure of not less than 8000 p.s.i. and a yield strength of not less than 7000 p.s.i.

2. A hot worked aluminum base alloy powder article according to claim 1 wherein the beryllium content is 10 to 30%.

3. A hot worked aluminum base alloy powder article according to claim 1 wherein the alloy also contains at least one hardening element selected from the group consisting of nickel, cobalt, manganese, titanium, vanadium, zirconium, chromium and tungsten in amounts of 0.1 to 10% by weight of each, the total not exceeding 10% by weight, the beryllium content of said alloy exceeding the amount of hardening elements added thereto.

References Cited in the file of this patent

UNITED STATES PATENTS

2,796,660 Irmann ---------------- June 25, 1957

OTHER REFERENCES

Gregory et al.: "Journal of Metals," vol. 6, pp. 247–252, February 1954.