

United States Patent

Lyle, Jr. et al.

[15] 3,637,441

[45] Jan. 25, 1972

[54] **ALUMINUM-COPPER-MAGNESIUM-
ZINC POWDER METALLURGY
ALLOYS**

[72] Inventors: John P. Lyle, Jr., New Kensington, Pa.;
Raymond J. Towner, Lima, Ohio

[73] Assignee: Aluminum Company of America, Pitts-
sburgh, PA

[22] Filed: Mar. 2, 1970

[21] Appl. No.: 18,781

Related U.S. Application Data

[62] Division of Ser. No. 719,752, Apr. 8, 1968, Pat. No.
3,544,394.

[52] U.S. Cl. 148/32.5

[51] Int. Cl. C22c 21/00, C22f 1/04

[58] Field of Search 148/32.5, 12.7; 75/141, 142,
75/144, 0.5 B

[56] **References Cited**

UNITED STATES PATENTS

2,506,788 5/1950 Hobbs 148/12.7

3,198,676	8/1965	Sproles	148/32.5
3,265,493	8/1966	Foerster	75/142
3,291,654	12/1966	Foerster	148/159
3,307,978	3/1967	Foerster	148/12.7

Primary Examiner—L. Dewayne Rutledge

Assistant Examiner—W. W. Stallard

Attorney—Abram W. Hatcher

[57] **ABSTRACT**

Aluminum base powder metallurgy alloy article having an improved combination of high-transverse yield strength and high-stress corrosion cracking resistance. The alloy contains the basic precipitation hardening elements zinc, magnesium and copper plus dispersion strengthening elements iron and nickel. It may additionally contain chromium and/or manganese. The alloy is prepared by atomization of a melt of the elements, hot-working, solution heat treating, quenching and artificial aging. Components of the alloy in percent by weight are, in addition to the aluminum, from at least 6.5 to 13 zinc, 1.75 to 6 magnesium, 0.25 to 2.5 copper, 0.75 to 4.25 iron and 0.75 to 6 nickel, up to 3 manganese and up to 0.75 chromium. The iron to nickel ratio is from 0.2:1 to 2.0:1.

5 Claims, No Drawings

ALUMINUM-COPPER-MAGNESIUM-ZINC POWDER METALLURGY ALLOYS

This application is a division of parent application Ser. No. 719,752, filed Apr. 8, 1968 now U.S. Pat. No. 3,544,394.

BACKGROUND OF THE INVENTION

This invention relates to aluminum-copper-magnesium-zinc alloys prepared by powder metallurgy techniques. More particularly, it pertains to improving tensile and stress corrosion properties of articles prepared from aluminum-copper-magnesium-zinc alloys by the addition of certain dispersion strengthening elements to the melt from which the alloys are prepared by atomization. By powder metallurgy techniques we mean those processes in which the molten alloy is atomized to make fine powder, the powders are compacted, and the compact is fabricated into the desired form by hot working.

One way in which to improve tensile properties, that is, in general, to strengthen aluminum base alloys is by precipitation hardening. This occurs when a supersaturated solid solution precipitates its excess solute. The process is favored in alloy systems with appreciably greater solubility for the solute at elevated temperatures than at lower or ambient temperatures. The precipitate effects strengthening of the structure by setting up coherency strains in the matrix by the precipitated particles. Zinc, magnesium and copper are well known as elements which contribute substantially to precipitation hardening. It is also known that strengthening may be improved by adding to the alloy system one or more elements which form compounds having low solubilities and low diffusibilities in the solid state at elevated temperatures to impart a strengthening effect which lasts even after extensive heat treatment. This type of reaction is commonly referred to as dispersion strengthening or interference hardening.

Copper, magnesium and zinc have been disclosed to be useful precipitation hardening elements for use in aluminum base alloys. Individual dispersion strengthening elements which have been suggested for use in improving the properties of aluminum base alloys include manganese, iron, nickel, chromium, titanium, vanadium, zirconium, cobalt, molybdenum and tungsten. Thus far it has not proved too difficult to add precipitation hardening elements because of their characteristic high-liquid solubilities, high-solid solubilities at high temperatures, and high-solid diffusibilities at high temperatures. However, for addition of dispersion strengthening elements, standard ingot casting procedures have been of limited use when it was desired to modify the alloy composition by addition of considerable amounts of these elements. This has been due to the fact that dispersion strengthening elements are characterized by low-liquid solubilities near the solidification temperatures and low-solid solubilities and low-solid diffusibilities at elevated temperatures. It has been proposed to combine the strengthening characteristics of both precipitation hardening and dispersion strengthening elements by using atomization of alloys from the melt to permit use of higher concentrations of elements than is possible in ingot metallurgy where the casting solidification rates are slow relative to atomizing solidification rates. Use of atomized alloy powders has helped improve the strength properties of aluminum base alloys by resulting in a structure which is several orders of magnitude finer than standard ingot metallurgy alloy structures.

While considerable improvement in strength has been possible by the aforementioned combination of dispersion strengthening and precipitation hardening, particularly with the improved results obtained by atomization of a melt of the alloy containing the dispersion strengthening elements, improvements in stress corrosion cracking resistance, one of the main features desired for lightweight rocket motor and aircraft parts, have thus far been rather limited, probably partly because of the fact that, in increasing stress corrosion resistance by standard age hardening procedures, the strength properties of the alloys have been somewhat impaired, making them not entirely satisfactory for some high-stress applications.

OUTLINE OF THE INVENTION

Accordingly, it is an object of this invention to provide a novel hot-worked powder metallurgy alloy article which combines a transverse yield strength which is equal to or superior to that of presently known aluminum base ingot metallurgy alloy articles containing the precipitation hardening elements copper, magnesium and zinc with a stress corrosion cracking resistance which is greater than that of such known ingot metallurgy alloy articles. Another object is to provide a method for production of novel powder metallurgy alloys which have a transverse yield strength comparable to that of known aluminum-copper-magnesium-zinc ingot metallurgy alloys plus a higher resistance to stress corrosion cracking. These and other objects of the invention will be apparent from the description and claims which follow.

In accordance with this invention a hot-worked powder metallurgy alloy article is prepared in which the alloy contains in percent by weight from at least 6.5-13 zinc, 1.75-6 magnesium, 0.25-2.5 copper, 0.75-4.25 iron and 0.75-6 nickel. The alloy may additionally contain up to 3 manganese, (preferably 0.25-2) and up to 0.75 chromium. It may also contain up to 1.5 percent by weight Al_2O_3 and up to a total of about 1 percent by weight of other elements such as titanium, silicon, vanadium or the like, generally as impurities. The Fe:Ni ratio should be from 0.2:1 to 2.0:1.

One feature of the alloy article of this invention is its combination of high resistance to stress corrosion cracking with high-transverse yield strength as great as or superior to that of prior art conventional ingot metallurgy aluminum-zinc-copper-magnesium alloy articles which contain less zinc and no combination of iron and nickel. By high-transverse yield strength we mean at least about 60-67 k.s.i. (thousands of pounds per square inch), which is the transverse yield strength of conventional 2-inch diameter ingot metallurgy extruded rods of aluminum-zinc-copper-magnesium alloys containing less than 6.5 percent by weight zinc and not having a combination of iron and nickel. By high resistance to stress corrosion cracking we mean an absence of cracking or breaking apart of a solution heat treated and artificially aged 2-inch diameter extruded rod after at least 84 days under a stress in a transverse direction of 50 percent of its transverse yield strength in the standard stress corrosion test of alternate immersion in a 3.5 percent by weight sodium chloride solution. [ASTM STP 425 (1967), pp. 8 and 188]. The aforementioned conventional rods fail, that is, crack or break apart, in this test in less than 84 days.

To obtain this combination of high-stress corrosion resistance and high-transverse yield strength, the aging is preferably at a temperature of from about 225° to 350° F. for from about 3 to about 100 hours. According to another embodiment, a two-stage aging procedure may be used in which the first stage is at from about 225° to about 275° F. for from about 6 to about 96 hours and the second at from about 315° to about 350° F. for from about 3 to about 40 hours. The solution heat treatment is preferably at a temperature of from about 750° to 1,000° F. The solution heat treatment and aging procedures described in Sprowls et al. U.S. Pat. No. 3,198,676 may be used according to this invention.

One method for preparation of the alloy articles of our invention is as follows:

1. melting and alloying,
2. atomizing, collecting and screening (for example, to 100 mesh powder with a Sharples Micromerograph mass median diameter (MMD) of 5-60 microns),
3. compacting to less than 100 percent density e.g., in a tapered or split die,
4. degassing by heating in a flowing nonoxidizing atmosphere,
5. hot compacting to substantially 100 percent density and then
6. hot working.

The hot working may be by conventional extrusion, forging, impact extrusion or rolling.

United States Patent

Bonyata et al.

[15] 3,637,444

[45] Jan. 25, 1972

[54] **PROCESS OF MAKING DETERRENT-COATED AND GRAPHITE-GLAZED SMOKELESS POWDER**

[72] Inventors: John O. Bonyata, Mountain Lakes; Lynn G. Rohrbaugh, Lake Hopatcong, both of N.J.

[73] Assignee: Hercules Incorporated, Wilmington, Del.

[22] Filed: Apr. 14, 1969

[21] Appl. No.: 816,023

[52] U.S. Cl. 149/10, 149/9, 149/11, 149/12, 264/3 C

[51] Int. Cl. C06b 19/02

[58] Field of Search.....149/100, 97, 98, 9, 11, 12, 149/10; 264/3

[56] **References Cited**

UNITED STATES PATENTS

1,393,623 10/1921 Henning 149/9

1,390,740	9/1921	Woodbridge	149/9
2,008,889	7/1935	Wagner	149/10
2,113,418	4/1938	Woodbridge	149/10
2,152,509	3/1939	Troxler.....	149/10
2,179,312	11/1939	Allison.....	149/10
2,346,125	4/1944	Goodyear	149/10
2,440,267	4/1948	Hale	149/10
2,407,967	9/1946	Thomson.....	149/9
2,865,728	12/1958	Cook	149/10
3,506,505	4/1970	Herzog et al.....	149/9

Primary Examiner—Carl D. Quarforth

Assistant Examiner—Stephen J. Lechert, Jr.

Attorney—S. Grant Stewart

[57]

ABSTRACT

An improved process for manufacture of deterrent-coated and graphite-glazed smokeless powder is provided with deterrent coating and graphite glazing being done in an aqueous slurry at elevated temperatures.

20 Claims, No Drawings