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# ALUMINUM BASE PELLET ALLOYS CONTAINING COPPER AND MAGNESIUM AND PROCESS FOR PRODUCING THE SAME

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This invention relates to aluminum base alloys and more particularly concerns a novel aluminum base alloy having special utility in the preparation of high strength fabricated articles thereof and the process for preparing these articles.

In general, the known aluminum base alloys containing copper and magnesium possess only moderate strength. Therefore, in applications requiring higher strength, these alloys of the aluminum-copper-magnesium system have heretofore been limited in their utility.

The object of the present invention, therefore, is to provide a novel aluminum base alloy containing copper and magnesium capable of being processed to obtain high strength fabrications thereof, and the process for preparing these high strength fabrications.

It has been found, in accordance with the present invention, that the above and other objects are obtainable in an aluminum base alloy containing copper and magnesium by incorporating therein certain alloying metals, hereinafter referred to as additive metals, in particular amounts, and processing the so-prepared novel alloy under particular conditions to obtain optimum strength.

All percents referred to herein are to weight unless otherwise indicated.

In general, the novel aluminum base alloy of the present invention contains copper in an amount of at least 4 percent, preferably at least 5 percent, up to 15 percent, an additive metal or combination of additive metals in an amount within the range of from about 0.1 to about 10.0 percent selected from the group consisting of barium, chromium, manganese, nickel and vanadium, and magnesium in an amount of from about 1.0 percent, up to 3.0 percent, the balance being essentially aluminum. In Table I below, examples of both the operable and preferred concentration ranges for each additive metal are set forth, the second column is for the alloys containing at least 4 percent copper, while the third column is for the alloys containing at least 5 percent copper.

TABLE I

| Additive | Range at 4% minimum Cu | Range at 5% minimum Cu (Preferred) |
|---|---|---|
| Barium | 0.5 to 10.0 | 2.0 to 8.0 |
| Chromium | 0.2 to 4.0 | 1.0 to 3.0 |
| Manganese | 1.5 to 6.0 | 2.0 to 4.0 |
| Nickel | 2.5 to 10.0 | 3.0 to 6.0 |
| Vanadium | 0.2 to 2.5 | 0.5 to 1.5 |

Also depending on the effect desired other alloying elements conventionally employed can be added to the alloy of the present invention provided it does not detract from the excellent strength properties obtained under the present invention.

In practicing the present invention, the novel aluminum base alloy, as specified herein, is prepared by using the alloying and melting techniques commonly employed in the aluminum art and then rapidly solidified as, for example, by jet or disc type atomizing devices either in cool air or in a cool inert atmosphere such as, for example, argon. The molten alloy may also be cast into



ordinary ingots. However, the strength values thereby obtained are generally less satisfactory than when thin-walled cold molds are used. When the alloy is prepared by atomizing or pelleting, it is preferred to convert this into massive metal by die expression to obtain maximum properties in fabricated articles, using normal extrusion techniques and equipment. If desired, however, other hot working fabrication methods may be used such as, for example, rolling and forging. In addition, the present alloys may also be cast into thin walled cold molds. In the latter method, both rapid solidification and fabrication are accomplished in the same operation.

In extruding, the pellets are normally preheated to a temperature within the range of from about 600° F. to about 1000° F., and the extrusion container is at a temperature of from about 500° F. to about 850° F. If desired, the pellets may be precompacted prior to extruding.

In order to obtain optimum strength, regardless of the method of fabrication employed, the alloys of the present invention must thereafter be solution heat treated, rapidly quenched, and aged. Solution heat treating may be accomplished at a temperature within the range of from about 900° F. to about 1000° F. for a period of about one minute or more, followed by rapid quenching and aging the quenched article at a temperature of from about 300° F. to about 400° F. for a period of from about 5 hours to about 20 hours. Normally, the extrude is solution heat treated at about 920° F. for about 15 minutes, water quenched, then artificially aged at 340° F. for 16 hours. However, different heat treatment combinations can be employed, depending on the alloy system being used and the properties desired, without departing from the scope and substance of the invention. If desired, the extrude may be quenched as it emerges from the die then subsequently aged, rather than solution heat treated, quenched, then aged.

The term "fabrication" as used herein refers to mechanical working procedures such as extruding, casting, rolling, forging, and spinning.

The following examples serve to further illustrate the present invention.

A number of aluminum base alloys containing copper and magnesium were prepared, each containing one or more additive metals as listed in Table I above within the herein specified ranges. Each alloy was either cast into ingots (I) 3 inches in diameter or atomized into pellets (P) having a size such that about 85 percent of the pellets passed through a No. 20 sieve and was retained on a No. 200 sieve (U.S. Standard Sieve Series, Fine), while the remainder passed through the No. 200 sieve.

Both the ingots and pellets of the above-prepared alloy compositions were extruded by first preheating to a temperature of about 800° F., then placing the material in the container of a ram extruder, the container being about the same temperature as the pellets, and extruding at a rate of about 5 feet per minute (f.p.m.) into a strip having a rectangular cross section of 0.2 inch by 1.0 inch. The resulting strips were then solution heat treated at 920° F. for one hour, quenched, then aged for 16 hours at 340° F.

For comparison, both ingots (I) and pellets (P) of some of the above alloys were prepared and processed, using the same procedure and under the same conditions as above but containing no additive metals.

Standard test pieces of all the alloys, prepared as above, were made and tested at room temperature, including the blanks aforementioned for comparison in order to record percent elongation (percent E) (using a 2 inch gauge length), tensile strength (TS), and tensile yield strength (TYS) (at 0.2 percent offset). Representative results of these tests are presented in Table II below.

TABLE II

| Example | Percent Cu | Percent Mg | Percent Additive | Form | Percent E | 1,000 p.s.i.[1] | |
|---|---|---|---|---|---|---|---|
| | | | | | | TYS | TS |
| (Blank) | 5.0 | 1.5 | 0 | I | 24 | 38 | 59 |
| (Blank) | 4.5 | 1.5 | .6 Mn | I | 20 | 41 | 63 |
| (1) | 5.5 | 1.7 | 3.0 Mn | P | 2 | 65 | 77 |
| (2) | 5.0 | 2.1 | 1.6 Mn | P | 8 | 58 | |
| (3) | 5.0 | 1.5 | 3 Cr . 6 Mn | P | 10 | 60 | 80 |
| (4) | 5.0 | 1.5 | 3 Ni . 6 Mn | P | 6 | 54 | 71 |
| (5) | 5.0 | 1.7 | 5 Ba | P | 10 | 50 | 74 |
| (6) | 5.0 | 1.6 | 1.5 V | P | 4 | 63 | 75 |

[1] P.s.i.=pounds per square inch.

Table II representatively illustrates the excellent strength values obtained in the alloy of the present invention over that obtained in an aluminum base alloy containing copper and magnesium but no additive metal. Further, it can be seen from Examples 1 through 6 that the high strength powder alloy articles of the present invention may be particularly characterized by a minimum tensile yield strength of at least about 50,000 p.s.i. and in most cases are characterized by a tensile yield strength markedly greater than said minimum. This is significantly higher than that of aluminum base alloys which are similar (see Blanks) but not processed in accordance with the present invention.

I claim:

**1.** A process for preparing a hot worked high strength aluminum base pellet alloy article characterized by a tensile yield strength of at least about 50,000 p.s.i. which comprises:

(1) providing a molten aluminum base alloy consisting essentially of from about 4.0 to about 15 percent copper, from about 1.0 to about 3.0 percent of magnesium, and from about 0.2 to about 10.0 percent of at least one additive metal, the balance being aluminum, said additive metal being a member selected from the group consisting of barium, chromium, manganese, nickel, and vanadium;

(2) rapidly solidifying said molten aluminum base alloy into a pelleted form;

(3) hot working the so-solidified pelleted alloy into a shaped article; and

(4) solution heat treating the shaped article, followed by rapid quenching, and ageing of said article, thereby preparing a hot worked, high strength, aluminum base alloy article characterized by a tensile yield strength of at least about 50,000 p.s.i.

**2.** The process of claim **1** wherein the shaped article is solution heat treated at a temperature within the range of from about 900° F. to about 1000° F. for a period of time of at least about one minute, rapidly quenched, and then aged at a temperature within the range of from about 300° F. to about 400° F. for a duration of from about 5 to about 20 hours.

**3.** The process of claim **1** wherein within the total concentration of additive metal in the aluminum base alloy of step (1) each of said additive metals in said article is further characterized as being within the range of from about 0.5 to about 10.0 percent of barium, from about 0.2 to about 4.0 percent of chromium, from about 1.5 to about 6.0 percent of manganese, from about 2.5 to about 10.0 percent of nickel, and from about 0.2 to about 2.5 percent of vanadium.

**4.** A process for preparing an extruded high strength aluminum base pellet alloy article characterized by a tensile yield strength of at least about 50,000 p.s.i. which comprises:

(1) providing a pelleted aluminum base alloy consisting essentially by weight of from about 4.0 to about 15 percent copper, from about 1.0 to about 3.0 percent of magnesium, and at least one additive metal in an amount and selected from the group consisting of from about 0.5 to about 10.0 percent of barium, from about 0.2 to about 4.0 percent of chromium, from about 1.5 to about 6.0 percent of manganese, from about 2.5 to about 10.0 percent of nickel, and from about 0.2 to about 2.5 percent of vanadium, the balance being aluminum, the total amount of additive metal employed being within the range of from about 0.2 to about 10.0 percent;

(2) extruding said pelleted alloy at a temperature within the range of from about 600° F. to about 1000° F. into a shaped article;

(3) solution heat treating the article so-shaped; and

(4) rapidly quenching and ageing said article.

**5.** The process of claim **4** wherein the shaped article is solution heat treated at a temperature within the range of from about 900° F. to about 1000° F. for a period of time of at least one minute, rapidly quenched, and then aged at a temperature within the range of from about 300° F. to about 400° F. for a duration of from about 5 to about 20 hours.

**6.** The process of claim **4** wherein the copper concentration in the pelleted alloy of step (1) is within the range of from about 5 to about 15 percent, and wherein within the total concentration of additive metal each of said additive metals is within the range of from about 2.0 to about 8.0 percent of barium, from about 1.0 to about 3.0 percent of chromium, from about 2.0 to about 4.0 percent of manganese, from about 3.0 to about 6.0 percent of nickel, and from about 0.5 to about 1.5 percent of vanadium.

**7.** An aluminum base pellet alloy article consisting essentially of copper in an amount within the range of from about 4 to about 15 percent, magnesium in an amount within the range of from about 1 to about 3 percent, and at least one additive metal selected from the group consisting of barium, chromium, manganese, nickel, and vanadium, in a total amount of from about 0.1 to about 10.0 percent, the balance being aluminum said pellet alloy article being characterized in a hot worked form by a tensile yield strength at room temperature of not less than about 50,000 p.s.i.

**8.** The aluminum base pellet alloy article of claim **7** wherein, within the total concentration of the additive metal, each of said additive metals is in the range of from about 0.5 to about 10 percent of barium, from about 0.2 to about 4.0 percent of chromium, from about 1.5 to about 6.0 percent of manganese, from about 2.5 to about 10.0 percent of nickel, and from about 0.2 to about 2.5 percent of vanadium.

**9.** The aluminum base pellet alloy article of claim **7** wherein the concentration of copper is within the range of from about 5 percent to about 15 percent and wherein the total concentration of additive metal is within the range of from about 0.5 to about 8.0 percent.

**10.** The aluminum base pellet alloy article of claim **9** wherein, within the total concentration of additive metal, each of said additive metals in said article is further characterized as being within the range of from about 2.0 to about 8.0 percent of barium, from about 1.0 to about 3.0 percent of chromium, from about 2.0 to about 4.0 percent of manganese, from about 3.0 to about 6.0 percent of nickel, and from about 0.5 to about 1.5 percent of vanadium.

**11.** An aluminum base pellet alloy article consisting essentially of copper in an amount within the range of from about 4 to about 15 percent, magnesium in an amount within the range of from about 1 to about 3 percent, and at least one additive metal selected from the group consisting of from about 0.5 to about 10 percent of barium, from about 0.2 to about 4.0 percent of chromium, from about 1.5 to about 6.0 percent of manganese, from about 2.5 to about 10.0 percent of nickel, the balance being

aluminum, said pellet alloy article being characterized in an extruded form by a tensile strength at room temperatures of not less than about 50,000 p.s.i.


**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,932,853 | 10/1933 | Dean et al. | 75—142 |
| 2,273,061 | 2/1942 | Murphy et al. | 75—142 |
| 2,459,492 | 1/1949 | Bradbury et al. | 75—139 X |
| 2,966,731 | 1/1961 | Towner et al. | 29—182 |



FOREIGN PATENTS

| | | |
|---|---|---|
| 373,213 | 5/1932 | Great Britain. |
| 373,434 | 5/1932 | Great Britain. |
| 469,955 | 8/1937 | Great Britain. |



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