

1

2,944,889

ALUMINUM BRONZE ALLOY CONTAINING CHROMIUM AND HAVING IMPROVED WEAR RESISTANCE

John F. Klement, 2839 S. 46th St., Milwaukee, Wis.

No Drawing. Filed Nov. 20, 1957, Ser. No. 697,537

5 Claims. (Cl. 75-162)

This invention relates to an aluminum bronze alloy and more particularly to an aluminum bronze alloy having improved corrosion resistance, toughness and wear resistance.

Aluminum bronze alloys have for years been used as dies for forming and drawing operations for a large group of sheet and plate alloys, such as stainless steel, aluminum, nickel, titanium, mild steel and some copper base alloys. Aluminum bronze alloys used in die applications possess the properties of good corrosion resistance, wear resistance and non-galling against many wrought materials.

The aluminum bronze alloys which in the past have shown the optimum properties for deep drawing dies are those that contain approximately 14% aluminum, a small amount of iron and the balance copper. An alloy of this type has good corrosion resistance and non-galling properties. However, under heavy use in die application, this alloy sometimes wears undesirably fast so that close dimensional tolerances cannot be maintained because of the wear that occurs on the die surface.

The present invention is directed to an aluminum bronze alloy having the non-galling properties characteristic of aluminum bronze alloys but having greatly improved corrosion resistance, wear resistance and toughness. This is accomplished by the addition of a small amount of chromium to the alloy which renders the alloy less susceptible to eutectoid transformation and its embrittling structure.

The alloy of the invention has the following general composition by weight:

	Percent
Aluminum	13.0-20.0
Iron	1.0-8.0
Chromium	0.5-3.0
Copper	Balance

A specific illustration of the composition falling within the above range is as follows in weight percent:

	Percent
Aluminum	13.01
Iron	4.13
Chromium	1.51
Copper	81.35

The wear resistance of the alloy of the invention is substantially improved over that of aluminum bronze alloys which do not contain the chromium. The data contained in the following table shows the improved wear resistance of the alloy of the invention over similar aluminum bronze alloys which do not contain the chromium addition:

Alloy	Al	Fe	Cr	Cu	Hardness, Rc	Number of Draws Before Die Redressing
1.	14.14	4.14	0	81.72	37	77,000
2.	13.70	7.42	0	78.88	35	93,190
3.	13.01	4.13	1.51	81.35	32	134,493

2

The draws set forth in the above table were made on production presses drawing stainless steel parts for barrels and the results clearly show the superiority of the present alloy in regard to wear resistance over that of the other alloys which do not contain the chromium addition. As shown in the table, 134,493 draws were made with the die fabricated from the present alloy before it was necessary to redress the die due to loss of dimensional tolerance caused by wear, while the alloy samples 1 and 2, which did not contain the chromium addition, had to be redressed after only 77,000 and 93,190 draws, respectively.

The increase in the wear resistance of the alloy with the addition of chromium is particularly surprising since the hardness of the alloy containing chromium is less than the hardness of the alloys which do not contain chromium, as shown in the table. With the decrease in hardness, it would be expected that the wear resistance of the alloy would be correspondingly decreased; however, the opposite is true with respect to the alloy of the invention.

The alloy of the invention containing about 13% aluminum, 4% iron, 1.5% chromium and the balance copper can be cast statically or centrifugally to produce a fine grain tough structure having a hardness of approximately 32 Rockwell C. The hardness of the alloy can be varied within the range of 25 Rockwell C to 55 Rockwell C depending upon the specific aluminum and chromium content in the alloy.

The alloy with the above composition has unusual compressive strength and test specimens have been as high as 200,000 p.s.i. in ultimate compression. A centrifugally cast alloy of the above composition has a tensile strength of about 100,000 p.s.i., while a statically cast alloy has a tensile strength of about 80,000 p.s.i.

The metallographic structure of the alloy consists essentially of gamma two phase which is uniformly distributed in a matrix of beta. An intermetallic compound composed of iron, aluminum, copper and chromium exists in rosette and spheroid particles and is uniformly distributed throughout the cast section.

In addition to substantially increasing the wear resistance of the alloy, the chromium improves the corrosion resistance and also makes the alloy less susceptible to the eutectoid transformation. The eutectoid structure consists of alpha phase plus gamma two phase formed from the transformation-decomposition of the beta phase. This transformation occurs at temperatures below 1050° F. in aluminum bronze alloys and the resultant eutectoid structure is brittle and possesses low ductility and poor machinability.

The chromium also provides a finer grain structure which enables the alloy to be machined to a better finish.

In order to obtain optimum properties, the metals used with the alloy should be of high quality. Electrolytic or wrought fire refined copper, high purity aluminum, low carbon iron and high purity chromium are preferred to be used. It has been found that a very satisfactory method of obtaining the desired uniformity in the alloy is by using a double melting procedure whereby a pre-alloy is made. The most satisfactory pre-alloy is one that has approximately 50% aluminum, 20% copper, 20% iron and 10% chromium. The chromium can be added to the pre-alloy in the form of powdered briquets containing 35% chromium and the balance copper.

The melting procedure employed in making the pre-alloy is such that some copper, along with the iron and chromium, is placed into the crucible and melting begun. When the copper starts to melt, the iron and other additives are slowly dissolved into the copper during the period when aluminum is added to form an exothermic reaction which helps to dissolve the higher melting point

chromium addition. This pre-alloy is then cast into ingot form and is ready to use for the final alloy.

Alternately, instead of adding the chromium to the pre-alloy, the chromium can be added to the final alloy. In this case, an alloy of 10% chromium and 90% copper is added to the final alloy.

To establish complete uniformity of the micro-structure and hardness, the alloy is heat treated at an elevated temperature in the range of 1050° F. to 1400° F., such as about 1150° F. Small castings of simple shapes of this alloy can be placed directly into the heat treating furnace at temperature. Large massive castings or intricate shapes are preheated in the furnace at about 400° F. until the section reaches uniform temperature and then are heated directly to the elevated temperature. The castings are held at a temperature in the range of 1050° F. to 1400° F. for one hour plus one-half hour per inch of section thickness greater than one inch, up to a maximum of two and one-half hours.

After the required soaking time at the elevated temperature, the alloy is cooled at a rate faster than about 20° F. per hour per one inch of section thickness. This rate is conveniently obtained by fan air cooling.

Internal stresses created within castings during machining or other finishing operations, during weldments, or from metal overlays on base metals, are usually removed depending on the future application of the part. These stresses are removed by a stress relief heat treatment.

To stress relieve the alloy, the alloy is heated to a temperature below 600° F. and maintained at this temperature for a period up to 3 hours per one inch of section thickness. The article is then cooled to room temperature. More specifically, to stress relieve the alloy, the alloy is heated to a temperature of 500° F. and maintained at this temperature for approximately 2 hours per one inch of section thickness.

The alloy of this invention can be used to produce articles that require corrosion resistance, toughness and exceptional wearing properties. The articles may take the form of deep drawing dies, wear guides, forming rolls, etc.

The alloy can also be extruded into weldrods or weld wire. The alloy in the form of coated or uncoated weld-rod can be overlaid on a base metal by metal spraying or other welding methods, such as heli-arc, metal-arc, carbon-arc, etc. to obtain a corrosion resistant wear surface. The metal overlay can be given a stress relief treatment at temperatures in the range of 650° F. to 1150° F. and cooled to room temperature.

It has been found that the addition of chromium to

the copper aluminum iron alloy to be used as die materials greatly improves the resistance to surface oxidation, improves the toughness and wear resistance of the alloy and makes it less susceptible to eutectoid embrittlement.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. An aluminum bronze alloy consisting essentially of 13.0% to 20.0% aluminum, from 1.0% to 8.0% iron, from 0.5% to 3.0% chromium and the balance being substantially copper, said alloy being characterized by having excellent corrosion resistance and having improved toughness and wear resistance.

2. An aluminum bronze alloy consisting essentially of 13.0% to 20.0% aluminum, from 1.0% to 8.0% iron, from 0.5 to 3.0% chromium and the balance being substantially copper, said alloy having a hardness in the range of 25 to 55 Rockwell C and being characterized by having improved corrosion resistance, toughness and wear resistance.

3. An aluminum bronze alloy having improved corrosion resistance, toughness and wear resistance, consisting essentially of 13.01% aluminum, 4.13% iron, 1.51% chromium and the balance copper.

4. An aluminum bronze alloy welding electrode, consisting essentially of 13.0% to 20.0% aluminum, from 1.0% to 8.0% iron, from 0.5% to 3% chromium and the balance being substantially copper.

5. A die for use in working a metal selected from the group consisting of stainless steel, aluminum, nickel, titanium, mild steel and copper base alloys, said die being fabricated from an aluminum bronze alloy consisting essentially of 13.0% to 20.0% aluminum, from 1.0% to 8.0% iron, from 0.5% to 3.0% chromium and the balance being substantially copper, said alloy having a hardness in the range of 25 to 55 Rockwell C and being characterized by having improved corrosion resistance, toughness and wear resistance.

References Cited in the file of this patent

UNITED STATES PATENTS

2,210,673	Kelly	Aug. 6, 1940
2,585,613	Allen	Feb. 12, 1952
2,715,577	Payne et al.	Aug. 16, 1955
2,789,929	Cuthbert et al.	Apr. 23, 1957

FOREIGN PATENTS

537,404	Great Britain	Sept. 18, 1940
---------	---------------	----------------