[54] ZINC-ALUMINUM ALLOY

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[22] Filed: July 7, 1970

[21] Appl. No.: 53,039

[30] Foreign Application Priority Data
   July 9, 1969 Germany..................... P 19 34 788.7

[52] U.S. Cl. ............ 75/178 A, 75/178 AC, 148/11.5
[51] Int. Cl........................... C22c 17/00
[58] Field of Search .............. 75/178 A, 178 AC

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[57] ABSTRACT

A zinc-aluminum alloy consisting of 18 to 24% by weight (preferably 21% by weight) aluminum, the balance zinc and 0.1 to 1.5% by weight nickel (preferably 0.3 to 1.0% by weight). The nickel component represents a further metal for which can be substituted, to an amount of about 50% by weight, titanium in an amount of 0.05 to 0.5% by weight of the alloy, copper up to 0.5% by weight of the alloy, iron in an amount of up to 0.75% by weight of the alloy, and silicon in an amount of up to 0.75% by weight of the alloy. The lead, cadmium and tin content should be no greater than 0.05% by weight of the alloy and the magnesium content is preferably less than 0.0005% by weight of the alloy.

4 Claims, No Drawings
My present invention relates to zinc/aluminum alloys and, more particularly, to a zinc-aluminum alloy of high strength and considerable ductility and to a method of making such alloys and bodies containing same.

Numerous zinc and aluminum alloys have been proposed heretofore, generally as ductile metals facilitating shaping in dies or the like. Typical shaping methods include extrusion, drawing and die-casting and, depending upon the requirements of the alloy, bodies composed thereof must be capable of withstanding bending, folding, compression and tensile stresses. It is advantageous, therefore, to have high ductility and resistance to rupture, high resistance to fatigue and high strength, e.g. compressive strength and tensile strength. It is also important that these characteristics be present at room temperature, the bodies being most frequently used at this temperature or at a mean temperature close to room temperature.

It has been proposed to provide binary zinc-aluminum alloys in which some of the ductile characteristics of zinc and the compressive-strength characteristics of aluminum can be combined. For example, binary zinc-aluminum alloys containing between 1 and 63 percent by weight aluminum and 99 to 37 percent by weight zinc (the balance) have been studied. When such alloys, which have homogeneous solid-solution crystalline characteristics, are quenched from temperatures above 250°C, e.g. at room temperature, the solid solution develops in a fine-grained eutectic crystalline structure and yields an alloy of high ductility which can be plasticly deformed readily with relatively low mechanical stress. Such alloys are advantageous for die forming, extrusion and drawing. Of even more significance, however, is the fact that the alloy is amenable to vacuum-forming, i.e. foils of the metal, e.g. prepared by lowering, can be vacuum-formed in a manner analogous to the formation of blisters, bubbles, containers and the like from thermoplastic foils. In fact, this unique method of forming, which was not generally possible earlier in the metal-working art, opens new vistas in the processing of sheet metals.

Such zinc-aluminum alloys, in this state, with compressive strength of 16 to 20 kg/mm² have elongation values of more than 100 percent, so that bands, sheets and strips of the metal can be bent or folded through 180° without rupture or crack formation and can be used more effectively in deep-drawing. However, these highly ductile zinc-aluminum alloys have the disadvantage that the creep resistance of the metal is low. When reference is made herein to creep resistance, it will be understood that it is intended to designate the load which can be applied to the workpiece which will develop a shape change of more than 1 percent per year. The desired alloys under discussion have a creep resistance of, say, 0.4 kg/mm² and this value is extremely low, even lower than that of unalloyed zinc. To obtain improved alloys, it has been proposed to add metals such as copper, manganese, magnesium, titanium, chromium, silicon or iron or mixtures of these metals. This use of such additives results in a diminution of the ductility so that at strengths of 40 kg/mm² or more, the elongation falls to 10 percent or less.

It is, therefore, the principal object of the present invention to provide an improved zinc-aluminum alloy.

Another object of the invention is to provide a zinc-aluminum-based alloy having high tensile strength, a higher creep resistance than has been attainable heretofore with such alloys, and yet has an effective ductility.

These objects and others which will become apparent hereinafter, are attained in accordance with the present invention, with a high-ductility zinc/aluminum alloy which possesses high creep resistance, the alloy consisting essentially of 18 to 24 percent by weight of aluminum, 0.1 to 1.5 percent by weight of a further metal component consisting in larger measure of nickel and the balance, i.e. 74.5 to 81.9 percent by weight high-grade zinc. The term “high-grade zinc” is used herein to refer to zinc in accordance with ASTM specification B6-49 and containing a maximum of 0.006 percent by weight lead, 0.005 percent by weight iron, 0.004 percent by weight cadmium and, generally, having a total impurity level no greater than 0.050 percent by weight. In other words, the high-grade zinc of the present invention is 99.95 percent pure. Preferably, the third component, i.e. the nickel-containing component, constitutes 0.3 percent by weight to 1.0 percent by weight of the alloy while the aluminum content is preferably 21 percent by weight.

The third metallic component of the alloy may consist entirely of nickel (100 percent by weight of the third component which constitutes 0.1 to 1.5 percent by weight of the alloy), although it has been found desirable to add or provide other metals, preferably in lesser proportion than the nickel, as part of this third metallic component. The nickel content can, according to the invention, be replaced at least in part (up to 50 percent of the nickel or third metallic component) with 0.05 to 0.5 percent by weight titanium. According to another feature of the invention, the nickel and/titanium component can be substituted with up to 0.5 percent by weight copper (0 to 5 percent) as long as the copper content does not exceed 50 percent of the nickel and/titanium content. If it is assumed, therefore that the nickel content of the alloy is 1 percent by weight and the titanium content is 0.5 percent by weight, neither copper nor any of the other possible constituents of the third metallic component can be present. On the other hand, if the nickel content is 0.75 percent by weight, the titanium content can reach 0.375 percent by weight and a copper content of 0.375 percent by weight is permissible by virtue of the upper limit of the third metallic component (1.5 percent) of the alloy. Preferably, however, the copper content will be at most 50 percent of the titanium content so that, in the present example, the upper limit of the copper content will be 0.188 percent. I have found, moreover, that the alloy may contain, as part of the third component, iron and/or silicon in an amount ranging up to 50 percent by weight of the nickel and/titanium content. In all cases, however, it is important that the lead, cadmium and tin contents of the alloy be collectively less than 0.05 percent by weight and that the magnesium content be below 0.0005 percent.

Since the alloying components incorporated in the zinc-aluminum matrix are insoluble in zinc and aluminum in the solid state and constitute, in the dendritic structure, intermediate phases in finely defined form, I provide a rapid cooling of the melt to ensure the maintenance of the fine-grained structure. According to an important feature of the present invention, therefore,
for each mm² of cooling surface, the volume of the metal body (extruded) should be 5 to 25 mm³, preferably 8 to 15 mm³. With these dimensions, the extruded body, billet or bar may have a rollable thickness of 10 to 50 mm, preferably 16 to 30 mm. The rapid cooling and solidification results in rapid crystal formation so that it is advisable, according to the invention, to permit equilibration or homogenization of the lattice structure for a relatively long period at a temperature of 300°C to 380°C. I have found that such a procedure yields an increase in the creep resistance of the metal body of five to eight times as compared with conventional alloys. Independently of the fine distribution of the additives in the aluminum and in the zinc-aluminum mixtures resulting from rapid solidification, there is the fact that the aluminum-zinc solid-solution eutectic crystals decompose at room temperature so that the high ductility of the alloy according to the present invention is maintained. The alloy of the present invention is malleable and can be employed for the production of plates, strips, bands, tubes and bars of various configurations in the manner currently employed with the production of extruded articles.

The following Examples are illustrative of the present invention, Example I representing the system of the present invention and Example II representing a control in which features of the invention are omitted for the purpose of comparison.

EXAMPLE I

An alloy is prepared by melting high-purity zinc, aluminum and nickel to yield a composition of 78 percent by weight zinc, 21 percent by weight aluminum and 1 percent by weight nickel. The extruded block is provided with 1 mm² of cooling surface for each 10 mm³ of volume and is rolled to a square cross-section, 4 cm on each side. Upon solidification of the block to a temperature of 220°C over a period of 10 seconds, the elongation to break was 125 percent and the creep resistance was 1.2 kg/mm². A block of the same dimension cooled to room temperature over a solidification and cooling time of 2 seconds had an elongation to break of 120 percent and a creep resistance of 2.8 kg/mm².

EXAMPLE II

A zinc-aluminum alloy containing 79 percent by weight zinc and 21 percent aluminum was produced and treated in the manner described in Example I. Upon solidification to room temperature in a period of 2 seconds, the body had an elongation to break of 140 percent and a creep resistance of 0.4 kg/mm². The body prepared by solidification and cooling to 220°C over a period of 10 seconds had an elongation to break of 135 percent and a creep resistance of 0.5 kg/mm².

A comparison of the results obtained in Examples I and II demonstrates that creep resistance with the alloy of the present invention can be improved several times over that of an alloy which is generally similar but does not contain the third component, without materially reducing the elongation to break and, therefore, the ductility of the alloy.

EXAMPLE III

The following compositions, according to the present invention, were prepared and tested. In each case, the creep resistance was found to range between 1 and 3 kg/mm², or 2.5 to six times that of a composition omitting the third component, while the elongation to break or ductility was equal to that of the composition without the third component or deviated therefrom by less than 10 percent;

- a. 78.25 percent zinc, 21 percent aluminum, 0.5 percent nickel, 0.25 percent titanium, 0.25 percent copper
- b. 78.25 percent zinc, 21 percent aluminum, 0.5 percent nickel, 0.25 percent copper
- c. 77.5 percent zinc, 21 percent aluminum, 0.75 percent nickel, 0.5 percent titanium, 0.25 percent copper
- d. 78.25 percent zinc, 21 percent aluminum, 0.5 percent nickel, 0.25 percent iron
- e. 78.1 percent zinc, 21 percent aluminum, 0.6 percent nickel, 0.3 percent silicon
- f. 77.8 percent zinc, 21 percent aluminum, 0.8 percent nickel, 0.2 percent iron, 0.2 percent silicon
- g. 78.05 percent zinc, 21 percent aluminum, 0.5 percent nickel, 0.25 percent titanium, 0.1 percent copper, 0.1 percent iron
- h. 78.05 percent zinc, 21 percent aluminum, 0.5 percent nickel, 0.25 percent titanium, 0.1 percent copper
- i. 78 percent zinc, 21 percent aluminum, 0.5 percent nickel, 0.25 percent titanium, 0.1 percent copper, 0.1 percent iron, 0.05 percent silicon
- j. 81 percent zinc, 18 percent aluminum, 0.5 percent nickel, 0.25 percent titanium, 0.1 percent copper, 0.1 percent iron, 0.05 percent silicon

The alloy, in each case, was extruded at a temperature close to the melting point in a bar having a thickness of 20 mm and a circumference such that for each 10 mm² of extruded volume, the surface area at which cooling was effected was 1 mm². The bar was rapidly cooled to room temperature in a period of 2 seconds. Thereafter, the bar was brought to a temperature of 350°C and maintained at this temperature for a period
of 10 minutes to 5 hours (preferably 30 to 60 minutes) for homogenization.  

1. A zinc-aluminum alloy consisting essentially of a first metallic component consisting of aluminum in an amount between 18 and 24 percent by weight of the alloy, a second metallic component consisting of zinc in an amount between 81.9 percent and 74.5 percent by weight of the alloy, and a third metallic component in an amount between 0.1 and 1.5 percent by weight of the alloy, the major proportion of the said third component consisting of nickel, and the said third component including at least one other metal of the group consisting of titanium, copper, iron, and silicon, the amount of titanium being between 0.05 percent and 0.50 percent by weight of the alloy and not exceeding 50 percent by weight of the nickel content of the alloy, the amount of copper being up to 0.5 percent by weight of the alloy, and the total amount of copper, iron, and silicon in the alloy not exceeding 50 percent by weight of the total content of nickel and titanium in the alloy.  

2. The alloy defined in claim 1 wherein the lead, cadmium and tin content of the alloy is less than 0.05 percent by weight together and the magnesium content is below 0.0005 percent by weight.  

3. The alloy defined in claim 2 wherein the aluminum content is about 21 percent by weight of the alloy and said third component is present in an amount between 0.3 to 1.0 percent by weight of the alloy, said zinc making up the balance of the alloy.  

4. An extruded body composed of the alloy defined in claim 3.  

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