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TUNGSTEN BASE ALLOYS

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This invention relates to tungsten alloys, and more particularly to tungsten base alloys containing nickel and copper improved by the addition or substitution of certain other metals.

In applications requiring a high density alloy having good machinability characteristics and tensile strength, tungsten base alloys containing nickel and copper, such as the ternary alloys disclosed in Smithells, U.S. Patent 2,183,359, have been frequently utilized. When fabricating components from such alloys one of two powder metallurgy processes is commonly used; either cold pressing followed by a heat treatment (sintering), or hot pressing. There are two distinct advantages in utilizing the hot pressing method rather than the cold pressing method: (1) less component shrinkage; and (2) less expensive equipment can be used. When using the cold pressing method a component shrinkage of about 20% in linear dimensions occurs during the sintering operation. No significant component shrinkage occurs when using the hot pressing method. A steel die is commonly used in the cold pressing method while a graphite die can be used in the hot pressing method, thereby resulting in a substantial reduction in die cost. Also, when forming large components by the cold pressing method a larger and more expensive press must be used than when forming small components by that method.

However, certain undesirable effects are encountered when fabricating components from the prior art alloys by hot pressing in a graphite die. Reaction between the charge and the die causes a hard carbide case to form on the surfaces of the component being pressed, carbon atoms migrating into the alloy from the graphite die. Because of this reaction a high degree of adhesion develops between the surfaces of the compact and die necessitating destruction of the die in order to separate the compact from it, so each component fabricated requires a new die. In most applications a carbide case is undesired, so the compact must be perssed sufficiently oversize to allow for removal of the case while machining to the desired final dimensions. It is also necessary to use a relatively high pressing temperature (1350–1550° C). In addition, the prior art tungsten base alloys have the further disadvantage of containing an undesirably high percentage (3–10 w/o) of nickel, a relatively scarce and expensive element.

It is therefore an object of the present invention to provide a high density, tungsten base alloy having good machinability characteristics and high mechanical strength.

Another object of the present invention is to provide a method for obtaining an alloy having a high density, high mechanical strength and good machinability.

Another object of the present invention is to provide an alloy which, when formed by the powder metallurgy process of hot pressing in a graphite die, causes no reaction between the charge and the die.

Still another object of the present invention is to provide an alloy which can be formed by hot pressing in a graphite die without formation of a carbide case on the final compact.

Another object of the present invention is to provide an alloy which, when formed by hot pressing in a graphite die, enables reuse of the graphite die.

Yet another object of the present invention is to provide a tungsten base alloy formable at lower hot pressing temperatures.

A still further object of the present invention is to provide a tungsten base alloy which can be formed by hot pressing in a graphite die without the necessity of subsequent extensive surface machining.

Another object of the present invention is to provide a tungsten base alloy containing a low nickel fraction.

Still another object of the present invention is to provide an inexpensive tungsten base alloy capable of easy and inexpensive fabrication.

The present invention consists of a quaternary tungsten base alloy of low nickel content, containing by weight about 2–3% copper, 1½–3% nickel, 4–6% lead, and the balance tungsten. The presently preferred method for forming such an alloy is to intimately mix together the constituents in powdered form and then hot press the mixture at a pressure of from 1000 to 1300 p.s.i., and at a temperature of from 1200 to 1350° C. Pressing is commenced at a low temperature and is continued while the charge is heated, about one hour for the 900-gram charges to be described below, and during cooling, which takes approximately two hours. The charge is held at the maximum temperature for only about 15 minutes to minimize to insignificance the susceptibility to absorption of carbon from the die. The time utilized is sufficient to insure uniform heating of the charge, although more time must be allowed for heavier charges. The heating time is ordinarily determined by slowly heating the charge until it is all at the maximum temperature, as measured with an optical pyrometer sighted into a recess in the side wall of the die at a point adjacent to the charge.

During the heating cycle the lead, which has a lower melting point than the other constituents, melts first and probably forms a barrier between the charge and the die to prevent the penetration therethrough of carbon atoms from the die to the charge, thereby preventing formation of the undesired carbide case.

The word "alloy" is used herein in accordance with the definition in the Metals Handbook, 1958 edition (American Society for Metals: Cleveland, 1948), "a substance that has metallic properties and is composed of two or more chemical elements, of which at least one is a metal." From this definition it is apparent that the compounds of the present invention, while probably containing two or more phases of undetermined composition rather than consisting of single phase solid solutions, are correctly termed alloys.

Using the above specifically described hot pressing technique several 900–gram, 1-inch thick discs, 2 inches in diameter, were fabricated from different starting compositions. Test specimens measuring 0.250 inch x 0.250 inch x 1⅞ inches were prepared from the discs. At least three such specimens were prepared and tested for each different starting composition. The test results are reproduced below in Table I:

Table I

Starting Composition (weight percentages)				Density (gms./cc.)	Max. Fiber Stress (p.s.i.)	Deflection (inches)
Ni	Cu	Pb	W			
3	2	5	90	17.4	89,600	.004
2	3	5	90	17.6	120,000	.004
2	2	6	90	17.2	72,700	.003

The density and hardness of the specimens were measured by standard techniques. The values of maximum fiber stress and deflection are the results of transverse break tests, described on pp. 125–126 of the Metals Handbook, supra, under the heading "Bend Tests for Hard and Brittle Metals." The load was centrally applied through a knife edge having the same radius as the stationary supporting knife edges.

The average particle sizes used in preparing the specimens covered a range of 1–5 microns for the tungsten powder, 2–14.2 for nickel, 2–10 for copper and 5–20 microns for the lead. In the preparation of all specimens, care was taken to use only powders which were not contaminated by oxidation.

Analyses of pressed specimens show a relative gain in tungsten percentage at the expense of the lower melting components caused by "squeeze-out" of the latter into the clearances between die, punch and inner core. There was no significant squeeze-out into the pores of the die. For example, chemical analysis of a 2-inch diameter, 1-inch thick disc hot pressed with the starting composition of 2 w/o Ni, 3 w/o Cu, 5 w/o Pb and 90 w/o W showed a final composition of 1.72 w/o Ni, 2.47 w/o Cu, 4.13 w/o Pb and 91 w/o W. The amount of squeeze-out was found to increase with temperature and vary with alloy composition, and ranged from about 1 w/o at 1200° C. to about 5 w/o at 1300° C. for the samples tested.

In addition to the method of mixing all four powders and hot pressing them as disclosed above, the same compositions of quaternary alloys of the present invention have been prepared by using pre-formed alloys of two elements and combining them with the proper amounts of the remaining constituents. For example, commercially available Cu-Pb alloys in powdered form can be mixed with powdered nickel and tungsten in the proper amounts. However, the alloys of the present invention cannot be formed by the cold pressing plus sintering process because the lead will boil out.

An alloy typical of the prior art ternary alloys, which usually contain substantially more nickel than copper, is one having a starting composition of about 7 w/o Ni, 3 w/o Cu, and 90 w/o W. A test specimen of this prior art alloy identical in size to the aforementioned test specimens of the present invention was prepared by the hot pressing method and subjected to the aforementioned tests, yielding the following results: Density=17.5 gms./cc.; maximum fiber stress=82,000 p.s.i.; deflection in transverse break test=0.005 inch. Comparison with the alloy of the present invention having a starting composition of 2 w/o Ni, 3 w/o Cu, 5 w/o Pb and 90 w/o W (as shown in Table I) reflects a 46% greater maximum fiber stress for the alloy of the present invention, while still maintaining the desired high density.

Although the examples of the alloys of the present invention cited are confined to alloys containing approximately 1½–3% Ni, 2–3% Cu, 4–6% Pb and 90% W, it is to be understood that the present invention is directed to a general method of reducing fabricating costs and fabricating without formation of a carbide case while still retaining or even improving upon the desired physical characteristics and that reasonably wide formations in composition are contemplated without departing from the spirit of the invention, and are obtainable by routine experimentation by those skilled in the art.

What is claimed is:

1. A tungsten base alloy consisting essentially by weight of about 1.72% nickel, about 2.47% copper, about 4.13% lead and the balance tungsten.

2. The method of manufacturing a new tungsten base alloy comprising the steps of forming an intimate mixture of metallic powders, the composition by weight of the mixture being about 2% nickel, 3% copper, 5% lead and 90% tungsten, and hot pressing said mixture at a temperature within the range from about 1200 to about 1350° C. until said new alloy is formed.

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