United States Patent Office

3,166,414

Patented Jan. 19, 1965

3,166,414

TANTALUM BASE ALLOYS

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No Drawing. Filed July 9, 1962, Ser. No. 208,617
4 Claims. (Cl. 75—174)

This is a continuation-in-part of our application Serial No. 20,709, filed April 7, 1960, now abandoned.

The present invention relates to tantalum base alloys suitable for use in applications where high strength at elevated temperatures is required.

Fabricable alloys possessing strength and oxidation resistance at extremely high temperatures have many industrial and military applications, and it is generally recognized that future developments in many fields are closely tied to the availability of new and improved alloys possessing these properties. For example, the development of improved rocket nozzles and blades for gas turbines is dependent upon the availability of such alloys.

In accordance with this invention, it has been found that workable alloys possessing unusually high oxidation resistance and strength at temperatures above 2000° F. can be produced by alloying tantalum, hafnium, and tungsten, and, if desired, rhenium in specified proportions.

Therefore, the object of this invention is to provide workable alloys which possess high oxidation resistance and strength at elevated temperatures, comprising predetermined proportions of hafnium, and tungsten, with or without rhenium, the balance, over 50% by weight being tantalum, with incidental amounts of impurities.

Other objects of the invention will, in part, be obvious and will, in part, appear hereinafter.

In accordance with the present invention ternary tantalum base alloys have been produced comprising from 2 to 8% by weight of hafnium, from 2 to 10% by weight tungsten, and the balance being tantalum, with small amounts of incidental impurities and the alloy may include up to 10% rhenium. The alloys are characterized by high mechanical strength and good oxidation resistance at elevated temperatures, and the ability to be easily wrought to shape by hot or warm working, or in certain alloy compositions, by cold working. In a preferred embodiment, the alloys of this invention comprise from 2 to 4% by weight hafnium, from 7 to 9% by weight tungsten and the balance being tantalum, with small amounts of incidental impurities.

The alloys may be melted by one of several procedures which will insure homogeneity and a minimum of contamination. For example, unalloyed, high purity, tantalum together with the proper amounts of pure tungsten and hafnium can be fed into a conventional non-consumable arc melting furnace containing an inert atmosphere, such as argon, or vacuum. The resulting ingot should be remelted several times, preferably by non-consumably arc-melting it, to achieve homogeneity, then may be hot worked to the desired shaped. The alloy may also be prepared by levitation melting of a ball or rod of the alloy, using induction heating. Electron beam melting or consumable arc melting of the alloys is also satisfactory.

The following examples are illustrative of the present invention. In these examples, percentages given for the composition are by weight and the hardness values are diamond pyramid hardness (DPH).

EXAMPLE I

An alloy of the following composition was prepared by non-consumable arc melting: 92% tantalum, 4% tungsten, and 4% hafnium. Samples of the resulting ingot gained an average of 101 milligrams per square centimeter of surface per hour upon being subjected to a blast of hot undried flowing air for one hour at a temperature of 2190° F. The samples had an average hardness of 212 in the as-cast condition and 243 after annealing at 2000° C. for 16 hours in a vacuum of approximately 5×10^{-5} millimeters of mercury. The samples were hot workable at 1200° C. to effect a 60% reduction in thickness.

EXAMPLE II

An alloy of the following composition was prepared by non-consumable arc melting: 84% tantalum, 8% tungsten, and 8% hafnium. Samples of the resulting ingot had an average weight gain of 24 milligrams per square centimeter of surface per hour during exposure to a blast of hot undried flowing air for one hour at a temperature of 2190° F. The average hardness of these as-cast specimens was 289 and measured 353 after annealing for 16 hours at 2000° C. in a vacuum of approximately 5×10^{-5} millimeters of mercury. The samples also had a 53% reduction in area after hot working at 1200° C.

EXAMPLE III

An alloy of the following composition was prepared by non-consumable arc melting: 90% tantalum, 8% tungsten and 2% hafnium. A number of samples of the resulting ingot were reduced 95% and stress relieved at 2000° F. for one hour. The samples were tested for strength and ductility at various temperatures. The results of these tests are shown in Table I.

Table I

Temperature	0.2% Yield Strength (k.s.i.)	Ultimate Tensile Strength (k.s.i.)	Percent Elongation
—320	184	190	18
—100	146	150	17
75	130	135	15
2,200	78	85	15
2,400	49.5	57.6	24.7
2,500	38	54	26
2,700	23.7	29	64
3,000	19.5	20.5	60

Another group of samples were cold rolled to 90% reduction and each sample was annealed for one hour at a different temperature. The samples were tested for strength and ductility at room temperature. The results of these tests are shown in Table II.

Table II

Annealing Temperature	DPH	0.2% Yield Strength (k.s.i.)	Ultimate Tensile (k.s.i.)	Percent Elongation
As Rolled	373	159.6	167.2	4.4
2,000° F.	306	125	131	12.8
2,200° F.	291	115	122	16.9
2,400° F.	229	88.9	91.3	29.1
2,700° F.	232	90.4	91.9	30.8
3,000° F.	273	87.3	99.8	28.4

In addition, the following alloys were prepared as in Example I and were tested for their strength and elongation properties.

Ta	W	Hf	RT			2700° F.		
			Ult. Ten. Strength	0.2% Yield Strength	Percent Elong.	Ult. Ten. Strength	0.2% Yield Strength	Percent Elong.
96	2	2	110,000	105,000	16	16,000	14,000	51
94	2	4	113,000	106,000	16	21,000	20,000	105
90	5	5	100,000	90,000	16	32,000	20,000	73
88	8	4	147,000	140,000	15	32,000	30,000	67
80	10	10	123,000	120,000	4	35,000	30,000	2
80	15	5	128,000	128,000	2	56,000	36,000	3

The results indicate that tantalum base alloys comprising less than 10% tungsten and 8% hafnium have a combination of relatively high strength and high ductility at room and elevated temperatures and the alloys comprising greater proportions of tungsten and hafnium have relatively poor ductility at both room and elevated temperatures. A ductility of 2% to 4% elongation is very low and renders the use of the alloys for structural members dangerous.

It should be understood that the above description is only exemplary and not in limitation of the invention.

We claim as our invention:

1. A cast member comprising a tantalum base alloy consisting essentially of by weight 2 to 8% hafnium, 2 to 10% tungsten and the balance tantalum with incidental amounts of impurities.

2. A cast member comprising a tantalum base alloy consisting essentially of by weight 2 to 8% hafnium, 2 to 10% tungsten, up to 10% rhenium, and the balance tantalum with incidental amounts of impurities.

3. A cast member comprising a tantalum base alloy consisting essentially of by weight 2 to 4% hafnium, 7 to 9% tungsten and the balance tantalum with incidental amounts of impurities.

4. A cast member comprising a tantalum base alloy consisting essentially of by weight 2% hafnium, 8% tungsten and the balance tantalum with incidental amounts of impurities.

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