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METAL ALLOY

Rudolf H. Thielemann, Palo Alto, Calif., assignor to
Sierra Metals Corporation, a corporation of Delaware

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This invention relates to a columbium and/or tantalum base metal alloy, and particularly to an alloy that includes alloying metal additives which make the resulting alloy corrosion resistant and of great mechanical work strength at temperatures between 1500° F. and 2000° F.

Important characteristics of the alloy of this invention are that it (1) may be hot worked, (2) is highly resistant to oxidation and other forms of corrosion at temperatures up to about 2000° F. and higher, and (3) possesses great mechanical strength at these elevated temperatures.

As a result, this alloy may be used to form blades, vanes, and other parts of high temperature gas turbine engines. Other important uses of the alloy of this invention are that it may be used to form exhaust valves and manifolds in internal combustion engines, in heat exchangers, and as linings for retorts and container vessels used in the chemical and metallurgical industries.

Columbium has a melting point of about 4379° F., and tantalum, a melting point of about 5425° F. At elevated temperatures (i. e., of the order of 2370° F.) both columbium and tantalum have slightly greater strength properties than molybdenum under the same conditions. Columbium and tantalum do not have the embrittling characteristics of molybdenum. Unlike molybdenum welds, columbium or tantalum welds are ductile and are not subject to cracking.

It is important to note that substantially pure columbium or tantalum is, for all practical purposes, non-utilizable as a material for gas turbine blades, turbine vanes and turbine buckets, rocket nozzles and the like, because at temperatures of the order of 1500° F. and higher and in the presence of flowing air or corrosive gases for an extended period of time, they oxidize rapidly.

The prior art high temperature, high strength base metal alloys such as the nickel and/or cobalt base metal alloys which have been used as blades, vanes, and other parts of high temperature gas turbine engines have a maximum operating temperature of about 1500° F. For example, a common nickel-cobalt base metal alloy which incorporates molybdenum as a constituent is for all practical purposes non-utilizable as a structural member in a gas turbine engine if the metal temperature is above 1500° F. The oxidation resistance of such an alloy fails above 1700° F.

Since the alloy of this invention when used as a blade or vane in a high temperature gas turbine engine can be operated at markedly higher temperatures than was heretofore possible, the performance of the gas turbine engine is improved in that the total thrust is increased and the amount of fuel consumed per pound of thrust is decreased.

The metal alloy of this invention is comprised by weight of approximately: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; up to 5 percent of iron; up to 10 percent of tungsten; and the balance essentially columbium and/or tantalum.

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An alloy having the above composition is particularly resistant to oxidation and has high strength at elevated temperatures above 1500° F., so as to be suitable for use in forming liners for retorts and container vessels used in the chemical and metallurgical industries as well as for blades or vanes in high temperature gas turbine engines.

Preferred proportions by weight of the metals making up the alloy of this invention are approximately: 15 percent of chromium; 3 to 6 percent of aluminum; 3 to 5 percent of vanadium; up to 1 percent of iron; up to 5 percent of tungsten, and the balance essentially columbium and/or tantalum.

To achieve the optimum desired properties in an alloy of the present invention, it is preferred that the impurities named below be held to the indicated approximate limits by weight. The carbon content in the final alloy preferably should be no more than about 0.5 percent by weight. The oxygen content should be no more than 0.8 percent, as determined by an increase-on-ignition technique. The nitrogen content should be no more than about 0.2 percent.

It is to be noted that when the alloy of this invention contains a mixture of columbium and tantalum, it is preferred that the amount of tantalum in the mixture be from about 30 percent to about 95 percent by weight of those two metals alone, and the balance of the mixture be essentially columbium to achieve optimum oxidation resistance at elevated temperatures.

Following are examples of the preparation and test results of the columbium and/or tantalum base metal alloy of this invention:

Example 1

An ingot of an alloy of this invention containing by weight 15 percent of chromium, 3 percent of aluminum, 4 percent of vanadium, and the balance essentially columbium is prepared by arc melting composite consumable electrodes containing columbium and the other constituents in the above named proportions. The composite consumable electrodes are prepared by pressing a uniform powder mix of chromium, aluminum, vanadium, and columbium in the above proportions in the form of bars under a pressure of about 50 tons per square inch. The pressed bars are then sintered under a vacuum condition of about 1 micron for a period of about 3 hours. The composite electrodes are then arc melted in an inert gas atmosphere of helium and argon.

The arc melted alloy of this example is tested for oxidation resistance in moving air at about 2000° F. for twenty-four hours. According to this test, the resistance to oxidation of the alloy is found to be more than 700 times greater than the resistance to oxidation of substantially pure columbium under the same conditions.

In the test procedure for oxidation resistance, test samples of the alloy are first prepared and the dimensions of such test samples determined. The test samples are then subjected to oxidation test conditions. The oxide film which forms on the test samples during testing is removed, and the thickness of each tested sample is then measured and compared with the thickness of the test sample prior to submitting it to the test conditions. The same procedure is carried out to determine the oxidation resistance of substantially pure columbium, and a comparison is made between the oxidation resistance of columbium and the alloy being tested.

Test bars (1/4 inch diameter and 3 inches long) are fabricated from the arc melted ingot of this example by hot working procedure. The test bars of this example have a rupture life in excess of 100 hours under a load of 15,000 p. s. i. at a temperature of about 2000° F. in moving air.

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manner as set forth in Example 1, with substantially the same test results.

Example 16

An ingot of an alloy of this invention containing by weight 15 percent of chromium, 6 percent of aluminum, 5 percent of vanadium, 3.75 percent of columbium, and the balance essentially tantalum is prepared in the same manner as set forth in Example 1.

The arc melted alloy of this example is tested for oxidation resistance in air and for rupture life in the same manner as set forth in Example 1, with substantially the same test results.

Example 17

An ingot of an alloy of this invention containing by weight 15 percent of chromium, 6 percent of aluminum, 5 percent of vanadium, 30 percent of columbium, and the balance essentially tantalum is prepared in the same manner as set forth in Example 1.

The arc melted alloy of this example is tested for oxidation resistance in air and for rupture life in the same manner as set forth in Example 1, with substantially the same test results.

Example 18

An ingot of an alloy of this invention containing by weight 15 percent of chromium, 6 percent of aluminum, 5 percent of vanadium, 1 percent of iron, 5 percent of tungsten, 22.5 percent of tantalum, and the balance essentially columbium is prepared in the same manner as set forth in Example 1.

The arc melted alloy of this example is tested for oxidation resistance in air and for rupture life in the same manner as set forth in Example 1, with substantially the same test results.

The above detailed description of this invention is given for clearness of understanding only. No unnecessary limitations are to be understood therefrom, as modifications will be apparent to those skilled in the art.

I claim:

1. A metal alloy which comprises, by weight: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; and the balance essen-

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tially a metal of the group consisting of tantalum, columbium and mixtures thereof.

2. A metal alloy which comprises, by weight: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; and the balance essentially columbium.

3. A metal alloy which comprises, by weight: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; and the balance essentially tantalum.

4. A metal alloy which comprises, by weight: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; up to 10 percent of tungsten; up to 5 percent of iron; and the balance, essentially a metal of the group consisting of tantalum, columbium, and mixtures thereof.

5. A metal alloy which comprises, by weight: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; up to 10 percent of tungsten; up to 5 percent of iron; and the balance, essentially columbium.

6. A metal alloy which comprises, by weight: 3 to 20 percent of chromium; 2 to 8 percent of aluminum; 3 to 10 percent of vanadium; up to 10 percent of tungsten; up to 5 percent of iron; and the balance, essentially tantalum.

7. A metal alloy which comprises, by weight: 15 percent of chromium; 3 to 6 percent of aluminum; 3 to 5 percent of vanadium; and the balance, essentially a metal of the group consisting of tantalum, columbium, and mixtures thereof.

8. A metal alloy which comprises, by weight: 15 percent of chromium; 3 to 6 percent of aluminum; 3 to 5 percent of vanadium; and the balance, essentially columbium.

9. A metal alloy which comprises, by weight: 15 percent of chromium; 3 to 6 percent of aluminum; 3 to 5 percent vanadium; and the balance, essentially tantalum.

10. A metal alloy which comprises, by weight: 15 percent of chromium; 3 to 6 percent of aluminum; 3 to 5 percent of vanadium; 1 percent of iron; 5 percent of tungsten; and the balance, essentially a metal of the group consisting of tantalum, columbium, and mixtures thereof.

No references cited.