United States Patent Office 3,582,320 Patented June 1, 1971

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3,582,320

COBALT BASE ALLOY

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No Drawing. Filed Dec. 22, 1969, Ser. No. 887,376
Int. Cl. C22c 19/00
U.S. Cl. 75—171 3 Claims

ABSTRACT OF THE DISCLOSURE

A cobalt base alloy having superior oxidation and wear resistance which has a relatively high carbon content and contains a minor proportion of lanthanum.

This invention relates to cobalt base alloys. More particularly, this invention relates to cabolt-chromium-tungsten-nickel alloys containing relatively small amounts of lanthanum and relatively large amounts of carbon which are characterized by improved wear resistance and oxidation resistance at high temperatures in addition to having excellent high temperature mechanical properties.

Certain cobalt base alloys have been used extensively in the past for high temperature applications and have been found to be generally satisfactory except that in some instances they have been lacking in oxidation resistance, when compared to nickel base alloys. Other low carbon cobalt base alloys containing minor amounts of lanthanum as disclosed in U.S. Pat. 3,418,111 have been found to have highly improved oxidation resistance. It would represent an advance in the art if cobalt base alloys could be provided with superior wear resistance and oxidation resistance at high temperatures.

It is therefore an object of the present invention to provide a cobalt base alloy having improved oxidation resistance and wear resistance at elevated temperatures.

Other objects will be apparent from the following description and claims.

A cobalt base alloy in accordance with the present invention is an alloy consisting essentially of about

	Percent
Chromium	18–35
Tungsten	3–18
Iron	Up to 10
Carbon	0.4–1.3
Nickel	1–30
Silicon	0.2–1.2
Lanthanum	0.02–.12
Tantalum	Up to 10
Cobalt	Balance

A preferred range of the alloy of the present invention providing optimum wear resistance is as follows:

	Percent
Chromium	25–32
Tungsten	3–8
Iron	Up to 5
Carbon	0.7–1.3
Nickel	1–10
Silicon	0.2–1.2
Lanthanum	0.02–.12
Tantalum	Up to 10
Cobalt	Balance

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A preferred range of the alloy of the present invention providing optimum stress rupture and tensile properties in addition to excellent wear resistance is as follows:

	Percent
Chromium	18–24
Tungsten	6–18
Iron	Up to 10
Carbon	0.4–0.7
Nickel	10–30
Silicon	0.2–1.2
Lanthanum	0.02–.12
Tantalum	Up to 10
Cobalt	Balance

In addition to the specifically mentioned alloy constituents, other metals can be adventitiously present in the alloy of this invention in minor amounts. For example, zirconium may be present in amounts up to about 2%; vanadium up to about 2%; boron up to about 0.02%; manganese up to about 2%; Ti+Al up to about 4%; Cb up to about 2%.

It has been discovered, as part of the present invention that with alloy compositions as described above, a relatively small lanthanum addition and a relatively large carbon content provides remarkable oxidation resistance and wear resistant properties at high temperatures.

It has also been discovered that other rare earth metals can be present with the lanthanum, such as occurs when mischmetal is used to introduce lanthanum, without detrimentally affecting the improved oxidation resistance. However, the presence of other rare earth metals, in an aggregate amount exceeding the lanthanum content, results in the formation of stringers and non-metallic inclusions in the alloy which adversely affect its weld-ability and result in low strength welds. Consequently, for alloys intended for welding applications, the lanthanum is preferably added in essentially elemental form, and should, in any event, exceed the aggregate amount of other rare earth metals in the final alloy. For alloys which are not intended for welding, however, the lanthanum addition can be made using any convenient technique such as mischmetal, elemental lanthanum or lanthanum containing alloys.

Table I shows alloy compositions which have been prepared by being melted, cast into ingots of about 20–25 lbs., hot worked to sheet and annealed at 2100–2250° F. for 10–15 minutes and quenched. Lanthanum additions were made to portions of base melts as indicated.

Specimens of the alloys of Table I, in sheet form ¾ inch x ¾ inch x 0.06–0.125 inch thick, were tested for oxidation resistance and the results are shown in Table II.

The procedure for the oxidation tests to which the alloy specimens were subjected was as follows:

(1) Prepare specimen by grinding all surfaces to a 120 grit finish.

(2) Measure the surface area of specimen and weight.

(3) Expose the specimen at 2000° F. and 2100° F. in dry flowing air (greater than 1 cubic foot per hour per square inch of furnace cross section) for (4) twenty-five hour periods, permitting the sample to cool to room temperature between such period.

(4) Air cool the sample.

(5) Descale the sample in a salt bath.

(6) Carefully weigh the descaled sample and calculate the weight loss.

(7) Calculating the depth of penetration per year of exposure follows:

$$\frac{\text{Weight loss}}{\text{Density}} \times \frac{1}{\text{area of sample}} \times \frac{\text{hours/year}}{\text{100 hours}}$$

TABLE I

Alloy	Cr	W	Fe	C	Ni	Mn	B	Si	La	Zr	Ti	Co
A	22.38	6.95	1.20	0.49	13.59	0.13	0.005	0.36	0.06	0.21	0.25	Bal.
B	22.38	6.95	1.20	0.49	13.59	0.13	0.005	0.36	------	0.21	0.25	Bal.
C	29.38	5.46	2.80	1.11	2.94	1.0	0.007	0.96	0.06	-----	-----	Bal.
D	29.38	5.46	2.80	1.11	2.94	1.0	0.007	0.96	-----	-----	-----	Bal.

TABLE II.—OXIDATION RATE IN MILS PER YEAR

Alloy	Intermittent	
	2,000° F.	2,100° F.
A	21.2	---------
B	81.9	---------
C	15	25.2
D	58	---------

As can be seen from Table II, alloys A and C which contain lathanum and have relatively high carbon contents and are within the scope of the present invention and have superior oxidation properties as compared to alloys B and D which do not contain lathanum.

As shown by the test data of Table III, the alloy of this invention, in addition to having improved oxidation resistance, are also characterized by excellent mechanical properties at high temperatures.

TABLE III

Alloy A at 2000° F.

0.2% yield strength (k.p.s.i.)	6.9
Ultimate tensile strength (k.p.s.i.)	15.7
Elongation (percent)	78.3

The alloy corresponding to the composition of alloy A, in cast form, was found to have a stress rupture life at a stress of 13,000 p.s.i. at a temperature of 1800° F. of 202 hours and an elongation of about 14%.

Further tests were performed to demonstrate the superior wear resistance of the alloy of the present invention.

A cylindrical cast sample of alloy having a composition of alloy C was rotated against a flat stationary sample of the same composition at a bearing pressure of 100 p.s.i. The samples were at a temperature of 1400° F. during the test. The rotation was continued for 8 hours to provide a constant rate of 5.2 feet per minute measured at the circumference of the cylindrical sample.

The wear on the rotated sample was 17.3×10^{-6} inch per 1000 feet of travel. The wear for alloy D under the same conditions was 28×10^{-6} inch per 1000 feet of travel.

What is claimed is:

1. An alloy characterized by improved resistance to oxidation at elevated temperatures consisting essentially in weight percent of about:

	Percent
Chromium	18–35
Tungsten	3–18
Iron	Up to 10
Carbon	0.4–1.3
Nickel	1–30
Silicon	0.2–1.2
Lanthanum	0.02–0.12
Tantalum	Up to 10
Cobalt	Balance

2. An alloy in accordance with claim 1 consisting essentially of about

	Percent
Chromium	25–32
Tungsten	3–8
Iron	Up to 5
Carbon	0.7–1.3
Nickel	1–10
Silicon	0.2–1.2
Lanthanum	0.02–0.12
Tantalum	Up to 10
Cobalt	Balance

3. An alloy in accordance with claim 1 consisting essentially of about

	Percent
Chromium	18–24
Tungsten	6–8
Iron	Up to 10
Carbon	0.4–0.7
Nickel	10–30
Silicon	0.2–1.2
Lanthanum	0.02–0.12
Tantalum	Up to 10
Cobalt	Balance

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