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ALLOYS

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This invention relates to nonferrous alloys. More particularly, it relates to alloys having improved casting properties and strength. Still more particularly, it relates to alloys having cobalt or nickel as the major constituent of the composition and containing either columbium or tantalum or both.

Many alloys of chromium, nickel and tungsten either with or without molybdenum are well known. These alloys are characterized by hardness, resistance to abrasion, and resistance to atmospheric and chemical corrosion. They generally lack tensile strength. Also, they are difficult to machine and must be cast to size and shape.

Balke et al., in Patent No. 2,191,446, discloses an alloy comprising nickel or cobalt, chromium, tungsten, tantalum and carbon. This alloy is hard and very brittle. It is useful as a cutting tool since it contains the 1% to 3% of carbon, largely in the form of tungsten carbide or tantalum carbide. The tungsten and tantalum content of the alloy is high, i.e., it may contain from 15% to 50% of either metal.

Since machining of these alloys is difficult, it is imperative when casting the alloys into monolithic structures, as by investment casting, to have good flowability or high fluidity in order to completely fill the mold and to attain the complete surface detailing desired.

Alloys embodying the present invention have the desired high fluidity for casting and, in cast form, exhibit strength, ductility, oxidation and corrosion resistance and thermal shock resistance. Further, these alloys have melting points low enough to permit melting in refractory crucibles or equivalent equipment and casting according to recognized procedures.

The alloys of this invention are basically cobalt or nickel or mixtures thereof and contain tantalum and/or columbium. They contain from about 15% to about 25% chromium, from about 2% to about 15% tungsten, from about 3% to about 25% tantalum or columbium or mixtures thereof, the remainder being nickel or cobalt or a combination thereof and incidental impurities. Titanium and aluminum may be utilized to increase the hardness and strength of the above compositions. Titanium may be present in amounts up to about 4%. Aluminum may be present in amounts up to about 3%. Of the impurities, up to about .3% of manganese and silicon can be tolerated. Carbon may be present in quantities up to 1.0%. In predominantly cobalt base alloys the carbon content is preferably limited to between about 0.4% and about 0.5%. In the predominantly nickel base alloys, the carbon content is preferably limited to between about 0.1% and about 0.3%.

Columbium can be used interchangeably or conjointly with tantalum. When these two metals are used jointly in the above alloys, it is preferable that one or the other should be limited to a minor amount. Generally no more than about 20% of the total weight of tantalum plus columbium may be either tantalum or columbium.

Alloys having compositions containing from about 18% to about 25% chromium, from about 7% to about 12% tungsten, from about 8% to about 15% tantalum or columbium or mixtures thereof, the remainder being nickel or cobalt and incidental impurities, are preferred. Molybdenum may be present in these alloys in quantities

up to 10%. When molybdenum is used, it should be accompanied by an equivalent reduction in the amount of tungsten in the alloy.

In producing these compositions, mixes are prepared from relatively pure metals or metal hydrides. These metals or hydrides vary in physical form. Chromium is available as a powder, as pressed powder pellets, and as high purity thin metal sheets. When sheet materials are used, they are cut into desired particulate size for ease of handling. Nickel and cobalt are available as powders, pressed powder pellets or granules. Molybdenum, tantalum, and mixtures of tantalum and columbium are available as powders and as pressed powder pellets. Titanium is available as sponge, powder or sheet. Aluminum is available as pellets, ingots, or sheet. The various physical forms of any particular metal have equal utility in the preparation of the mixes.

The various metal components are usually commingled to produce a uniform feed for the heating furnaces.

Mixtures of metals or metal hydrides are reduced to a molten state preparatory to casting, in suitable furnaces, for example an arc furnace such as the Detroit Rocking Arc type, an induction furnace such as an Austenal furnace, an Ajax-Northrup furnace, etc. Melting of the metals must be carried out in the absence of oxidizing gases such as oxygen. For this reason, heating is usually carried out in a vacuum or under a blanket of inert gas such as argon.

Prior to melting all alloy constituents except tantalum or columbium or both are mixed together. After melting has started, the desired quantity of tantalum or columbium is added to the melt. This procedure minimizes the tendency of the tantalum and columbium to oxidize when melting. During the heating operation the melt is heated to a minimum of about 2800° F. and generally to a temperature in the range of from about 3000° F. to about 3500° F.

The molten alloys may be cast to the desired forms such as turbine buckets, turbine blades, parts for gas combustion chambers and the like by conventional operations. Such an operation may consist of gravity pouring while centrifugally casting in a mold in a controlled atmosphere. Alternatively, the entire heating and casting operation may be carried out under vacuum conditions.

When heating operations are carried out in a vacuum, the metal constituents are first heated until melting is initiated. The furnace is then degassed at a temperature of, for example, about 1400° F. After degassing heating is continued while a vacuum is drawn on the furnace and the pressure of the system is reduced to about 10 microns or less and preferably to about 5 microns or less. This vacuum is maintained by means of oil diffusion pumps backed by a mechanical pump, or the like.

Casting of the melted alloys is usually carried out in molds of zirconia or quartz sand bonded with alumina, clay or other suitable bonding agent. The molds are usually heated to temperatures in the range of from about 1500° F. to about 2000° F., just prior to casting. Preferably they are heated to a temperature between about 1600° F. and about 1700° F.

If it is desirable that the high temperature strengths of the alloys be a maximum for the particular composition, this property can be improved by aging treatments. In aging treatment for hardening, an alloy is heat treated at a temperature between about 2200° F. and about 2400° F. for about 3 hours. The heat treated alloy is cooled rapidly as by quenching. The quenched alloy is then reheated at a temperature between about 1300° F. and 1600° F. for a period of 4 to 10 hours and again quenched or cooled in air.

Specimens for testing were prepared in accordance

with the following procedures. Tensile specimens of alloys embodying this invention were cast and machined to have a gauge diameter of 0.300"±.001" and a gauge length of 1.562". Tensile strength and ductility values were obtained with these specimens. The ductility is based on the percent elongation prior to fracture as measured over one inch of the gauge length.

Cross break loads were obtained with surface ground specimens having dimensions of ⅜" x ⅜" x 2". For these tests the specimens are supported 1½" apart and loaded in the center with a 10 mm. ball. The deflection in inches, prior to fracture, and the maximum load are recorded. Hardness values were obtained on the bend specimens in accordance with the standard Rockwell procedures.

Table I lists eight alloys made by the procedure described above.

TABLE I

Composition (Percent by Weight)

	Ni	Co	Cr	W	Cb	Ta	Ti	Al	C
A	54.85		20	15	10				0.15
B	59.85		20	5		15			0.15
C		58.6	20	11	10				0.4
D		71.6	20			8			0.4
E		53.6	20	11		15			0.4
F	66.85		20		8		3	2	0.15
G	54.85		20	12	8		3	2	0.15
H	55.85		20	12	8			3	0.15

Properties of the various alloys are set forth in Table II.

TABLE II

Properties at Room Temperature

	Hardness, R "C"	Ductility Elongation, Percent/In.	Break Load, lbs.	Tensile Strength (lbs./sq. in.)×10³
A	25.2	4.5	6,296	82.5
B	20.9	3.0	4,866	71.7
C	46.1		5,070	
D	30.7	3.0	5,093	71.7
E	45		5,100	
F	43.8	2.0	5,633	87.8
G	46.5	2.0	4,870	102.2
H	45	2.0	5,306	85.7

These alloys have outstanding characteristics. The alloys exhibit fluidity which makes the alloys excellent casting alloys. The alloys also exhibit strong resistance to oxidation at elevated temperatures. Further, the alloys possess a combination of hardness, ductility and high tensile strength. Strength and ductility of the alloys at elevated temperatures can be increased by aging treatments.

In addition, from the tests it can be seen that reduction of tungsten content of alloys containing either columbium or tantalum reduces the strength. This loss of strength upon reduction in tungsten content can be compensated by adding small amounts of titanium and aluminum to the alloy with the added advantage of a marked increase in Rockwell hardness.

As used herein, the term "percent" or the symbol "%," when used with respect to the constituents of an alloy means percent by weight of the alloy.

Although the invention has been described in connection with specific embodiments thereof, it will be understood that these are not to be regarded as limitations upon the scope of the invention except insofar as included in the accompanying claims.

We claim:

1. A cobalt base casting alloy consisting essentially by weight of from about 15% to about 25% chromium, from about 2% to about 15% tungsten, up to about 4% titanium, up to about 3% aluminum, up to about 10% molybdenum, from about 3% to about 25% of at least one of the metals selected from the group consisting of tantalum and columbium, the remainder being cobalt and incidental impurities, and impurities including up to about 0.5% carbon.

2. A cobalt base casting alloy consisting essentially by weight of from about 18% to about 25% chromium, from about 7% to about 12% tungsten, up to about 4% titanium, up to about 3% aluminum, up to about 10% molybdenum, from about 8% to about 15% of at least one of the metals selected from the group consisting of tantalum and columbium, the remainder being cobalt and incidental impurities, and impurities including up to about 0.5% carbon.

3. An alloy consisting essentially by weight of 58.6% cobalt, 20% chromium, 11% tungsten, 10% columbium and 0.4% carbon.

4. An alloy consisting essentially by weight of 53.6% cobalt, 20% chromium, 11% tungsten, 15% tantalum and 0.4% carbon.

5. A cobalt base casting alloy consisting essentially by weight of 0.3 to 0.7% carbon, 18 to 24% chromium, 8 to 15% tungsten, 3% of a member selected from the group consisting of columbium and mixtures thereof with tantalum, said mixtures containing up to 20% by weight of tantalum, the balance cobalt.

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