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WELDABLE NICKEL BASE ALLOY

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The present invention relates to alloys suitable for use at high temperatures in highly corrosive atmospheres such as are produced by lead oxide.

More particularly, the invention relates to a nickel base alloy containing molybdenum and which is suitable for facing valves and valve seats and has good weldability characteristics, high hot strength and corrosion resistance, and a wide tolerance for iron.

It has previously been suggested that certain nickel base alloys, containing substantial proportions of chromium, together with smaller amounts of tungsten, are suitable for use under conditions where a corrosive deposit of lead oxide is present, as around the exhaust ports of internal combustion engines utilizing fuels containing tetraethyl lead. While the nickel-chromium alloys containing tungsten show good corrosion-resistance properties under oxidizing conditions where protective oxide films are formed, the corrosion resistance of these alloys decreases considerably when the oxygen content of the atmosphere is reduced to a point when the oxide films are not formed. Since exhaust gases are non-oxidizing, these known alloys are deficient for exhaust valve usage. A further disadvantage of this type of alloy is the fact that weldability characteristics are not particularly good, so that it is difficult to puddle the alloy onto the face of the exhaust valve or other structural element which is to be used in the corrosive atmosphere.

The present invention now provides an alloy containing molybdenum in place of tungsten which will withstand lead oxide corrosion in either non-oxidizing or oxidizing atmospheres, and especially in non-oxidizing atmospheres such as the exhaust gases of engines having leaded gasolines. The alloy of the present invention also has excellent welding characteristics imparted thereto by the incorporation of controlled amounts of calcium and zirconium. Further, this molybdenum-containing nickel base alloy exhibits better hot hardness characteristics, especially in the higher carbon ranges, than the tungsten-containing alloy.

It is therefore an object of the present invention to provide an alloy which has the ability to withstand the deleterious effects of lead oxide corrosion in non-oxidizing atmospheres and which exhibits good hardness properties at elevated temperatures.

A further object of the present invention is to provide a structural element suitable for use in atmospheres containing lead oxide which can withstand the effects of such an atmosphere without excessive loss in weight or pitting of the surface of the element.

Another object of the present invention is to provide a nickel base alloy containing substantial amounts of chromium and molybdenum and containing minor amounts of calcium and zirconium to impart good weldability characteristics thereto and to increase the corrosion-resistance properties thereof.

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I have now discovered that an excellent corrosion-resistant alloy having good hardness properties at high temperatures may be prepared from a nickel-chromium base alloy containing relatively smaller proportions of molybdenum and capable of being appreciably diluted with iron. The molybdenum content of such alloy compositions causes a totally unexpected and remarkable increase in hot hardness characteristics of the alloy, as compared with similar alloys containing tungsten instead of molybdenum. In addition, such molybdenum-containing alloys have excellent lead oxide corrosion resistance. These characteristics are very pronounced in nickel-chromium-iron alloys which contain relatively high percentages of carbon in the range from about 1.5% to about 2.5%.

A further advantage of the use of molybdenum in place of tungsten in the above-mentioned type of alloy is the fact that the alloy exhibits a higher tolerance for iron than does the tungsten-containing material. Thus, a higher percentage of iron may be included in the composition without decreasing the corrosion-resistance properties.

In addition to the chromium, nickel, molybdenum, carbon and iron, the alloy compositions of the present invention preferably also contain specific small amounts of calcium and zirconium. Further, the silicon content of the alloy is carefully held below a definite maximum value. The presence of calcium and zirconium in minor specified concentrations controls the weldability of the product. Alloys of this nature tend to give a gaseous weld, and this effect is substantially inhibited by the addition of certain minor proportions of calcium and zirconium. In this respect, it is also important to keep the silicon content as low as possible, since silicon lowers the corrosion resistance of the alloy.

In addition, the present alloys contain no cobalt. The latter element has been found to adversely affect the ability of nickel-chromium alloys to withstand lead oxide corrosion.

The alloys of the present invention have the following composition, the percentages being percentages by weight:

	Per cent
Nickel	45–65
Chromium	20–30
Molybdenum	6–15
Carbon	1.5–2.5
Calcium	.001–.06
Zirconium	.001–.06
Silicon	.75 maximum
Iron	Balance

An especially preferred alloy within the above range is the following:

	Per cent
Nickel	53
Chromium	25
Molybdenum	9
Carbon	1.75
Calcium	.03 maximum
Zirconium	.03 maximum
Iron	10.5

As noted above, the presence of small quantities of calcium and zirconium is highly desirable since these elements improve the weldability of the alloy, but the concentration of each of these two elements should be kept below about .06%, since the weld becomes sluggish when this concentration is exceeded. The calcium and zirconium apparently act to cause the formation of preferential oxides of molybdenum and chromium which protect the surfaces of the body against further oxidation.

The alloys of this invention are especially useful in structural elements which, in use, are subject to high temperature, abrasion and wear in highly corrosive atmospheres such as are formed by burning leaded gasoline. These structural elements are preferably stabilized and hardened by heat treatment.

The following table illustrates the distinct advantages of using molybdenum in place of tungsten in nickel-chromium base alloy compositions. In addition to the elements listed in the analyses below, each of the alloys contained from .001% to .06% calcium, from .001% to .06% zirconium, and less than .75% silicon.

Melt No.	Cr	Ni	Mo	C	Fe	PbO Corrosion Loss, g./sq. dm.		Brinell Hardness No.	
						In Air	Non-Oxidizing Atmosphere	Room Temp.	1400° F.
A	25	63	6	1.5	3.5	2.9	4.2	302	255
B	25	60	9	1.5	3.5	3.6	4.2	336	253
C	25	59	9	2.5	3.5	4.2	4.8	358	285
D	20	65	9	1.75	3.5	4.2	5.1	325	250
E	30	55	9	1.75	3.5	4.7	4.0	350	265
F	25	57	12	1.5	3.5	4.4	5.2	376	289
G	25	56	12	2.5	3.5	5.9	9.6	352	262
H	25	54	15	1.5	3.5	7.0	7.4	369	285
I	25	53	15	2.5	3.5	4.6	6.8	363	244

Melt No.	Cr	Ni	W	C	Fe	PbO Corrosion Loss, g./sq. dm.		Brinell Hardness No.	
						In Air	Non-Oxidizing Atmosphere	Room Temp.	1400° F.
A'	25	63	6	1.5	3.5	3.2	5.7	298	235
B'	25	60	9	1.5	3.5	3.2	8.5	302	241
C'	25	59	9	2.5	3.5	3.8	47.3	335	256
D'	20	65	9	1.75	3.5	12.6	49.4	307	245
E'	30	55	9	1.75	3.5	6.5	12.3	333	252
F'	25	57	12	1.7	3.5	4.6	11.9	358	259
G'	25	56	12	2.5	3.5	6.0	52.4	356	263
H'	25	54	15	1.6	3.5	7.6	22.0	363	281
I'	25	53	15	2.5	3.5	58.3	52.3	361	281

Each of the samples was sand cast, stabilized at 1650° F. for one hour, heat-treated at 1400° F. for about twenty-four hours, and thereafter air-cooled.

The corrosion resistance of the samples was measured in a standard lead oxide corrosion test

wherein the alloys are packed in lead oxide and heated for one hour at 1675° F., both in air and in a non-oxidizing atmosphere.

The above results clearly indicate that the molybdenum-containing alloys of the present invention are superior generally to those containing tungsten with respect to their ability to withstand corrosion by lead oxide and also with respect to their hardness at elevated temperatures. The effect is very apparent at relatively high carbon contents, above about 1.5% carbon.

To show the exceptional tolerance for iron dilution possessed by the alloys of this invention, a heat was prepared containing 25% chromium, 53% nickel, 9% molybdenum, 1.75% carbon, .02% calcium, .02% zirconium, .50% silicon, and 10.5% iron. This alloy showed a lead oxide corrosion loss of 4.7 grams per square decimeter in air and 4.2 grams in a non-oxidizing atmosphere. The Brinell hardness number at room temperature was 331, and at 1400° F. the hardness number was 255. This heat compared very favorably to heat I above, which contained only 3.5% iron. The welding characteristics of the alloy containing 10.5% iron were found to be excellent.

The iron tolerance of the present alloys is of considerable importance in that various ferrochrome alloys may be used as the source of chromium and iron in the composition, thus decreasing the cost of the preparation of these alloys from that necessary where pure chromium metal is used.

From the foregoing, it will be apparent that I have herein provided alloy compositions which are especially adapted for use in structural elements which must be capable of withstanding the corrosive effects of lead oxide, especially at elevated temperatures.

I claim as my invention:

1. A readily weldable nickel-base alloy adapted to withstand the combustion of a leaded fuel in a combustion engine and suitable for use in ex-

haust valves for internal combustion engines, having the following composition by weight:

	Per cent
Chromium	20–30
Nickel	45–65
Molybdenum	6–15
Carbon	1.5–2.5
Calcium	.001–.06
Zirconium	.001–.06
Silicon	Less than 0.75
Iron	Balance

2. A readily weldable nickel base alloy adapted to withstand the combustion of a leaded fuel in a combustion engine and suitable for use as valve facing material, having the following composition by weight:

	Per cent
Chromium	25
Nickel	53
Molybdenum	9

	Per cent
Carbon	1.75
Calcium	.001 to .06 maximum
Zirconium	.001 to .06 maximum
Silicon	Less than 0.75
Iron	Balance

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