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PROCESS OF MAKING NICKEL-COPPER ALLOY CASTINGS

Edmund Merriman Wise, Westfield, N. J., assignor to The International Nickel Company, Inc., New York, N. Y., a corporation of Delaware

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The present invention relates to nickel-copper alloys which, despite the presence of lead in fractional percentages, have satisfactory mechanical properties at elevated temperatures.

The strength and ductility of nickel-copper alloys and articles, e. g., castings, made of such alloys are seriously impaired by very small contents of lead at temperatures as low as the melting point of lead. The deleterious effect of lead on the high temperature mechanical properties increases with increasing lead content and with temperature. So far as is known, no remedy has been found by those skilled in the art for overcoming this effect of lead. In practical operations it has been necessary scrupulously to avoid its presence in the raw materials and scrap used in the manufacture of such nickel copper alloys and in these times of stress this is increasingly hard to accomplish due to the reuse of scrap which almost without exception contains appreciable quantities of lead.

It has now been discovered that the addition of zirconium as an alloying element overcomes the deleterious effect of lead on the high temperature mechanical properties of nickel-copper alloys.

It is an object of the present invention to overcome the deleterious effects of lead on the strength and ductility of nickel-copper castings at elevated temperatures by the addition of zirconium.

It is another object of the present invention to provide nickel-copper alloys with considerable tolerance for the presence of lead.

It is a further object of the present invention to make possible the utilization of raw materials and scrap which contain fractional percentages of lead in the production of nickel-copper castings having satisfactory mechanical properties at elevated temperatures.

A still further object of the present invention is to provide castings of nickel-copper alloys containing lead and zirconium which retain a substantial proportion of the room temperature strength and ductility at temperatures above the melting point of lead.

Other objects and advantages of the present invention will become apparent from the following detailed description thereof.

Generally speaking, the present invention is based upon the discovery that the deleterious effects of lead on the mechanical properties of nickel-copper castings at elevated temperatures can be overcome by the addition of zirconium. Lead in very small amounts, even of the order of about 0.003%, is effective to lower appreciably the high temperature strength and ductility of nickel-copper castings. The effect is noticeable even at temperatures as low as the melting point of lead (about 621° F.) and it increases in intensity with increasing lead content and with rising temperature. This is illustrated in Table I which gives the short time mechanical properties at about 800° F. of several castings made of an alloy containing about 28% copper, 1.5% iron, 0.75% manganese, 1.25% silicon, 0.25% carbon and the balance nickel, to which various amounts of lead were added.

Table I

Alloy No.	Lead, percent	Temperature, °F.	Tensile strength p. s. i.[1]	Reduction in area, percent	Elongation percent in 2"
1	0	796	59,400	28.7	34
2	0.005	791	51,700	21.6	19
3	0.009	799	42,000	21.3	15.5
4	0.022	799	36,220	13.4	10
5	0.052	805	27,350	3.9	2.5
6	0.083	800	21,470	6.4	3

[1] Pounds per square inch.

It will be noted from the data given in Table I that the tensile strength and especially the ductility of the alloys suffer markedly when lead is present. Thus, the presence of the very small amount of 0.005% lead in alloy No. 2 reduced the tensile strength 13%, lowered the reduction in area 25% and depressed the elongation 44% as compared with alloy No. 1 which contained no lead; whereas the presence of only 0.083% lead reduced the tensile strength 64%, lowered the reduction in area 78% and depressed the elongation 91% as compared with the lead-free alloy.

The surprising and remarkable improvement in strength, and particularly in the elongation, of lead-containing castings produced by the presence of zirconium is shown in Table II. These castings were made of an alloy having substantially the same base composition as the alloys of Table I to which various amounts of lead and zirconium were added.

Table II

Alloy No.	Lead, per cent	Zr, per cent	Temperature, °F.	Tensile strength, p. s. i.[1]	Reduction in area, per cent	Elongation per cent in 2"
7	0.049	0.21	797	44,200	17	
8	0.058	0.21	801	44,375	21.3	15.5
9	0.033	0.24	800	60,500	28.9	32
10	0.051	0.38	801	52,400	25.2	20
11	0.094	0.38	795	46,375	15.9	16
12	0.19	0.34	801	39,050	10.5	11.9

[1] Pounds per square inch.

It will be seen from the data of Table II that the tensile strength of alloys containing up to about 0.1% lead can be raised to very satisfactory levels by the addition of zirconium and that this beneficial effect extends to at least as high as about 0.2% lead. Thus alloy No. 7 which has practically the same lead content as alloy No. 5 is vastly improved by 0.21% zirconium, the tensile strength being 62% higher, and the reduction in area being improved by 335%. Alloy No. 10 which has about the same lead content as alloys Nos. 5 and 7 is even further improved by a zirconium content of 0.38% and as compared with alloy No. 5, the tensile strength is 92% higher, the reduction in area is improved about 545% and the elongation is higher by about 700%.

The present invention is of particular advantage in castings made of the nickel-copper alloys which contain as essential ingredients about 50% to 90% nickel, 10% to 48% copper and over 0.5% up to 5% silicon. Castings made of metal within the foregoing ranges which is contaminated with lead in amounts from about 0.002% to at least as high as 0.2% are vastly improved in high temperature mechanical properties by incorporating zirconium from effective amounts of the order of about 0.02% or 0.03% up to about 1% in the metal. The minimum amount of zirconium effective to improve the high temperature mechanical properties in any given case will depend upon the amount of lead present, a greater amount of zirconium being required for larger amounts of lead. Ordinarily a zirconium content between about 0.1% and 0.4% is sufficient to overcome the effects of the amounts of lead that are commonly encountered when lead-contaminated scrap is used in the charge. Thus about 0.3% to 0.4% zirconium seems very satisfactory in nickel-copper alloys containing lead within the range of about 0.02% to 0.07%, e. g., about 0.05%. When zirconium is present in an amount higher than 0.4% in alloys low in lead, or even lead-free, there is some loss in fluidity of the metal although the time-to-fracture properties continue to improve. The zirconium usually is added in the form of commercial grade zirconium addition alloy which contains aluminum and some other ingredients and impurities.

When the high temperature properties of wrought nickel-copper alloys are deleteriously affected by lead contamination, which may be present as a result of the raw materials used, by contact with lead during production, fabrication, etc., zirconium likewise is effective in counteracting the effects of lead. In the wrought nickel-copper alloys the silicon content varies from about 0.05% to not more than 0.5%, ordinarily being about 0.1% by weight of the alloy.

Castings of nickel base alloys embodying the present invention, e. g., valve bodies and the like, preferably contain about 25% to 35% of copper and 1% to 1.5% silicon. When silicon exceeds about 3% in alloys containing about 65% nickel, there is marked increase in hardness and decrease in ductility, but due to their high resistance to galling and steam corrosion, high silicon alloys are valuable for certain special purposes such as valve elements and similar high temperature parts which are exposed in use to sliding friction, particularly for valve seats.

Manganese or iron preferably will be present in the nickel-copper alloys where high fluidity and good castability are essential and in general both will be used in small amounts although satisfactory castings of simple geometric shape can be produced when neither iron nor manganese is present. Preferably manganese is present within the range of 0.5% to 1.5% although higher percentages of the order of 2% to 3% or even 5% are sometimes desirable for special purposes. Iron may be present in moderate amounts, preferably within the range of about 0.5% to 2%, and generally iron will not exceed about 2.5% although it may be present in amounts as high as 5%. Carbon ordinarily is maintained between about 0.04% and 0.35%, preferably within the range of about 0.05% to 0.25%, and it may be present up to about 0.6% in some castings.

Castings embodying the present invention may be made by preparing a melt of nickel-copper alloy from the lead-contaminated scrap and/or raw materials. The zirconium may be added to the molten casting alloy in any suitable form. Satisfactory results have been obtained using commercial silicon-zirconium alloy containing about 48% silicon, 41% zirconium and the balance principally iron. Similarly, a special zirconium-nickel alloy of high purity containing about 70% zirconium and 30% nickel has given satisfactory results. The melt should be deoxidized with a suitable deoxidizer, e. g., silicon, manganese and the like, before the zirconium is added to minimize the loss of the latter metal. It is also generally necessary to add an element having high affinity for sulfur, e. g., magnesium, calcium and the like, as a desulfurizing or sulfur fixing agent. Ordinarily, magnesium within the range of about 0.05% to 0.1% is added to the metal in the ladle just before pouring. Valve bodies and other castings ordinarily will be poured into sand molds although for some castings of relatively simple geometric form, centrifugal and other casting methods may be used. The recovery of zirconium has been found to vary under ordinary conditions from about 50% to 85%.

Some typical specific examples of castings subjected in use to elevated temperatures contemplated by the present invention are valve parts including cast valve bodies, valve seats, discs, pistons, piston rings, valve stem guides, reaction vessels, stirrers, etc., operating at temperatures of about 600° to 1100° F., particularly where strength, freedom from cracking and the ability to withstand stress and sustain stress loads, etc., are required. Many of these castings are hollow, characterized by having walls defining an enclosed space, e. g., valve bodies, reaction vessels, piston rings, etc. Often structures of the above types will be united by welding and in this operation reasonably good high temperature properties are required to avoid cracking. The presence of zirconium in welded structures made of nickel-copper alloys is of advantage even though the finished apparatus is finally used at ordinary temperatures.

The beneficial effect of zirconium in overcoming high temperature weakness of nickel-copper alloys caused by lead contamination obtains over a broad range of nickel and copper content. The nickel-copper alloys form a very simple series with complete miscibility of copper and nickel both in the liquid and solid states. Commercial nickel-copper alloys include the so-called cupronickels as well as the nickel base alloys of the type sold under the Trade-Mark "Monel" and the term nickel-copper alloys is used herein to include these alloys. Commercial alloys ordinarily contain impurities derived from the ores, raw materials, furnace linings, manufacturing processes, etc., used in preparing the alloys, as

well as minor constituents of special addition agents including desulfurizers, deoxidizers, carbide formers etc., among which may be mentioned fractional percentages of magnesium calcium, titanium and phosphorus. The term "nickel-copper alloy" as used herein is neither to be construed to exclude any such impurities and minor constituents that may be present nor to require their presence.

The present invention is a novel development of the principle of the invention disclosed in my copending application with Raymond Herman Schaefer, Serial No. 340,988, filed June 17, 1940, Patent No. 2,283,246, dated May 19, 1942, and is of a continuation-in-part thereof.

Although the present invention has been described in connection with certain preferred embodiments thereof, modifications and variations may be resorted to as those skilled in the art will readily understand without departing from the scope of the invention as set forth in the following claims.

I claim:

1. In the process of making a nickel-copper alloy casting, that improvement which comprises melting down lead-contaminated scrap and adding zirconium to the lead-containing molten bath in such an amount as to leave a residue within the range of about 0.02% to 1% in the finished alloy casting thereby substantially overcoming the delterious effect of lead on the high temperature properties of the casting.

2. In the process of making a casting of nickel-copper alloy containing 0.5% to 5% silicon, 0.04% to 0.6% carbon, and at least one metal from the group consisting of iron and manganese from a small amount up to not more than 5% of each, that improvement which comprises melting down lead contaminated scrap to form a molten bath of nickel-copper alloy containing about 0.002% to 0.2% lead sufficient to affect deleteriously the high temperature properties of the casting and adding zirconium to said lead-contaminated bath in such an amount as to leave a small but effective amount up to 1% of zirconium in the finished alloy thereby substantially overcoming the deleterious effect of lead on the high temperature mechanical properties of the casting.

3. In the process of making a casting of a nickel-copper alloy containing about 50% to 90% nickel, about 10% to 48% copper, over 0.5% to 5% silicon, 0.5% to 3% manganese, 0.5% to 2.5% iron and 0.04% to 0.35% carbon, that improvement which comprises melting down lead contaminated scrap to establish a molten bath of nickel-copper alloy contaminated with about 0.002% to 0.2% lead, and adding zirconium to said lead-contaminated bath in such an amount as to leave a residue of about 0.02% to 1% of zirconium in the finished alloy.

4. In the process of making a casting of a nickel-base nickel-copper alloy containing about 25% to 35% copper, 1% to 5% silicon, 0.5% to 1.5% manganese, 0.5% to 2% iron, and 0.05% to 0.25% carbon, that improvement which comprises melting down lead-contaminated scrap to establish a molten bath of nickel-copper alloy containing 0.02% to 0.07% lead, and adding zirconium to said lead-containing bath in such an amount as to leave a residue within the range of about 0.3% to 0.4% in the finished alloy.

EDMUND MERRIMAN WISE.