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ALLOY SUITABLE FOR USE AT HIGH TEMPERATURES

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In the manufacture of turbo-superchargers the bucket material must possess high strength and stability at the operating temperature of the supercharger, for example about 815° C. Heretofore supercharger buckets have been made either by forging the buckets to the desired size and shape or by a casting process employing a mold such for example as disclosed in the patent to Ray 2,027,932. Such processes, however, are long and expensive.

It is one of the objects of the present invention to provide an alloy which may be cast in sand, or chill-cast, and which, either in the as-cast or heat-treated condition, has physical properties which make it desirable for high temperature uses.

The alloy I employ consists principally of nickel but in addition contains as essential ingredients chromium, metal from the group molybdenum and tungsten and metal from the group iron and cobalt. The nickel content may vary from about 36 to 58%; the chromium from about 4 to 12%; the metal from the group molybdenum and tungsten may vary from about 5 to 25%; and the metal from the group consisting of iron and cobalt may vary from about 5 to 35%. A typical composition may contain 16 to 18% molybdenum, 10 to 14% iron, 5 to 7% tungsten, 5 to 7% cobalt, 4 to 6% chromium with the remainder substantially all nickel. The alloy also contains about 0.75 to 1.75% manganese and 0.5 to 1.25% silicon. The silicon and manganese act as deoxidizers and facilitate casting in a manner well known in the art. In addition to the above elements the alloy may contain small quantities of impurities such as carbon and sulphur. In general the carbon content should not exceed 0.15% and the sulphur 0.05%. The above percentage range of ingredients provides alloys which have high physical properties which are stable at elevated temperatures such as 815° C.

A sand cast alloy consisting substantially of 17% molybdenum, 12% iron, 6% tungsten, 6% cobalt, 5% chromium, 1.25% maganese, 0.75% silicon, 0.15% carbon, 0.05% sulphur and about 52% nickel in the as-cast condition has a tensile strength of 90,000 pounds per square inch and an elongation of 20% in one inch. The same alloy at 815° C. has a tensile strength of 60,000 pounds per square inch and an elongation in one inch of about 20%.

If chill cast, the alloy in the as-cast condition and at room temperature has a tensile strength of about 105,000 pounds to 145,000 pounds per square inch and an elongation in one inch of

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15%. At 815° C. the chill cast alloy has a tensile strength of about 65,000 pounds per square inch and an elongation in one inch of 15%. At room temperature, however, the chill cast alloy has a tendency to become somewhat brittle and to have reduced elongation.

In a turbo-supercharger it is desirable that the bucket alloy should not only possess high strength and ductility but that these properties should be stable at elevated temperatures, in other words, not subject to considerable change during operation under service temperature condition, for example 815° C. The stability of the present alloy may be affected by the manner in which it is cast. For example, if cooled slowly from the molten condition the alloy shows good stability, that is, it can be maintained for a long period of time at 815° C. without material change in its properties. If the alloy is chill cast, for example cast in a carbon mold at room temperature, the hot properties of the alloy are stable but it has a tendency to become brittle at room temperature. Under such conditions it may be found desirable to give the alloy a stabilizing treatment which consists of spheroidizing the alloy at 1200 to 1300° C. and slowly cooling. For example, if the alloy has been heated at 1200° C. for 24 hours it has at room temperature a tensile strength of 100,000 lbs. per square inch and an elongation in one inch of 10%. At 815° C. the alloy has a tensile strength of 65,000 lbs. per square inch and an elongation in one inch of 20%. If desired, the alloy may be further stabilized by a draw at 900 to 950° C. The aging treatment does not affect the tensile properties of the alloy and may lower the elongation slightly.

The alloy may be precipitation hardened by heating at 1100 to 1200° C. for about two hours, quenching and then aging at 800 to 900° C. Such a process improves the properties of the alloy. For example, the sand cast precipitation hardened alloy may have a tensile strength of 100,000 lbs. per square inch at room temperature and an elongation in one inch of 15%. At 815° C. the same alloy has a tensile strength of 70,000 pounds per square inch and an elongation in one inch of 15%.

If the sand cast alloy without other heat treatment is aged for about 100 hours at 815° C. it has at room temperature a tensile strength of 110,000 lbs. per square inch and an elongation in one inch of 5%. At 815° C. the alloy has a tensile strength of 70,000 lbs. per square inch and an elongation of 15%.

If the chill cast alloy, without other heat treatment is aged about 100 hours at 815° C. it has at room temperature a tensile strength of 140,000 lbs. per square inch and an elongation in one inch of 3%. At 815° C. the alloy has a tensile strength of 80,000 lbs. per square inch and an elongation of 15%.

The cobalt, nickel and iron in the alloy may be replaced by each other to a certain extent and if desired the iron may be omitted entirely and replaced with nickel or cobalt. If the iron is replaced entirely with cobalt the cobalt content of the alloy may be about 30%.

If desired, tungsten may be replaced by molybdenum and cobalt by nickel to provide an alloy consisting of about 58 to 60% nickel, 20 to 22% molybdenum, 4 to 6% chromium, 10 to 15% iron with the usual quantities of silicon and manganese. The alloy, as sand cast, has at room temperature a tensile strength of about 100,000 lbs. per square inch and an elongation in one inch of 30%. At 815° C. the alloy has a tensile strength of about 60,000 lbs. per square inch and an elongation in one inch of 25%. If the alloy is aged for about 100 hours at 815° C. it has a tensile strength of about 125,000 lbs. per square inch and an elongation in one inch of 12%. At 815° C. the alloy has a tensile strength of about 60,000 lbs. per square inch and an elongation in one inch of about 30%.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An alloy which in normal operation is subject to stress at temperatures in the neighborhood of 815° C., said alloy containing about 16 to 18% molybdenum, 10 to 14% iron, 5 to 7% tungsten, 5 to 7% cobalt, 4 to 6% chromium and a small quantity but not more than 0.15% carbon with the remainder substantially all nickel, said alloy being characterized by its stable properties at said temperature.

2. An alloy which in normal operation is subject to stress at temperatures in the neighborhood of 815° C., said alloy containing about 17% molybdenum, about 12% iron, 6% tungsten, 6% cobalt, 5% chromium and a small quantity but not more than 0.15% carbon with the remainder substantially all nickel, said alloy being characterized by its stable properties at said temperature.

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