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MACHINABLE HIGH COBALT LOW CARBON ALLOYS FOR DIE-CASTING MOLDS

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1

The present invention relates to machinable, high cobalt, low carbon alloys for die-casting molds and it particularly relates to die-casting molds useful for the die-casting of brass, aluminum and copper alloys.

It is among the objects of the present invention to provide novel, high cobalt, low carbon steels which are particularly useful in forming die-casting molds, particularly for the die-casting of metals and having melting points substantially above 700° F. and not in excess of 2100° F. and with a preferred range from 1100° F. to about 1900° F.

It has been found that a rather surprising change takes place in high cobalt, low carbon steel alloys where the proportions of silicon, cobalt and carbon are controlled in definite proportions.

For example, whereas an alloy containing 0.15 to 1.60% carbon, 0 to 3% silicon and 0 to 16% cobalt may be used quite satisfactorily in limited value as a base material for die-casting molds, rather it has a very short life when so used and tends to crack and craze. Moreover it has to be heat treated after machining to final form.

Surprisingly, it has been found that when the silicon content is kept below 1% and the cobalt content is kept from 16 to about 30%, with a low carbon not over 0.10% and desirably about 0.05%, that a new cobalt, low carbon alloy is obtained having quite remarkable properties. While it is not suitable for a machine cutting steel, nevertheless it serves most satisfactorily as a steel for making die-casting molds. This type of steel not only is machinable after hardening, so that the necessary mold may be readily formed, but in addition does not require any after-treatment. All heat treatment of this cobalt steel may be applied before the machining operation.

Moreover, the alloy will give die-casting molds of extremely long life. Cracking and crazing is substantially avoided altogether, even though the die-casting mold may be utilized for long periods of time.

The most satisfactory steels contain from about 0.02 to 0.05 per cent of carbon, about 2 to 6 per cent of chromium, about 16 to 30 per cent of cobalt, about 2 to 7 per cent each of molybdenum and tungsten, and from about 0.75 to 2.5 per cent of vanadium. The molybdenum present in the steels shall desirably exceed the amount of tungsten. Suitable results are had with the amount of molybdenum and tungsten substantially in the ratio of 5:4, and for some

2

purposes twice the amount of molybdenum plus the amount of tungsten shall be approximately 14.

Manganese and silicon are kept relatively low, say not over about 0.5 per cent each. Likewise, phosphorus and sulfur should not exceed about .025 per cent each. The remainder of the steels is iron together with impurities consequent upon the normal production of steels of this general type, but it will be understood that other alloying elements may be present in amounts that do not impair the properties characteristic of the invention. Inasmuch as such impurities and additional alloying elements exert no function influencing the invention, it may be said, for brevity, that the remainder of the steel is effectively iron.

For most purposes the carbon content should be at the lower end of the range stated, and desirably less than about 0.05 per cent. Particularly satisfactory results have been had from a steel of the following analysis:

Less than 6.1 per cent of carbon
About 4 per cent of chromium
About 25 per cent of cobalt
About 5 per cent of molybdenum
About 4 per cent of tungsten
About 1.5 per cent of vanadium

Steels conforming to these proportions possess characteristics rendering them outstanding for die-casting dies, especially for the die-casting of high melting metals and alloys, such, for example, as copper, brass, and other copper alloys. The tendency toward cracking or heat checking that has been a serious problem in this die-casting of such materials is greatly reduced and the dies exhibit greatly improved life.

As a preferred composition of the present invention, it is particularly suitable either for brass die-casting at 1800 to 1900° F. or aluminum die-casting at 1100° F. to use an alloy having the following composition in percentages by weight:

Ingredients	Preferred	Range
Silicon	0.15	Below 1 or 0.05 to 0.2.
Carbon	0.05	Not over 0.10 or 0.10 to 0.07.
Cobalt	25 to 30	Above 16 or 16 to 35.
Manganese	0.20 to 0.40	0.10 to 0.60.
Chromium	3.5 to 4	2 to 6.
Tungsten	4	2 to 6.
Vanadium	1.5	0.5 to 2.5.
Molybdenum	5	20 to 70.

This alloy, although not satisfactory as a cutting tool, is most satisfactory for making die-casting molds. It may be subjected to a heat treatment and then machined and then after heat-treating machining, no further treatment is necessary. Its composition is desirably adjusted as above to have a Brinell hardness of 440 to 490 with 477 being preferred. The Rockwell hardness will be between 44 to 48.

Even though subjected to many thousands of die-casting operations, dies of this alloy will neither crack nor will they be deformed.

Although various changes may be made in the above composition, desirably these changes are not productive of the most satisfactory alloy and the most desired, unusual properties. For example, if the tungsten is eliminated, the cobalt may be reduced between 10 to 20% with the carbon remaining at about 0.10%.

As other alloys which are much less satisfactory and do not have the peculiar effectiveness of the preferred alloy stated above, the following may be given:

Ingredient	Percentages by Weight		
Carbon	.10	.12	.09
Manganese	.40	.36	.54
Silicon	.81	.88	.46
Chromium	5.53	5.59	5.56
Vanadium	1.13	1.08	1.14
Molybdenum	2.51	2.50	1.20
Cobalt	12.19	15.26	11.75

As typical of an alloy which although of the same general composition is quite different from that of the present invention in having tool steel properties but not satisfactory die-cast steel properties, the following may be given in percentages by weight:

Silicon	up to 3%
Carbon	0.15 to 1.6
Cobalt	1 to 16%
Manganese	0 to 2
Chromium	0 to 15.0
Tungsten	0.2 to 6
Vanadium	0 to 5
Molybdenum	0.6 to 15

It is important at all times that the carbon be kept below 0.15% and desirably below 0.1%. It is surprising that the preferred cobalt alloy has no commercial value as a high speed steel, but unexpectedly has high value as a die-casting steel.

The dies made of a 0.05% carbon, 25 to 30% cobalt, and 0.15% silicon steel will not deform under metal casting temperatures up to 2200° F. These cobalt steels are precipitation hardening, and in annealing them it is important to cool them in the range from 1300° to 900° F. more rapidly than prevails in furnace cooling, as by cooling in air or by some other accelerated method, to avoid the rehardening that would otherwise occur. Dies from these steels are made by machining after heat treatment. For these purposes the dies may be air-cooled from about 1850° F. and drawn at 1200° to 1300° F.

In practice, the block of alloy of the present invention may be preheated, then cooled in air in about ½ hour from an elevated temperature of 1600 to 2200° F. or 1700 to 1900° F., whereupon it is subjected to another temperature treatment or precipitation hardening at 900° to 1500° F., to give the desired hardness, for about three hours. Finally, it is machined and then used.

These steels exhibit no surface impairment after many thousands of operating cycles, and in this respect are superior to high speed steels that have been used for the same purpose. They possess also other desirable physical and mechanical properties, they forge easily, and they are not difficult to machine, even at hardnesses of 350 Brinell.

In contrast to other steels, the alloys of the present invention contain substantially no free carbides.

In contrast to other steels which are machined from unannealed bar stock, then tempered by reheating to 1100 to 1200° C. followed by quenching in water and/or oil, the machining may take place as a last operation or after heat treatment in the novel steel composition of the present invention.

Any chromium or vanadium may be altogether omitted without loss of these valuable properties.

The embodiment of the invention shown and described herein is to be considered merely as illustrative, as the invention is susceptible to variation, modification and change within the spirit and scope of the appended claims.

Having now particularly described and ascertained the nature of the invention, and in what manner the same is to be performed, what is claimed is:

1. Die-casting steel of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., containing about 0.05 to 0.10 per cent of carbon, about 2 to 6 per cent of chromium, about 16 to 30 per cent of cobalt, about 2 to 7 per cent of molybdenum, about 0.75 to 2.5 per cent of vanadium, about 2 to 7 per cent of tungsten, and the remainder iron.

2. Die-casting die steel of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., containing about 0.02 to 0.10 per cent of carbon, about 2 to 6 per cent of chromium, about 16 to 30 per cent of cobalt, about 2 to 7 per cent of molybdenum, about 0.75 to 2.5 per cent of vanadium, about 2 to 7 per cent of tungsten, and the remainder iron, and the molybdenum being present in an amount greater than the tungsten.

3. Die-casting die steel of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., containing about 0.02 to 0.10 per cent carbon, about 2 to 6 per cent of chromium, about 16 to 30 per cent of cobalt, about 2 to 7 per cent of molybdenum, about 0.75 to 2.5 per cent of vanadium, about 2 to 7 per cent of tungsten, and the remainder iron, and the molybdenum and tungsten being present in the ratio of about 5:4.

4. Die-casting die steel of non-cutting tool steel variety, machinable after heat treatment and wholly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., containing not over about 0.1 per cent of carbon, about 4 per cent of chromium, about 25 per cent of cobalt, about 5 per cent of molybdenum, about 1.5 per cent of vanadium, about 4 per cent of tungsten, and the remainder iron.

5. Die-casting die steel of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., containing about 0.02 to 0.15 per cent

of carbon, about 2 to 6 per cent of chromium, about 16 to 30 per cent of cobalt, about 2 to 7 per cent of molybdenum, about 0.75 to 2.5 per cent of vanadium, about 2 to 7 per cent of tungsten, and the remainder iron, and the molybdenum and tungsten being present in amounts such that twice the former plus the latter is about 14.

6. As a new article of manufacture, a die-casting die of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., composed of steel containing about 0.02 to 0.10 per cent of carbon, about 2 to 6 per cent of chromium, about 16 to 30 per cent of cobalt, about 2 to 7 per cent of molybdenum, about 0.75 to 2.5 per cent of vanadium, about 2 to 7 per cent of tungsten, and the remainder iron.

7. As a new article of manufacture, a die-casting die of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., composed of steel containing about 0.02 to 0.10 per cent of carbon, about 2 to 6 per cent of chromium, about 16 to 30 percent of cobalt, about 2 to 7 per cent of molybdenum, about 0.75 to 2.5 per cent of vanadium, about 2 to 7 per cent of tungsten, and the remainder iron, and the molybdenum being present in an amount greater than the tungsten.

8. As a new article of manufacture, a die-casting die of non-cutting tool steel variety, machinable after heat treatment and highly resistant to cracking and crazing at aluminum and brass casting temperatures of 1100° F. to 2200° F., composed of steel containing not over about 0.1 per cent of carbon, about 4 per cent of chromium, about 25 per cent of cobalt, about 5 per cent of molybdenum, about 1.5 per cent of vanadium, about 4 per cent of tungsten, and the remainder iron.

9. A machinable high cobalt low carbon mold for die casting of brass and aluminum, said alloy being devoid of cutting steel characteristics and being machinable after hardening, which will stand up for long periods of time without cracking and crazing, said alloy having a silicon content of below 1%, a cobalt content of 16 to 30%, a carbon content of not over 0.1%, a chromium content of 2 to 6%, a molybdenum and tungsten content each of about 2 to 7% and a vanadium content of 0.75 to 2.5%, with phosphorus and sulphur not exceeding .025%, the remainder consisting of iron.

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