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HEAT EROSION RESISTANT ALLOY

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This invention relates to a steel alloy and more particularly relates to an alloy steel that is required to maintain its physical properties at substantially high temperatures and is especially useful for valves of internal combustion engines.

The primary object of this invention is to provide an alloy steel of new composition which will be resistant to scaling or pitting action at high temperatures ranging from a low red heat to temperatures as high as 1800° F., and which will in addition possess a hard surface and hot strength at this elevated temperature.

A further object of this invention is the use of an addition agent, as boron added in a small percentage, to produce a low melting point alloy and improve the hardness thereof in the "as-cast" condition and at elevated working temperatures. Another feature of this alloy is its comparatively fine grain structure, greater homogeneity and an alloy that lends itself to welding by the acetylene torch method without the production of blow-holes, rendering the application of the metal advantageous in the "as-cast" form for welding or puddling on a seating surface, for castings or blanks of given shapes, and for casting in a slab to be crushed into granular particles as used in centrifugal casting or lining of tubes.

An alloy steel containing as its essential elements cobalt-chromium within the ranges of the present invention and provided in addition with suitable amounts of tungsten and molybdenum, as hereinafter stated, serves to modify the effect of high temperatures on the steel, while the same alloy due to its relatively low melting point permits spinning or centrifugal casting operations on a supporting metal, without impairing the well-known corrosion resistance at elevated temperatures conferred thereon by the chromium.

The special purpose for which this alloy was originally designed was for poppet valves as used in high speed internal combustion engines, and where they are subjected to high heat temperatures and highly oxidizing conditions, especially when the engine is operated on a fuel containing tetra-ethyl lead, however, the alloy is equally as well adapted to any use of a similar nature or placed under similar conditions, and while its use and application to an engine valve is described, it is to be understood it also includes the application of this alloy to any casting, or use, subjected to similar operating conditions.

It is the general practice or commonly known, that in the manufacture of certain types of valves for high speed engines, where high temperatures and oxidizing conditions prevail, the valve is made of a construction which provides the use of a steel valve stem and head of comparatively low heat erosion resistance, and there is extended an alloy over those sections of the head, seat and valve throat exposed to the heat and oxidizing elements, this special construction greatly reduces the cost of manufacture over a valve composed entirely of the alloy, and yet is more desirable because of the distinct and/or combined physical properties requisite at different sections of the valve as will be presently described.

In the case of an exhaust valve those sections of the valve which need protection against severe operating influences are the seating portion, the top of the head portion, and the neck portion under the head which is subjected to impinging gases. The top of the head of a valve requires corrosive resistance, the underside requires corrosive resistance and hot strength. The seat of the valve requires, however, all these properties plus hardness under high temperature operating conditions, and resistance to the hot erosion effect which is set up when for any reason leakage takes place between the valve seat and the valve port. Therefore, a material which possesses the requisite properties of a valve seat is also suitable for the head portion of the valve.

An alloy steel made in accordance with this invention preferably has an analysis substantially as follows:

	Per cent
Carbon	2.23
Manganese	.30
Chromium	15.00
Silicon	1.80
Tungsten	2.90
Cobalt	30.25
Molybdenum	2.61
Boron	.50
Iron	Balance

Another alloy steel of slightly different composition also in accordance with the teaching of this invention has an analysis substantially as follows:

	Per cent
Carbon	2.09
Manganese	.25
Chromium	17.61
Silicon	1.58
Tungsten	3.58
Cobalt	32.48
Molybdenum	2.85
Boron	4.00
Iron	Balance

These alloys have a melting point of approximately 2200° F., and because of their low melting point will flow and deposit easily and soundly. The material while described as a heat-erosion resisting material is also a hard surface metal due to the presence of the tungsten and molybdenum combining to form a dense homogenous

grain structure. There are a number of hard facing materials available but they are usually of such a nature that when applied to the surface of another material by means of an acetylene torch they react in such a manner that it is difficult to produce a finished or ground surface which is free from defects such as blow-holes or porous spots. This alloy because of its oxidation resistance at application temperatures produces a sound deposit. Also because of the low melting point it readily lends itself to deposition on most steels, and the backing material is not adversely affected due to the low temperature of application.

While the foregoing analyses set forth preferred percentages it is obvious that a wider range in variation of these percentages between certain limits may be made, producing different grades of the alloy, without departing from this invention. Very good results are obtained by the use of the following workable range of the elements between the limiting percentages:

	Per cent
Carbon	1.50 to 3.00
Chromium	15.00 to 25.00
Silicon	1.50 to 3.50
Tungsten	.50 to 4.00
Molybdenum	1.50 to 7.00
Cobalt	25.00 to 45.00
Manganese	.25 to 1.50
Boron	.50 to 4.00
Iron	Remainder

To properly balance the material as made from the range given the iron content should not exceed 45.00% and not be less than 25.00% of the total.

The elements phosphorus and sulphur are common to this alloy as in all steel alloys. The presence of aluminum, titanium, and vanadium are not objectionable if such elements should be used in the making of the stock for their refining or cleansing influence.

This alloy has been found to have among others the following properties:

It is an excellent oxidation resistor. A sample exposed for eight hours to a temperature of 1750° F. remained bright in appearance and free from oxidation.

It may be easily applied commercially with assurance of uniform results by the acetylene torch, or melted and spun into place, without any reaction that creates blow-holes or porous areas. And the combination with its low melting point and dense homogeneous texture further commends it as a stable alloy for commercial usage.

The hardness value of the alloy "as-cast" is approximately 50–60 Rockwell, measured on the C-scale, dependent upon the proportions of the individual elements used in the workable range of the above analysis, and this hardness is retained under hot operating conditions as evidenced by a sample heated for eight hours at 1750° F. that retained its hardness at approximately 53 Rockwell, measured on the C-scale.

The hot hardness of this alloy is superior to Stellite, which is generally conceded to be particularly good. A sample heated to 1600° F. had a 208 Brinell, while the Stellite at the same temperature has a Brinell hardness of 177.

The resistance of the alloy to engine fuel having tetra-ethyl lead therein is proven by a hot operating test using lead bromide at 1100° F. and comparing it with a sample of proven heat resistance.

It has an extremely hard and substantially unmachinable surface in the "as-cast" condition, except by grinding, as is usual with wear resistant alloys of this character.

From a study of the above properties of this alloy, it will be readily apparent that the alloy is sharply distinguished from other boronized iron alloys devised for the purposes stated and other similar uses or conditions, and formal changes may be made in the elements from the limited percentages disclosed without departing from the workable range of elements as previously stated and to which the characteristic properties of this alloy is believed confined as covered in the following claims.

What I claim is:

1. An alloy consisting of carbon 1.50% to 3.00%, chromium 15.00% to 25.00%, silicon 1.50% to 3.50%, tungsten .50% to 4.00%, molybdenum 1.50% to 7.00%, cobalt 25.00% to 45.00%, manganese .25% to 1.50%, boron .50% to 4.00%, and balanced by the addition of iron in an amount not less than 25% and not more than 45% of the total.

2. A non-oxidizing, heat resisting alloy comprising carbon 2.09%, chromium 17.61%, cobalt 32.48%, manganese .25%, molybdenum 2.85%, silicon 1.58%, tungsten 3.58%, boron 4.00%, and the balance iron.

3. An alloy consisting of carbon 1.50% to 3.00%, chromium 15.00% to 25.00%, silicon 1.50% to 3.50%, tungsten .50% to 4.00%, molybdenum 1.50% to 7.00%, cobalt 25.00% to 45.00%, manganese .25% to 1.50%, boron .50% to 4.00%, and balanced by the addition of iron in an amount not less than 25.00% and not more than 45.00% of the total, said alloy characterized by a melting point of 2150° F. to 2250° F.

4. A non-oxidizing, heat resisting alloy comprising carbon 2.09%, chromium 17.61%, cobalt 32.48%, manganese .25%, molybdenum 2.85%, silicon 1.58%, tungsten 3.58%, boron 4.00%, and the balance iron, said alloy characterized by a melting point of 2150° F. to 2250° F.

5. An alloy consisting of carbon 1.50% to 3.00%, chromium 15.00% to 25.00%, silicon 1.50% to 3.50%, tungsten .50% to 4.00%, molybdenum 1.50% to 7.00%, cobalt 25.00% to 45.00%, manganese .25% to 1.50%, boron .50% to 4.00%, balanced by the addition of iron in an amount not less than 25% and not more than 45% of the total, and having a melting point below 2250° F.

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