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FERROUS ALLOY

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This invention relates to steel alloys especially adapted for use as valve seat rings and in lining cylinder sleeves for internal combustion engines and similar uses where it is necessary to have a material that is highly resistant to wear and corrosion, both at normal temperatures and at relatively high temperatures such as 1200° F. This application is a continuation of applicant's co-pending application for Ferrous alloy, Serial Number 269,164, filed April 21, 1939.

The term "wear resisting" as applied to ferrous alloys may have different meanings. For instance, one piece of metal may work well in contact with a piece of another metal and the one will show no wear and the other considerable wear. On the other hand, two pieces of different metals can work in contact under the same conditions as in the first instance, and neither will show appreciable wear although the difference in hardness between the metals may be as great in one instance as in the other. The tendency of a metal to "pick up" particles from another metal with which it is in working contact is aggravated as the temperature is increased.

Alloys which have good wear resistance at room temperature may wear rapidly when the operating temperature increases to the neighborhood of 1200° F. The same is true as to corrosion resistance and an alloy which may exhibit satisfactory corrosion resistance at room temperature may corrode rapidly at an elevated temperature of approximately 1200° F.

In order to improve liners for the cylinders of internal combustion engines used in automobiles and aircraft and the like, it has been necessary to produce an alloy which will have improved properties with respect to wear resistance and corrosion in that part of the cylinder which is subjected to maximum heat. The wear resistance, which is an object of this invention, is the ability of the alloy to resist "pick up" either under hot or cold conditions, and also show a minimum loss of size when subjected to the working contact of standard piston ring material. The products of combustion of an internal combustion engine are such that when deposited on the walls of a cylinder, which may be dry because of heat conditions, may, when the motor is idle, have a corrosive effect and it is, therefore, important that the cylinder liner of the motor shall be corrosion resistant.

In addition to the qualities above stated as necessary for an alloy for making cylinder liners or valve seats, it is important that the alloy, when it has to lend itself to the making of bi-

metal parts by centrifugal casting, have a relatively low melting point as compared with ordinary steel, so that it will be possible to line a steel tube with the alloy by the spinning process in which the molten metal is deposited on the inside of the tube by the rotation of the latter at high speeds. Valve seat rings have also been made from this alloy and manufactured by the spinning method, and actual performance tests have determined them to be a good commercial job. A further desirable property of the alloy in the case of seat rings is a hardness in the "as cast" or "as spun" condition which permits the final finishing of the parts by machining, that is to say, the alloy has machinability and yet is sufficiently high in "hot" hardness to provide a good wearing surface at elevated temperatures up to 1200° F. for sustained periods of time. The fact that the stock is machinable provides, in certain instances, the very desirable feature of being able to ream the face of the seat after assembly or use in the motor block.

Accordingly, the primary object of this invention is to provide a ferrous alloy having the above and other desirable properties which will be apparent to those skilled in this art and especially adaptable for use in internal combustion engine parts subjected to relatively high operating temperatures, and highly corrosive conditions, yet having a degree of hardness providing machinability and a sufficiently low melting point permitting manufacture or processing by centrifugal casting in ordinary steel tubing.

An alloy which has the requirements above stated, which is within the contemplation of this invention, and produces an improved engine part may be comprised of a range of material substantially as follows:

	Per cent
Carbon	.25 to 2.00
Chromium	5.00 to 15.00
Silicon	.25 to 2.00
Nickel	20.00 to 40.00
Boron	.25 to 3.00
Phosphorus	.005 to 2.00
Sulphur	.005 to 2.00
Iron	Balance

It is, of course, recognized that the elements sulphur and phosphorus are present in all ordinary ferrous alloys and ordinarily an effort is made to keep these elements as low in percentage as possible, because their presence creates problems of forgeability and segregation. The element manganese may be present in the alloy

because of its presence in the base materials used to make the alloy following the ordinary practice of alloy making, and its presence does not adversely affect the properties of the alloy.

In the case of the sulphur and phosphorus content in this application, low or high percentages can be used and a certain structural condition which they provide can be utilized to obtain increased degrees of wear-resistance. When this material is employed to produce a cylinder liner or seat by the spinning process, problems of forgeability are not encountered; and, also, because of the centrifugal action, constituents formed by the elements are uniformly distributed and segregated areas do not form.

It is preferable, in the case of the sulphur and phosphorus content, to have, when one of the elements is high, a low content of the other; and the intentional use of an upper content of these elements well beyond the conventional range thereof is believed novel in the controlled percentages stated. The high sulphur or phosphorus content produces in the material a structural network which has the surface property of presenting a wear-resisting face which substantially reduces galling or metal pick up when subjected to a metal-to-metal sliding.

Tests under heat and corrosive conditions with more severe conditions than encountered in an engine have proven the above material to wear well, retain its hardness, and due to the high nickel-chromium content to be an excellent corrosion resistor.

One specific analysis of this alloy which fills the above requirements is approximately as follows:

	Per cent
Carbon.....	.73
Chromium.....	8.82
40 Silicon.....	.87
Nickel.....	34.27
Boron.....	1.22
Phosphorus.....	.035
45 Sulphur.....	.86
Iron.....	Balance

In this "heat" of the alloy it will be noted that the phosphorus content is relatively low and the sulphur content relatively high, in accordance with the teaching of this invention.

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

	Per cent
Carbon.....	.91
Chromium.....	11.40
Silicon.....	1.37
60 Nickel.....	33.34
Boron.....	1.78
Phosphorus.....	1.09
Sulphur.....	.02
65 Iron.....	Balance

It will be noted that this specific alloy as aforementioned has in this instance a high phosphorus content and a low sulphur content in accordance with the teaching of this invention. However, the use of the aforementioned relationship between the phosphorus and sulphur content is not the controlling factor in securing the desired properties of this alloy, because in certain instances it may be desirable to hold both the phosphorus and sulphur content near the lower limit

of the workable range of this alloy as hereinbefore described.

These alloys have a melting point of approximately 2250° F., although it may range from 2000° F. to 2400° F. depending upon the particular percentages of the component elements of the broad range that is used, especially the element boron which has a marked effect upon the control of the melting point and when used to reduce the melting point provides an alloy that will flow and deposit easily and soundly on ordinary steel. The material while described as a hard surface, wear-resisting metal is also an excellent heat-erosion and corrosion resistant material because of its high nickel-chromium content. 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 metal they react, possibly because of having a high melting point, in such a manner that it is difficult to produce a finished or ground surface which is free from such defects as blowholes or oxidized areas. Because of the low melting point, provided in part by the controlled boron content, it readily lends itself to deposition on most steels, and the backing material is not adversely affected due to the low temperature of application. For this reason the alloy should be in the molten condition at approximately 2300° F. and this temperature is sufficiently below the melting point of ordinary steel (2700° F.) to insure the steel tube will still be strong enough to permit the spinning operation. While in the hereinbefore mentioned method of lining a cylinder sleeve, or centrifugally casting the lining alloy in a tube preliminary to removal and subsequent operations for producing a valve seat ring, it is important that the lining alloy have a melting point not in excess of 2300° F. However, in certain instances the economics of such a method would justify the use of an alloy steel backing tube which would normally have a higher melting point than the ordinary steel tube previously described, and in this case the higher melting point of the lining alloy may be safely utilized. It is also possible to use the alloy in forming a lining by another method in which the melting point of the alloy is not so critical. In this latter method the molten alloy is poured into a spinning cylinder which is practically at room temperature, and in this case the lining material does not adhere to the cylinder, whereas in the first method the lining material is bonded to the cylinder.

From a study of the above properties and advantageous features embodied in this alloy it will be readily apparent that the alloy has decided meritorious application for use in valve seat rings and in lining cylinder sleeves for internal combustion engines, where the material is subjected to wear and corrosion both at normal temperatures and relatively elevated operating temperatures, however, the alloy is equally as well adapted to any use of a similar nature or when placed under similar conditions, and while its use and application have been confined hereinbefore to a valve seat ring or a cylinder sleeve line, it is to be understood it also includes the application of this alloy to any casting, or use, subjected to similar operating conditions, and formal changes may be made in the percentages of the elements disclosed in the particular analyses 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:

5 1. A cast alloy steel engine part subjected to a normal working temperature of several hundred degrees Fahrenheit comprised of carbon .25% to 2.00%, chromium 5% to 15%, silicon .25% to 2.00%, nickel 20% to 40%, boron .25% to 3.00%, phosphorus .005% to 2.00%, sulphur
10 .005% to 2.00%, and the balance iron, said alloy characterized by a melting point of 2000° F. to 2400° F.

2. An alloy steel according to claim 1 consisting of carbon .73%, chromium 8.82%, silicon .87%, nickel 34.27%, boron 1.22%, phosphorus .035%, sulphur .86%, and the balance iron.

3. An alloy steel according to claim 1 consisting of carbon .91%, chromium 11.40%, silicon 1.37%, nickel 33.34%, boron 1.78%, phosphorus 1.09%, sulphur .02%, and the balance iron. 5

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