

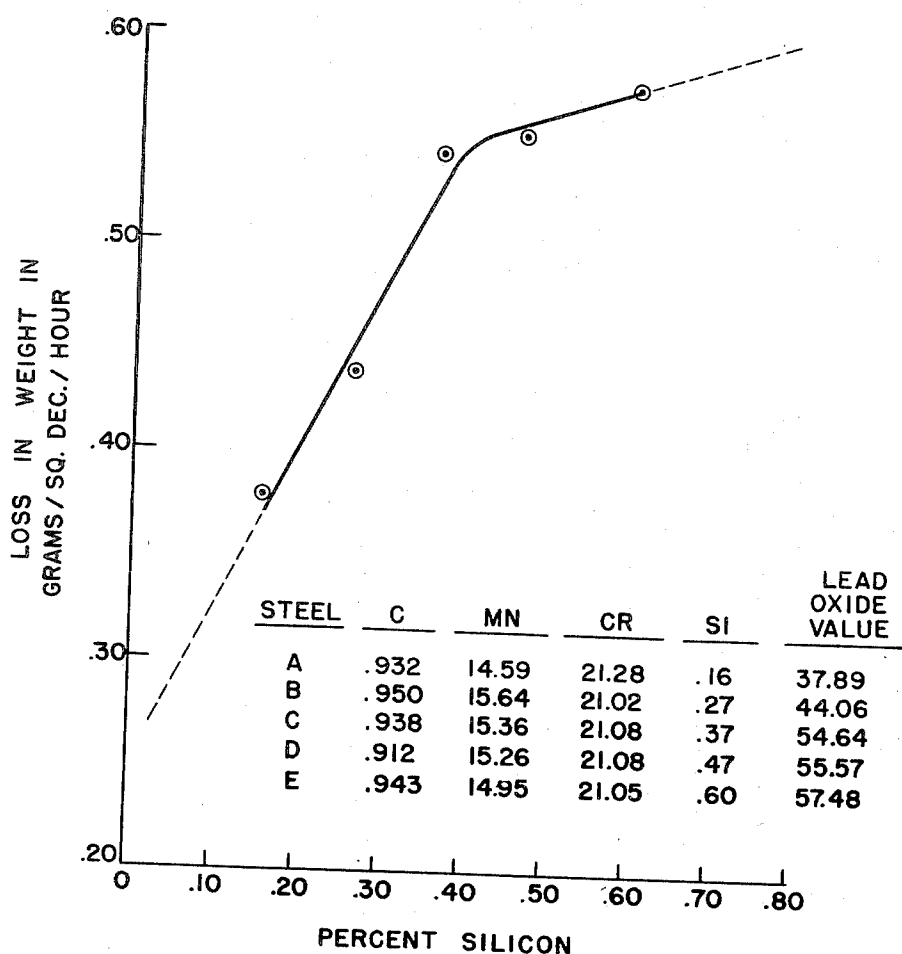
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P. A. JENNINGS
HIGH-TEMPERATURE ARTICLE

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INFLUENCE OF SILICON ON
CORROSION RESISTANCE OF
AUSTENITIC CHROMIUM -
MANGANESE VALVE STEEL
IN MOLTEN LEAD OXIDE.



INVENTOR.
PAUL A. JENNINGS
BY *John H. Jorgensen*
HIS ATTORNEY

UNITED STATES PATENT OFFICE

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HIGH-TEMPERATURE ARTICLE

Paul A. Jennings, Baltimore, Md., assignor to
Armco Steel Corporation, a corporation of Ohio

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1 This invention relates to high-temperature stainless steel and more especially to stainless steel valves and valve parts which are useful at elevated temperatures and in corrosive atmospheres.

An object of my invention is the provision of reliable and durable internal combustion engine valves, valve parts, and other engine components, which are thoroughly capable of resisting scaling and corrosion in hot corrosive atmospheres containing the combustion products of leaded fuel.

Another object of the invention is that of providing products of the character indicated which are heat-resistant and have excellent hot hardness and strength properties.

A further object of my invention is the provision of internal combustion engine exhaust valves, and parts and components intended for use in or adjacent to these valves, which products are strong and tough under the severe temperature conditions of the particular use, and which endure against contact and scour by the hot combustion products of leaded fuel.

Other objects of this invention in part will be obvious and in part pointed out hereinafter.

The invention, accordingly, consists in the combination of elements, composition of materials and features of products, and in the relation of each of the same to one or more of the others as described herein, the scope of the application of which is indicated in the following claims.

The single figure of the accompanying drawing represents the effect of silicon on corrosion resistance of 21% chromium-15% manganese austenitic stainless steel in molten lead oxide.

As conducive to a clearer understanding of certain features of my invention, it may be noted at this point that internal combustion engine valves, valve parts, and the like, employed in modern engines, are exposed to heat and corrosive agents which very rapidly ruin ordinary low-carbon steel. In this connection, it will be appreciated that the average temperatures encountered by valves in passenger cars reach as high as 700° F. or more on the fuel intake side of the engine, and as high as 1100° F. to 1450° F. or more on the exhaust side. These temperatures usually are considerably higher in truck or aeroplane engines, especially at the region where the exhaust valves operate.

Among the factors contributing to high temperatures in the vicinity of the valves of present-day internal combustion engines are the particular fuels employed, increased engine speeds, and greater power demands. Under the severe heat

2 developed, low-alloy steel valves usually warp or burn very quickly, this impairing efficiency and requiring frequent replacement. For the most part too, the low-alloy steel valves are highly susceptible to corrosion by the combustion products of leaded gasolines as of the so-called anti-knock varieties.

Another class of valves heretofore used in internal combustion engines, is that of the straight chromium martensitic or ferritic stainless steel grades. Some of these valves have a high silicon content and, as a result, enjoy adequate scaling resistance. Regardless of this, however, they have rather poor resistance to corrosion by hot lead compounds and are often poor with regard to the properties of hot hardness and resistance to creep under operating conditions.

Apart from straight-chromium stainless steel valves, there are valves in the prior art which are made of certain grades of austenitic chromium-nickel stainless steel. The amounts of silicon in the conventional chromium-nickel stainless steel valves range from about 0.50% to 4.0% or more. As a general class, it may be noted that austenitic stainless steel valves have a more favorable lattice structure for resisting stress-rupture and creep at elevated temperatures than do the ferritic or martensitic products. It is also true that the relatively high-alloy content of the stainless austenitic steels favors resistance to scaling from heat at elevated temperatures. The steels are free of phase transformation, and, in this respect, suffer no volume changes, warping, sticking or cracking during the heating and cooling cycles brought about by repeated engine operation. For the most part, however, the conventional austenitic stainless steel valves leave much to be desired of such properties as their resistance to corrosive attack by the combustion products of leaded fuels. The metal pits and corrodes and thus is impaired in its valve function, particularly when brought into contact with the hot exhaust gases. In the instance of poppet valves or related parts having the usual chromium, nickel and other alloy elements in the composition thereof, the hot combustion products of leaded fuels soon destroy the full closing effect of the valves and, accordingly, blow past and burn or otherwise ruin the metal for the intended valve function.

An outstanding object of my invention, accordingly, is the provision of high temperature heat and corrosion-resistant austenitic stainless steel internal combustion engine valves, valve parts and other engine components, which possess

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great hardness at the high operating temperatures encountered, resist creep at these temperatures, withstand oxidation and scaling, and effectively and reliably resist attack by leaded fuels and their combustion products.

Referring now more particularly to the practice of my invention, I provide high-temperature austenitic chromium-manganese stainless steel valves, valve parts, and any of a variety of other high-temperature components, which by virtue of having a particular alloy content, restricted with regard to the amount of silicon present, and including manganese, are very resistant to the effects of leaded fuels and the high temperature combustion products of these fuels. The manganese constituent of my steel products has a favorable effect upon corrosion resistance where the metal is subjected to hot lead compounds such as lead oxide or lead oxybromide. I find that by using the manganese as an austenite former, instead of any substantial quantity of nickel, an adverse effect of nickel on the corrosion resistance to hot lead compounds is avoided.

The components which I provide, as for example internal combustion engine intake or exhaust poppet valves, heads, stems, springs, seats, claddings, linings, surfacings or other components of these engines and valves, contain approximately 0.08% to 1.5% carbon, 12% to 30% chromium, from 4% to 17% manganese, silicon not exceeding 0.35% and preferably below about 0.25%, and even better, below about 0.15%, and the remainder substantially all iron. Nickel, if present at all, does not exceed about 2%. On occasions, I use the element nitrogen in amounts for example up to about 0.30% as a substitute for an equivalent amount of carbon or manganese in the steel. The nitrogen additions, when used, serve the function of increasing the hot-hardness of the steel a small degree, but primarily are valuable as a partial substitute for other austenite-forming elements to maintain the austenitic balance. Also, at times, I substitute the element cobalt in discreet amounts as an austenite-former. There are occasions too where my stainless steel products include in the alloy composition thereof, as for special purposes, one or more such elements as molybdenum, titanium, columbium, tungsten, vanadium, copper, tantalum, aluminum, zirconium, or the like, ranging from quite small amounts to substantial amounts not inconsistent with the properties desired.

My chromium-manganese stainless steel valves, valve parts, and engine components have a sulphur content which may be some quantity below about 0.04% or even as much as 0.15%. Sulphur, especially between about 0.04% to 0.15% contributes to the improvement gained by low-silicon on resistance to attack by the combustion products of leaded gasolines and the like. The larger quantities of sulphur, say those approaching 0.15%, usually improve the machining properties of the steel as well. The phosphorus content of my products preferably is below about 0.04%.

The internal combustion engine valves, and the like, in containing chromium, manganese, and not more than about 0.25% silicon, have excellent heat resistance and resistance to oxidation at the high temperatures of operation. Also, the presence of manganese as an alloy element in the substantial absence, or total absence, of nickel, and with the restriction of silicon to

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the critically small amounts indicated, importantly contributes to corrosion resistance of the steel where the latter is exposed to hot combustion products of leaded fuels. In view of the excellent properties, my products of the steel often are in the form of internal combustion engine exhaust valves, valve parts, or other components intended for use in the vicinity of the valves, as in aircraft, truck, bus, passenger car engines where anti-knock fuel exhaust gases are encountered. My stainless steel valves and other components of the steel, where used for operation under stress at high temperatures, are resistant to creep. The metal is hot-hard and strong, and resists scour and abrasion while heated. By virtue of the austenitic quality of the steel, substantially no phase transformation is suffered during heating and cooling cycles. The products accordingly are substantially free of volume changes and related difficulties recognized as following upon change of phase. The valves resist scaling, warping and cracking at full temperature and also upon being cooled and re-heated.

In the accompanying drawing, a graph is provided depicting the effect of silicon on corrosion resistance of austenitic chromium-manganese valve steel containing about 0.9% carbon, 21% chromium, 15% manganese, and the remainder substantially all iron. In the examples given on the face of the drawing, it will be seen that steels A, B and C have an alloy content falling within the range of that of my valve products, and further represent a highly satisfactory composition in accordance with the invention, while steels D and E are outside the range because of containing too much silicon. For decreases in the silicon content below about 0.35% silicon, there is a sharp increase in the corrosion resistance of the chromium-manganese steel in molten lead oxide. This will be observed by noting the effect in terms of weight loss, the latter being given in grams per square decimeter per hour in the accompanying drawing.

Thus it will be seen that in this invention there are provided a wide variety of low-silicon austenitic chromium-manganese stainless steel articles and products, in which the various objects noted hereinbefore, together with many thoroughly practical advantages, are successfully achieved. It will be noted that the products are well suited for resisting corrosion in the presence of the combustion products of leaded fuels.

While certain of the steels which I provide take the form of internal combustion engine components, it will be understood that certain advantages of the invention are had with other products of the chromium-manganese low-silicon steel, among which are high temperature gas turbine nozzles, turbine parts adjacent to the nozzle, and any of a number of supercharger components.

As many possible embodiments may be made of my invention, and as many possible changes may be made in the embodiment hereinbefore set forth, it will be understood that all matter described herein will be interpreted as illustrative and not as a limitation.

I claim as my invention:

1. Stainless steel having substantial hardness at high temperatures and substantial resistance to corrosion in the presence of leaded fuel combustion products, and containing about 0.08% to 1.5% carbon, about 12% to 30% chromium, about 4% to 17% manganese, all in such proportions as to assure a substantially fully austenitic struc-

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ture, silicon not exceeding 0.25%, about 0.04% to 0.15% sulphur, phosphorus not exceeding about 0.04%, and the remainder substantially all iron.

2. Austenitic stainless steel internal combustion engine exhaust valves containing about 0.9% carbon, about 21% chromium, 15% manganese, silicon not exceeding about 0.15%, and the remainder substantially all iron.

3. Austenitic stainless steel containing about 0.08% to 1.5% carbon, about 12% to 30% chromium, about 15% manganese, silicon not exceeding about 0.25%, and the remainder substantially all iron.

4. Austenitic stainless steel having substantial resistance to corrosion in the presence of leaded fuel combustion products at operating temperatures, and containing about 0.08% to 1.5% carbon, about 21% chromium, about 15% manganese, silicon not exceeding about 0.35%, nickel not exceeding about 2%, and the remainder substantially all iron.

PAUL A. JENNINGS.

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