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METHOD OF TREATING METALLIC ARTICLES

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My invention relates to the production of a hard surface on metal articles. The invention is particularly directed to producing a hard, abrasion- and corrosion-resistant surface on iron and steel.

In many industrial operations it is necessary to protect metallic equipment against excessive wear. By applying a hard surface or facing to protect the underlying metal, the life and efficiency of such metallic equipment can be increased. For example, pumps, pipe lines, and other apparatus for handling corrosive and erosive materials can be made more durable by providing an abrasion- and corrosion-resistant facing on their exposed surfaces.

It is well known that various carbides are extremely hard and abrasive compounds, and in the past certain carbides, such as tungsten carbide, chromium carbide, tantalum carbide and vanadium carbide, have been suggested for hardening steel by fusion of the carbide onto the surface of the steel. So far as is known, all of the carbides suggested by the prior art have been metallic carbides and, while certain of them, for example tungsten carbide, have been generally satisfactory, they are nevertheless relatively expensive. The high cost attending the use of metallic carbides is well recognized and attempts have been made to reduce this cost. For instance, it has been suggested to apply a relatively cheap ore of the metal and some form of carbon to the surface of the steel and then apply heat to form the metal carbide, whereupon it is fused into the steel. An excess of carbon, an atmosphere of hydrogen, or some other reducing agent must be supplied in this latter process to first effect a reduction of the ore to the pure metal. An analogous process has been suggested which eliminates this initial reduction step by starting with an uncombined form of the metal in place of the ore. However, as the uncombined metal is a comparatively expensive material, this process is relatively costly.

It is an object of my invention to provide a convenient and economical method for producing a hard, abrasion-resistant and corrosion-resistant surface on metals, especially on iron and steels.

As contrasted with the relatively expensive or complicated prior processes involving the use of metallic carbides, I have made the discovery that a hard and abrasion-resistant surface may be produced upon metal in a convenient and economical manner by fusing or dissolving silicon carbide, a non-metallic carbide, into the surface thereof.

The product of my invention is a solid metal body, of whatever desired form, having a high concentration of silicon and carbide at the surface. It is a unitary mass in that the portion having the high silicon and carbide content is a part of rather than separate from the metal body.

Although the use of silicon carbide as a packing material during heat-tempering of high speed steel (at relatively low temperature) to prevent change in carbon content of the steel has been suggested, the silicon carbide used in this way does not become a part of the treated surface and the surface thus produced does not possess the high corrosion and erosion resistance obtainable by the process of the present invention.

In the practice of my invention comminuted silicon carbide is applied to the metal surface to be hardened. The metal surface is then heated until it begins to fuse. The heating is continued until the silicon carbide apparently goes into solution. After the metal cools it is found to have a very hard surface resistant to abrasion and to corrosion by saline liquors.

The depth of the layer may be on the order of $\frac{1}{16}$ inch to $\frac{1}{8}$ inch. With a much thinner layer it becomes difficult to provide a uniform coating, whereas a thicker layer requires longer heating. Variations in thickness of the layer are also reflected in the depth of the hard protective alloy but the depths of hard alloy provided by thicknesses within the range specified have been found entirely satisfactory in practice.

The size of the silicon carbide particles applied to the metal surface may vary between wide limits; for instance, they may be particles of $\frac{1}{16}$ inch mesh down to the finest powder. Large particles are usually cheaper and stay in place better during fusion; small particles, on the other hand, are dissolved more rapidly and may provide a slightly more uniform surface.

Articles treated by the process of my invention may be distinguished by the fact that they have their silicon and carbide content concentrated along the treated surface, as a layer, which may be between 0.05 inch and 0.4 inch in thickness. Thus a steel article containing less than 0.4% of silicon and less than 0.4% of carbon, when treated by the process of the present invention may have the silicon content raised to between 1% and 4% and the carbon content to between 0.6% and 2% along its surface without affecting the silicon and carbon content of

the metal mass beyond the depth of the treated layer.

In the preferred embodiment of my invention, I employ an electric arc for effecting the fusion of the metal, the arc being struck between a suitable electrode and the metal surface being treated. Nitrogen introduced into the metal from the ionized atmosphere in the vicinity of the arc increases the hardness of the metal surface.

The invention will be further illustrated by the following specific example, but it is understood the invention is not limited thereto, as there may be wide deviations without departing from the spirit or scope of the invention.

Number 24 grain silicon carbide was spread in a layer about one-eighth of an inch thick on the surface of a cast carbon-steel pump casing plate, the metal of which was about one inch thick. The plate was at normal room temperature. An electric arc of 200 to 250 amperes was struck from a pointed ½ inch diameter carbon electrode through the layer of carborundum to the steel. The electrode was played back and forth over a small area (about an inch) of the surface until the steel in this area was fused and formed a small puddle of molten steel with the silicon carbide floating on the surface. After a few seconds the silicon carbide seemed suddenly to be swallowed up by the liquid metal. The arc was then moved on to solid metal at the edge of the puddle. This procedure was repeated until the whole surface of the steel plate had been treated. As the arc was moved away from each puddle of liquid, the latter cooled within a few seconds sufficiently to solidify since the heat was rapidly removed by normal radiation and especially by conduction to the relatively cool solid metal of the plate. Upon cooling to room temperature, the treated surface of the plate possessed a hardness of 500–700 Brinell and was resistant both to abrasion and to corrosion by hot saline solutions. This hard alloy facing had an average depth of about ¼ inch.

Comparative analyses of a facing made in the above manner upon a 1 inch plate of tank steel and of the plate itself were as follows:

	Facing	Plate
	Percent	*Percent*
Silicon	2.71	0.13
Carbon	0.96	0.15
Nitrogen	0.035	0.004

Steel which has been hardened by my invention has been found to be well adapted for the manufacture of centrifugal pumps designed for pumping corrosive and erosive chemicals such as the hot, saline waste liquors from the ammonia still of a crude sodium bicarbonate manufacturing plant. These waste liquors contain sodium and calcium chlorides in solution and are somewhat corrosive to steel. Moreover, they contain solid calcium carbonate, lime, and sandy material derived from the lime, and are so highly abrasive that they rapidly erode ordinary (carbon) steel pump casings.

A carbon-steel pump casing hardened with silicon carbide in accordance with my invention was still satisfactory after 105 operating days pumping waste liquors from an ammonia still and could be expected to last much longer. Cast iron pumps operating under similar conditions are satisfactory for only about 30 operating days, as an average.

The present invention may be used for providing a hard surface for metal objects in general which are to be subjected to highly corrosive and/or erosive materials; for instance, pump casings and impellers, stuffing box liners, the tips of mixers in soda ash apparatus, shafts where they run through bushings in milk of lime reservoirs, shovel teeth used at quarries, spiral conveyor walls and flights, etc.

I claim:

1. The process for producing a hard surface on a ferrous metal, which comprises applying a layer of finely divided silicon carbide to the surface, subjecting the silicon carbide to an electric arc, of which the ferrous metal forms one electrode and a carbon rod forms the other electrode, so as to fuse a layer of the metal in contact with the silicon carbide and to dissolve silicon carbide in the fused metal.

2. The process for producing a hard surface on carbon steel, which comprises applying a layer about $\frac{1}{16}$ to about ⅛ inch thick of finely divided silicon carbide to the surface, subjecting the silicon carbide to an electric arc, of which the steel forms one electrode and a carbon rod forms the other electrode, so as to fuse a layer of the steel, between 0.05 and 0.4 inch in thickness but less than the thickness of the steel, in contact with the silicon carbide and to dissolve silicon carbide in the fused steel.

3. The process for producing a hard surface on a carbon steel containing not more than about 0.4% of silicon and not more than about 0.4% of carbon, which comprises applying a layer of about $\frac{1}{16}$ inch to about ⅛ inch thick of finely divided silicon carbide to the surface, subjecting the silicon carbide to an electric arc, of which the steel forms one electrode and a carbon rod forms the other electrode, so as to fuse a layer of the steel, between 0.05 inch and 0.4 inch in thickness but less than the thickness of the steel, in contact with the silicon carbide and to dissolve silicon carbide in the fused steel whereby a layer of steel containing between 1% and 4% of silicon and between 0.6% and 2% of carbon is formed of said layer of the steel, and allowing the metal to cool rapidly.

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