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METHODS OF TREATING STEEL SURFACES TO MODIFY THEIR STRUCTURE

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ABSTRACT OF THE DISCLOSURE

A method of treating a steel surface to modify the surface to improve its hardness or resistance to corrosion characterised in that the surace is subjected to the implantation of selected ions adapted so to modify the surface structure as to improve its hardness or corrosion resistance.

The present invention relates to methods of treating steel surfaces to modify their structure.

It is well known that steel articles may be case hardened; in known methods of carrying out this process, a hard, resistant surface may be produced on a low carbon (tough) steel core by subjecting a low carbon steel article, maintained at elevated temperatures (about 910° C.), to an atmosphere rich in carbon. This may be achieved by use of a hydrocarbon gas or by packing in charcoal. The carbon diffuses into the surface of the steel to a depth of about 0.05 in., forming a high carbon content surface which is subsequently quenched to martensite for maximum hardness and wear resistance. The hardness is dependent on the carbon content and increases as the carbon content increases.

The thermal hardening process, as mentioned above, involves subjecting the articles to be treated to relatively high temperatures; in some circumstances, for example with stainless steel, this may be undesirable and it is one object of the present invention to provide a method of hardening stainless steel which does not involve the use of high temperatures.

According to one aspect of the present invention, there is provided a method of treating a stainless steel surface to modify the structure of the surface, wherein the surface is hardened by subjecting the surface to bombardment of carbon ions to implant carbon in the surface and thereby to modify its structure.

It will be appreciated that in introducing ions into the suface of a metal the composition of the surface will be modified in addition to the structure of the surface.

According to another aspect of the invention, a somewhat similar technique may be applied to modifying the surface structure of mild steel by ion implantation, in the surface, of chromium ions.

In treating a suface in accordance with the invention, the depths of penetration of ions may be greater than is measured as Angstroms and can be such that a hardened structure is formed within a body rather than right at the surface. Thus, a hardened surface may be produced at a depth of say 0.001 in. A body can thus be formed in which a soft outer region is provided on a harder inner region. A body so treated to have a "buried layer" may have its outer region removed, down to the hardened surface, by abrading, grinding, etc.

Such treatments are within the scope of the present invention.

The depth to which ions are implanted depends on the energy of the ions, high energy giving rise to buried layers.

It is also possible to implant at different energies so as to build up a series of implanted regions to give a layer of the required thickness.

Implantation may be carried out from low energies up to energies of several thousand kev. A typical working range is from 1–200 kev. with energies in the range 50–100 kev. being practically convenient.

In the case of ion implantation of stainless steel surfaces, the introduction of carbon into the surfaces by this ion implantation method, which may be carried out at relatively low temperatures, offers advantages over methods involving the use of high temperatures and carbon rich atmospheres. The term "low temperature" is used in this specification to indicate temperatures of approximately room temperature. The implantation process may cause the temperature of the specimen undergoing implantation to rise slightly, say 1 or 2° C.; however, this is insignificant. By use of the present invention it is possible, for example, to produce hardened regions on stainless steel articles which have been previously fabricated to high precision standards because the risk of distortion and the resulting loss of dimensional precision arising from subjecting the articles to high temperatures is obviated. Thus, surface hardened ball bearings, watch bearings and similar articles may be produced after they have been fabricated to the required tolerances in stainless steel; a hardened edge may be produced on a stainless steel razor blade. The cost of such a hardening process would be very small per item in the case of watch bearings, where, by virtue of their size, it would be possible to treat a multiplicity (perhaps several hundred) articles in one implantation operation.

It is also possible to select, quite precisely, the regions of the surface to be treated by appropriate control of the ion beam, which may be typically a few millimetres in width; alternatively a mask may be used which permits the ion beam to contact only the exposed regions of the surface to be treated.

It is to be understood that the foregoing statements regarding the treatment of a multiplicity of articles and the way in which areas may be treated selectively will also apply to the implantation of chromium into mild steel.

Several methods of carrying out the invention will now be described by way of example.

In the first example, regions of 316 stainless steel surfaces were treated with a beam of carbon ions. A sample of 316 stainless steel was mounted in the sample chamber of a linear accelerator and the chamber was evacuated. The linear accelerator was switched on and run-up in accordance with normal linear accelerator operating procedures until a beam of ions impinged on the target. The ions in this implantation operation had energies in the 100 kev. range. A carbon dioxide gas source was used and magnetic analysis was utilised to separate and select, from the ions produced by the source, carbon ions for implantation. The treated regions, where carbon ions had been implanted to a depth of a few thousand Angstroms, were found to be completely resistant to vibratory polishing, whilst the untreated regions of the surfaces were removed rather easily.

In the second example, regions of 18–8 stainless steel surfaces were treated with a beam of carbon ions according to a procedure essentially similar to that described above. Results were obtained which were similar to those in the case of the 316 stainless steel in the first example.

In the third example, mild steel surfaces were treated with a beam of chromium ions having energies in the 100 kev. range, using a linear accelerator in a manner similar to that described above. A sputtering source with a chromium strip was used as a source of chromium ions and magnetic analysis was used to select chromium ions for implantation. Chromium was implanted to a depth of a few thousand Angstroms in the treated regions and it was found that the corrosion resistance (for example, to rusting) was greatly improved in these regions.

Carburising of metal by hitherto known techniques is carried out at high temperatures, about 900–1000° C. and depends on carbon diffusing into the metal as hereinbefore mentioned. Thus, if the present invention is utilised to implant carbon at a high temperature there is a risk that carbon may diffuse into the metal and that the hardening effect at or near the surface will be lost. Therefore, the present invention is conveniently used to implant carbon at temperatures below about 600° C.

A similar situation exists in relation to chromium ions.

What is claimed is:

1. A method of treating a mild steel surface to modify the structure of the surface whereby the corrosion resistance of the surface is increased, comprising the steps of producing chromium ions, forming the chromium ions into a beam of predetermined energy such that the ions can penetrate the mild steel surface to be treated and directing the beam of chromium ions at the region to be treated thereby to cause chromium ions to be implanted into the mild steel.

2. A method according to claim 1, wherein the implanted ions are implanted to a depth of a few thousand Angstroms.

3. A method according to claim 1, wherein the implantation is carried out with ions having energies such that a buried layer is formed.

References Cited

UNITED STATES PATENTS

3,232,853	2/1966	Cook	204—39
2,916,409	12/1959	Bucek	204—298 X
3,127,283	3/1964	Chadwick	117—106 R
3,177,134	4/1965	Gartner et al.	204—192
3,645,710	2/1972	Plumat et al.	204—192 X

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204—192