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DRY SLIDING WEAR BEHAVIOUR ANALYSIS OF NITRIDED 316LN GRADE AUSTENITIC STAINLESS STEELS USING GAS NITRIDING PROCESS

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ABSTRACT

The paper presents the results of an investigation into wear behaviour of gas nitrided stainless steel. Stainless steel has a good corrosion resistance, where they possess a low hardness, wear resistance. By case hardening the stainless steel, the hardness can be increased. Surface hardness can be increased by diffusion of carbon or nascent nitrogen. The gas nitriding is done at 450 – 540^0 C for three different specimens. Nitriding is done in which hard complex nitrides are formed which improves the surface hardness. Non treated austenitic stainless steel specimen was used as a reference material. Wear test were also carried out for comparision. The layers were characterized by optical microscope, scanning electron microscope and XRD. Wear test were conducted to characterize the tribological wear behaviour.

Keywords: *Wear, Nitriding, Surface hardness, Stainless Steel, X-Ray diffraction*.

1. INTRODUCTION:

Austenitic stainless steel is used because of their high resistance to oxidation and corrosion resistance. They find applications extensively used [3-5] in nuclear reactors, automotive parts like cam shafts, cam followers, injectors, bio medical implants, chemical and food industries. Of the various surface hardening techniques available, [1-2] nitriding offers the benefits of high dimensional stability. Stainless steel is a difficult material to nitride, due to the presence of passive oxide film on the surface.

Chosen for this work, on the basis of their application and availability, gas nitriding is done for removal of passive oxide film. In the current work, wear experiments were carried out on AISI 316LN material. The specimens were gas nitrided at different time period and wear test was conducted. Also the wear rate was investigated. Untreated specimen was used as reference material. The results are discussed using metallographic techniques.

2. EXPERIMENTAL DETAILS:

2.1 Materials

AISI 316LN material was used in the experiments and its composition is presented in Table1. Polished cylindrical disc specimen measuring 50 mm diameter, 10 mm height is used. The diameter of the pin is 8 mm and length is 30 mm.

2.2 Treatments:

Three cylindrical specimens and three pin of these stainless steels were subjected to gas nitriding process. Prior to all treatments, the specimens were cleaned ultrasonically, rinsed and dried, with care taken to avoid finger contact. Before gas nitrided, the specimens were sand blasted, pickled in 15% sulphuric acid for 20 minutes. The gas nitriding process were done in a bell type furnace at 450^0 C (14 hours), 500^0 C (20 hours), 540^0 C (72 hours) and named as GN 1, GN 2, and GN 3 respectively.

2.3 Wear Measurements:

Using a standard pin on disc machine, with the test pin rotated at 1460 rpm, with a constant load of 15 Kg was applied for a fixed period of 7 minutes under dry conditions. The wear rate was calculated by determining the weight loss and the time was recorded when the sample is before tested and after tested. The difference between the specimen before and after testing gives the wear loss.

2.4 Surface appearance:

Gas nitrided specimens exhibit a deep grey surface. The specimens also showed a blue hue, indicating the presence of a thin oxide film.

2.5 Hardness profile:

The hardness profile for the gas nitrided AISI 316LN material was investigated. GN 3 sample have imparted a good surface hardness, with maximum value of 1410 HV.

3.0 RESULTS AND DISCUSSIONS:

Gas nitriding process results were performed and wear test was conducted. This nitriding results in precipitation of chromium nitrides. GN 3 sample results inferior wear performance. Thus the wear rate of untreated specimen is specified to be lower that of nitrided material. Hence good surface hardness is obtained. High temperature gas nitriding results in good wear performance to relative case depth, which improves wear resistance.

3.1 Optical Microscope Results:

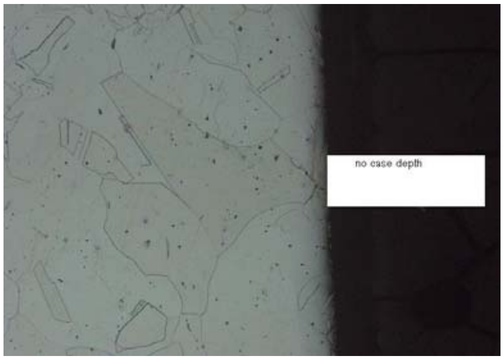

Fig1 - Untreated Specimen.

Fig2 - GN1 Specimen with 30 microns.

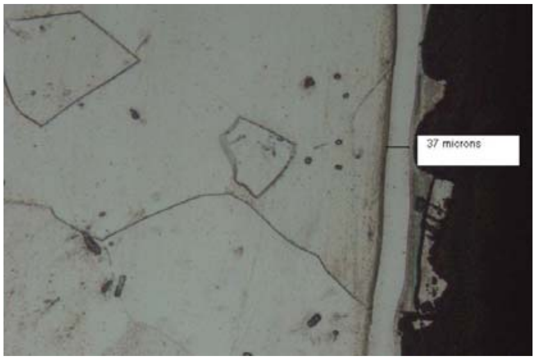

Fig3 - GN2 Specimen with 37 microns.

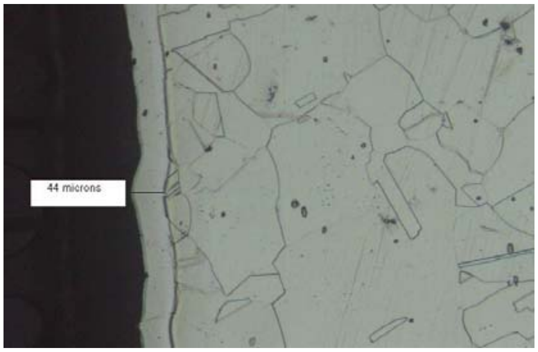

Fig4 - GN3 Specimen with 44 microns.

From the figure 1, 2, 3 and 4 it is seen that, as the time of nitriding increases, case depth also increases. Therefore the case depth is increased from 30, 37, 44 microns in GN 1, GN 2, GN 3 Specimens respectively. The results are compared with untreated specimen. Hence GN 3 specimen improves its wear resistance causing low wear loss and wear rate.

3.2 Scanning Electron Microscope Results:

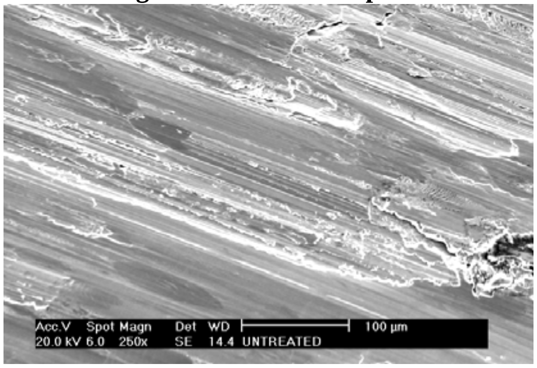

Fig5 - Untreated PIN Specimen

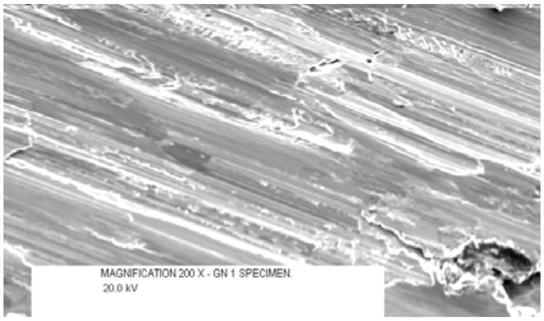

Fig6 – GN1 PIN Specimen

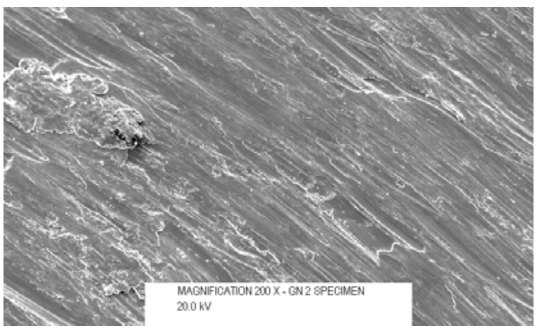

Fig7 – GN2 PIN Specimen

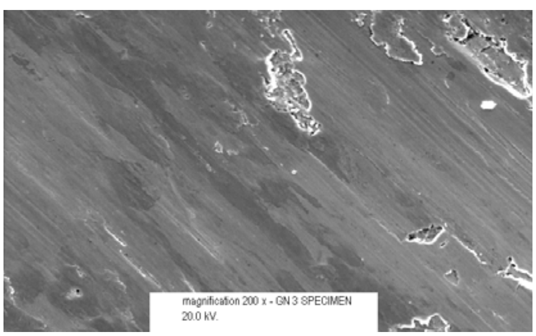

Fig8 – GN3 PIN Specimen

From the figure 5, 6,7and 8 it is seen that, the specimens were compared with untreated specimen. The peel of material is very high in untreated specimen. The wear of material is high. As the case depth increases, wear loss of the material decreases. In GN 3 the wear loss of material is less when compared to GN 2 and GN 1. From SEM images it is proved that GN 3 specimen improves its wear resistance. It was found that volume wear loss was low and specific wear rate was very low.

3.3 X-Ray Diffraction Analysis:

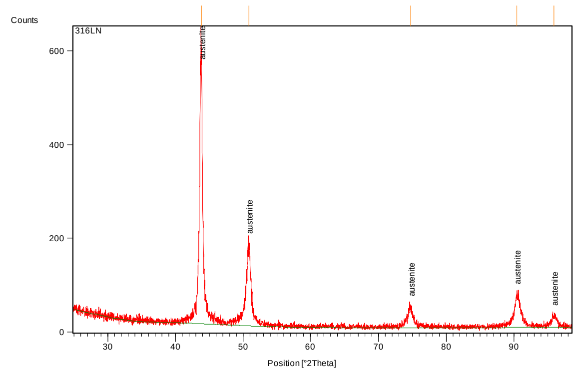

Fig9 - XRD of Untreated Specimen

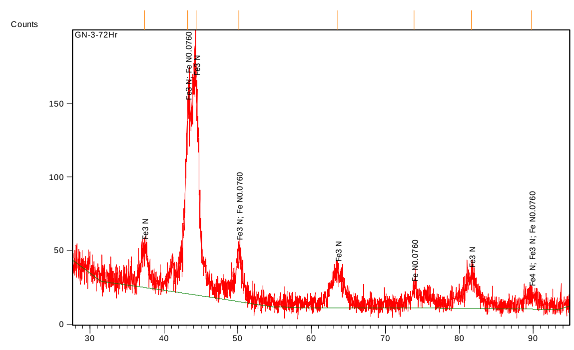

Fig10 - XRD of GN3 Specimen

From the figure 9 and 10 XRD analysis, the phase formation of nitrides were obtained. From the XRD pattern, it was observed that iron nitrides are formed at the peaks with nitrogen formation. The formation of Cr-Ni-Fe-C elements, siderozot, and roaldite in GN 3 improves the wear resistance of the material. As it was found that, no presence of nitrogen compounds in the untreated specimen.

4.0 CONCLUSION

The result of this work confirms that, gas nitriding has effectively improved its wear resistance. As the time for treatment increases, the case depth also increases. From the wear studies, it is observed that GN 3 specimen has a very good wear resistance. It is showed that, as the time of nitriding increases, weight loss decreases. XRD confirms the presence of nitride compounds like iron nitride, roaldite, siderozot and magnetite. Among these three specimens, GN 3 has improved the wear resistance and hence the life of the material is increased.

Nomenclatures

AISI - American Iron and Steel Institute

GN - Gas Nitriding

XRD - X Ray Diffraction

HV - Vickers Hardness

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