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Salt Bath Nitriding on 316LN Austenitic Stainless Steel Material

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ABSTRACT

The wear behavior of salt bath nitrided austenitic stainless steel, AISI 316LN has been investigated under a dry sliding contact at constant load. It was found that salt bath nitriding was effective in improving the wear behavior of stainless steel material. A low temperature salt bath nitriding has been carried out for four different specimens at 60 minutes (430^{0}C), 80 minutes (480^{0}C), 100 minutes (530^{0}C), 120 minutes (560^{0}C) and named as SBN 1, SBN 2, SBN 3, SBN 4 respectively. Unnitrided austenitic stainless steel was used as a reference material and underwent wear test for comparision with nitride specimens. The nitrided specimens reveals that hard complex nitrides are formed which improves the surface hardness. Micro hardness measurements revealed a significant increase in hardness after treatment. The layers were characterized by optical microscope and scanning electron microscope analysis.

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INTRODUCTION

Salt bath nitriding is done to obtain high surface hardness, increase wear resistance, improve fatigue life, and improve corrosion resistance, high dimensional stability. Austenitic stainless steel is used because of their high resistance to oxidation and corrosion resistance. They find applications extensively used 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, nitriding offers the benefits of high dimensional stability. The high levels of chromium contribute to excellent corrosion resistance in these austenitic stainless steel materials.

Chosen for this research work, on the basis of their application and commercial availability, salt bath nitriding produces more uniform metallurgical formed case depth. The depth and quality of case would be determined by the chemical composition of liquid. Liquid or salt bath nitriding is carried out in a molten salt bath in a temperature of 430^{0}C-560^{0}C. Salt bath containing cyanides, cyanates and mixture of sodium and potassium salts. Salt bath nitriding utilizes the melting of salt containing rich nitrogen source. The salt melts and liberates nitrogen into the steel for diffusion. The case hardening medium in this method is molten nitrogen. The specimens were introduced into the salt bath and heated in molten salt, therefore controlled amounts of nitrogen are released to diffuse into the surface.

2. Experimental Details:

2.1 Materials Used:

The material used in the present work was AISI 316LN austenitic stainless steel. The specimens were prepared in following forms. (i) Polished cylindrical disc specimen measuring 50 mm diameter and 10 mm height were used. (ii) Pin specimen with diameter 8 mm and height 30 mm were used with taper edged surface.

2.2 Treatments:

Prior to all treatments, the specimens were cleaned ultrasonically, rinsed and dried, with care taken to avoid finger contact. Before salt bath nitriding, the specimens were sand blasted, pickled in 15% sulphuric acid for 20 minutes. The samples were degreased using acetone and preheated in an air circulated furnace for 15 minutes. The nitriding processes were carried out in salt bath comprising of cyanates and carbonates. The nascent nitrogen diffuses into the surface of steel. The samples were immersed into salt bath for four different

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temperatures at 60 minutes (430^{0}C), 80 minutes (480^{0}C), 100 minutes (530^{0}C), 120 minutes (560^{0}C) and named as SBN 1, SBN 2, SBN 3, and SBN 4 respectively.

2.3 Wear Measurements:

Wear tests were carried out on a pin on disc machine. A stationery pin was mounted horizontally against a vertically rotating disc. The disc is rotated at a constant speed of 1460 rpm at a constant load of 15 Kg, which was applied continuously for a fixed period of 7 minutes under dry conditions. Wear test was conducted and the samples were replaced in the following order Untreated, SBN 1, SBN 2, SBN 3 and SBN 4 respectively. The weights of the specimens were measured using a standard caliberometer. The difference between the specimen before and after testing gives the wear loss.

2.4 Hardness Profile:

The hardness profile for the salt bath nitrided AISI 316LN material was investigated using Vickers hardness tester. The hardness tests were performed under an indentation load of 150 grams for 15 seconds. For an untreated 316LN stainless steel specimen, the hardness was found to be 196 $H_{v.}$ For SBN 1, SBN 2, SBN 3, SBN 4 it was found to be 1340 H_v, 1383 H_v, 1426 H_v and 1480 H_v respectively.

RESULTS AND DISCUSSIONS

The salt bath nitriding results were compared with the untreated 316LN specimen and it was found that, in nitrided specimen, the mixture of chromium nitrides were precipitated on the surface, to improve the hardness of material. The wear rate of untreated specimen is specified to be lower that of nitrided material. Hence good surface hardness is obtained. Low temperature salt bath nitriding results in good wear performance to relative case depth, which improves wear resistance. This nitriding results in precipitation of chromium nitrides. The wear loss was found to be 0.0093 grams, 0.0076 grams, 0.0047 grams, 0.0032 grams, 0.001 grams respectively for untreated, SBN 1, SBN 2, SBN 3, and SBN 4 specimens. From the wear studies, SBN 4 specimen results inferior wear performance and improves life of the material.

Optical Microscope Results

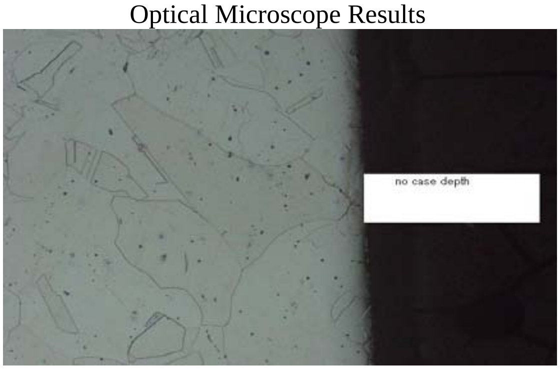

Fig. 1: Untreated specimen.

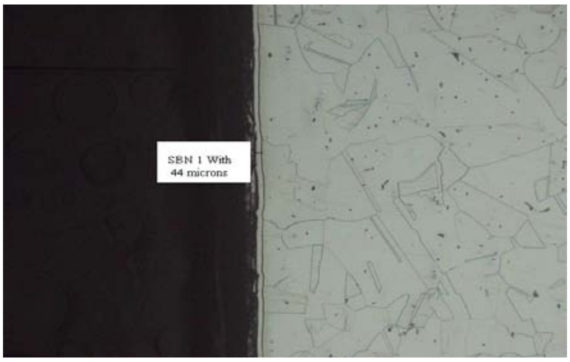

Fig. 2: SBN1 Specimen with 44 microns.

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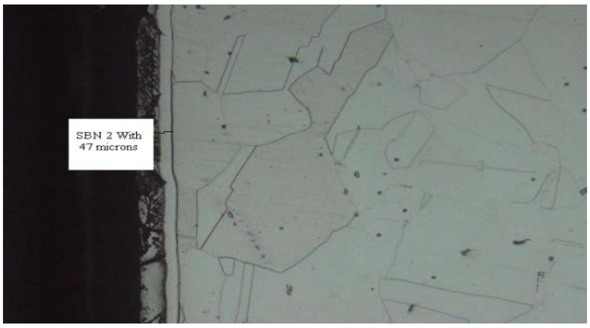

Fig. 3: SBN2 Specimen with 47 microns.

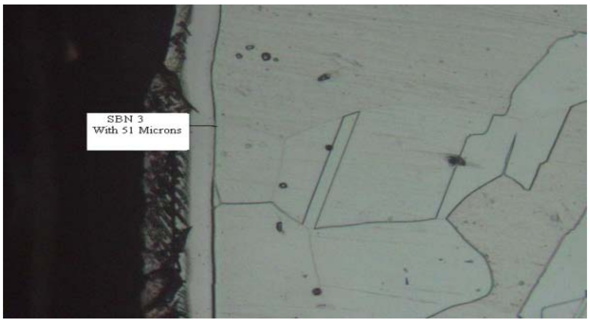

Fig. 4: SBN3 Specimen with 51 microns.

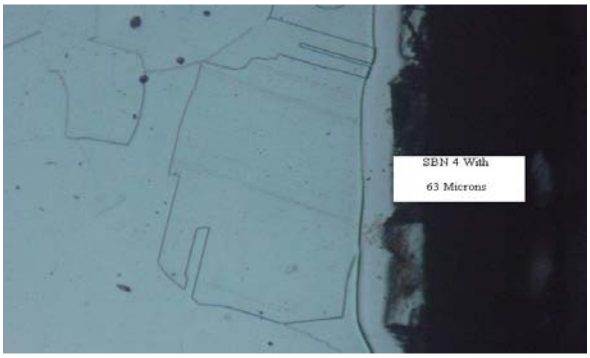

Fig. 5: SBN4 Specimen with 63 microns.

From the figure 1,2,3,4 and 5 it is seen that, as the time of nitriding increases, case depth also increases. Therefore the case depth is increased from 44, 47, 51 and 63 microns in SBN 1, SBN 2, SBN 3 and SBN 4 specimens respectively. The results are compared with untreated specimen. Hence SBN4 specimen improves its wear resistance causing low wear loss and wear rate.

Scanning Electron Microscope Results

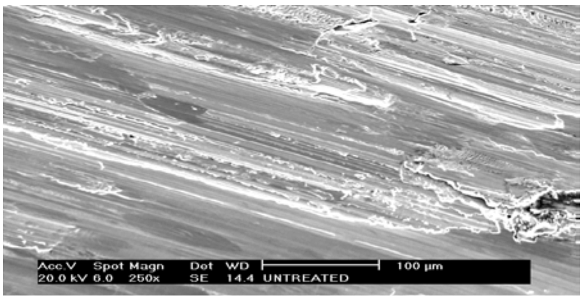

Fig. 6: Untreated PIN Specimen.

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Fig. 7: SBN1 SEM image.

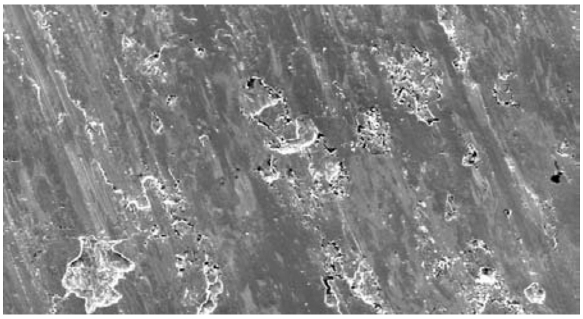

Fig. 8: SBN2 SEM image.

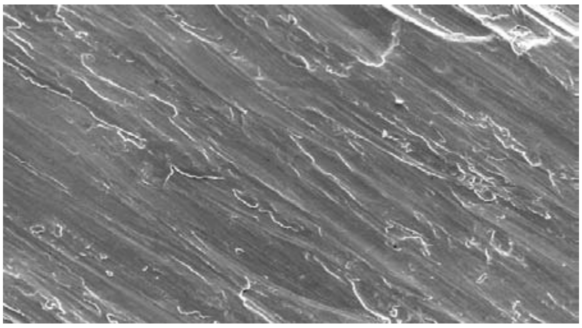

Fig. 9: SBN3 SEM image.

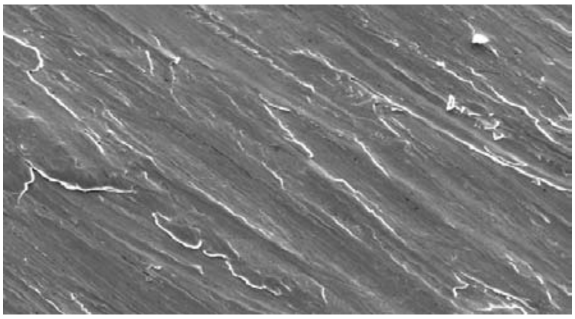

Fig. 10: SBN4 SEM image.

From the figure 7, 8, 9 and 10 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 SBN 4 the wear loss of material is less when compared to SBN 3, SBN2 and SBN 1. From SEM images it is proved that SBN 4 specimen improves its wear resistance.

Conclusion:

The result of this work confirms that, salt bath 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 SBN 3 specimen has a very good wear resistance. It is showed that, as the time of nitriding increases, weight loss

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decreases. Among these three specimens, SBN 3 has improved the wear resistance and hence the life of the material is increased.

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