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SALT BATH NITRIDING ON 316L AUSTENITIC STAINLESS STEELS

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ABSTRACT
This paper examines on salt bath nitriding process with a specific end goal to enhance the wear conduct of the 316L Austenitic steel. The specimens were nitrided at 590°c on five distinctive planning hours, such as 60minutes, 80 minutes, 120 minutes, 150 minutes and 180 minutes and named as SBN1, SBN2, SBN3, SBN4, SBN5 respectively. A pin on disc machine is used to conduct wear test, so that wear loss can be determined. The specimens are to be magnified by metallographic test like Optical Microscope and scanning electron microscope. The best specimen is chosen which determines the life of the material and it improves the wear resistance. The hardness of untreated material and nitrided specimens are analyzed.

Keywords
316L Austenitic steel, salt bath nitriding, pin on disc, Optical Microscope, scanning electron microscope.

1. INTRODUCTION
Salt bath nitriding process is an alternative process of gas nitriding process, which would produce more uniform and better metallurgical formed case. A liquid would fulfill the uniformity requirement through surface contact of the liquid to the steel. The depth and the quality of the case would be determined by the composition of the liquid.A heat source would be compulsory to drive the nitrogen into the steel surface. Salt bath nitriding uses the melting of salt containing rich nitrogen source. When heat is applied from either internal or external source, the salt melts and liberates nitrogen into the steel for diffusion. When the steel work piece is introduced into the salt bath and heated up to a temperature in the molten salt, controlled amounts of nitrogen are released to diffuse into the surface.

Compositions of case-producing salts may vary from manufacturer to manufacture, however they use sodium and potassium cyanates, or cyanides as basic ingredient. The active ingredient (cyanide), is oxidized to cyanate by aging. The commercial salt mixture (30 - 40% potassium salts, 60 - 70% sodium salts) is melted at 823 to 890k.

As melting stage begins, a cover should be placed over the retort to guard against spattering, unless the equipment is completely hooded and vented. A liquid nitriding composition does not contain a substantial amount of cyanate in the original melt. it must be aged before use in production. It is the surface air (oxygen)-to salt contact that oxidizes cyanide to cyanate, and during age treatment no work should be placed in the salt. The ratio of cyanide content to cyanate content depends on the salt bath process and the salt bath composition. The typical commercial bath for nitriding consists of NaCN, NaCO3 and NaCNO mixture of 60-70%. The bath used in liquid pressure nitriding operates with a cyanate content of 15 to 20% and cyanide content of 30 to 35%. The liquid bath initially aged at a selective time temperature for combination to increase the cyanates content and then parts are immersed in the liquid for further processing. Salt bath nitrided components exhibit excellent sliding and running in properties as well as greater wear resistance. This nitriding improves wear resistance, lubricity, and fatigue strength and corrosion resistance as a result of the presence of iron nitride compounds formed at the surface in integration to a zone of diffused nitrogen in solid solution with the base metal adjacent to the compound layer. Both of these zones are metallurgically discernible, each providing engineering properties like anti galling, anti-seizing characteristics and reduced tendency for fretting corrosion. Salt bath nitriding is an effective and economical means to enhance performance of engineered components made up of ferrous metals

2. EXPERIMENTAL PROCEDURE
Austenitic stainless steel 316L in cylindrical rod with dimensions of 5mm diameter and 30mm length is selected. The untreated specimen undergoes pin on disc to determine the wear behavior of the material. The specimens undergoes salt bath nitriding at different time interval like 60 minutes , 80 minutes, 120 minutes, 150 minutes and 180 minutes and named as SBN1, SBN2, SBN3, SBN4, SBN5 individually . The untreated specimen and treated specimens undergoes pin on disc to determine the wear behavior of the material. vicker test is performed on specimens to find hardness of the individual specimen.

2.1 PIN ON DISC
Experiments were conducted on pin on disc machine and the following parameters were varied. The load was carried keeping the speed of rotation, sliding distance, sliding velocity and the time constant for one set of readings. And for the other set of readings, time was varied keeping the load, sliding distance and sliding velocity constant.

EXPERIMENTAL PARAMETERS

Load	:	5kg (constant)
Speed	:	1000rpm (constant)
Time	:	3 mins (constant)

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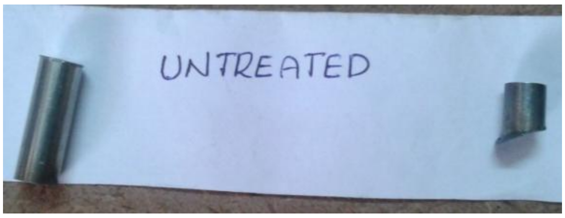
Density : 0.08kg/cm³This

S.No	Specimen description	Weight before testing (gms)	Weight after testing (gms)	Weight loss (gms)	Volume wear loss (cm^3)
1	UNT	5.3	4.8	0.5	6.25
2	SBN1	5.28	5.01	0.27	3.375
3	SBN2	5.29	5.06	0.23	2.875
4	SBN3	5.27	5.13	0.14	1.75
5	SBN4	5.28	5.19	0.09	1.125
6	SBN5	5.29	5.24	0.05	0.625

As the process time increases the weight and volume loss decreases. The specimen SBN5 is resistant to material loss when compared to the untreated specimens and treated specimens.

SPECIMEN IMAGES AFTER PIN ON DISC METHOD

1. UNTREATED SPECIMEN



It is untreated specimen undergoing pin on disc method

The different specimens are tested on pin on disc.

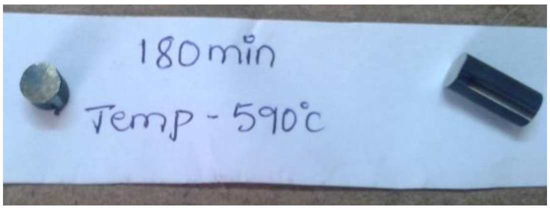
2. SBN1 SPECIMEN

3. SBN2 SPECIMEN

4. SBN3 SPECIMEN

5. SBN4 SPECIMEN

6. SBN5 SPECIMEN



2.2 OPTICAL MICROSCOPE RESULTS:

Optical Microscope Results for Untreated Specimen

Fig 1 Case Depth for Untreated Specimen

Optical Microscope Results for SBN 1 Specimen

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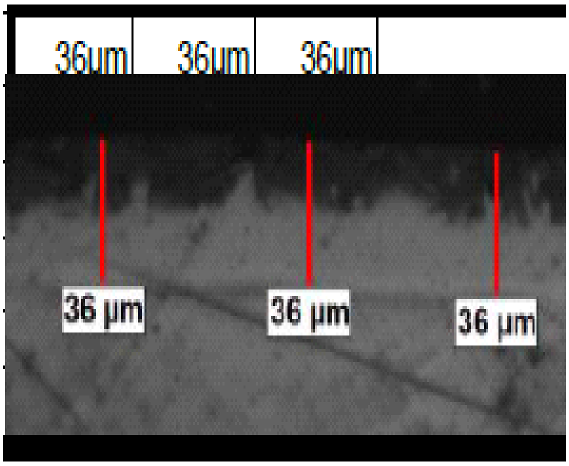

Fig 2 Case Depth for SBN1 Specimen for 60 minutes

Optical Microscope Results for SBN 2 Specimen

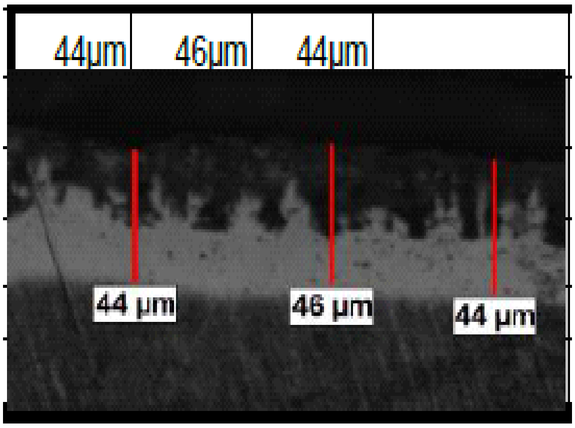

Fig 3 Case Depth for SBN2 Specimen for 80 minutes

Optical Microscope Results for SBN 3 Specimen

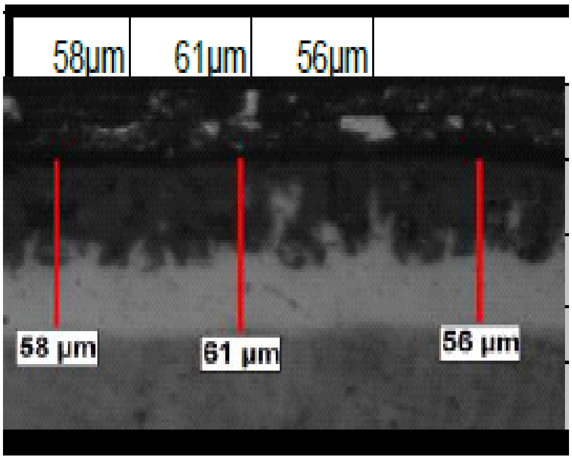

Fig 4 Case Depth for SBN3 Specimen for 120 minutes

Optical Microscope Results for SBN4 Specimen

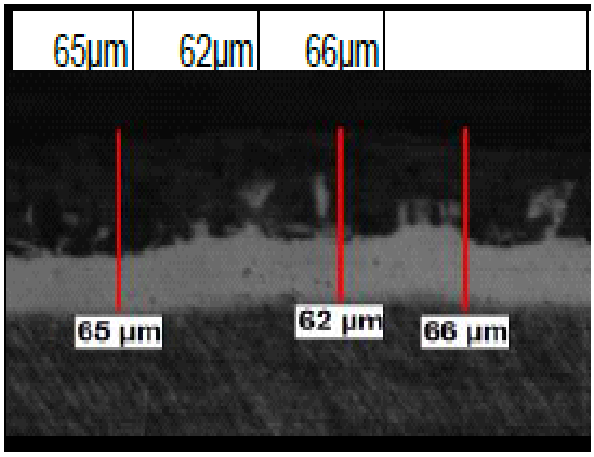

Fig 5 Case Depth for SBN4 Specimen for 150 minutes

Optical Microscope Results for SBN5 Specimen

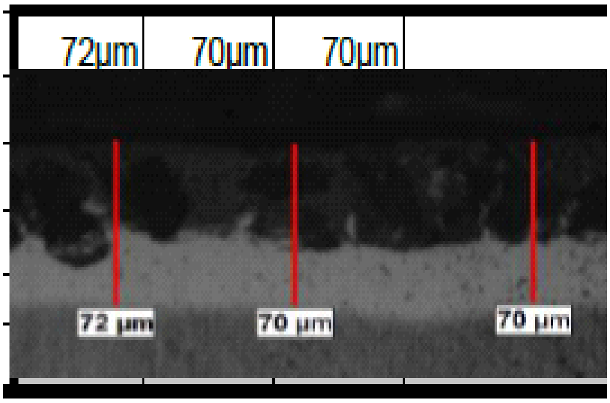

Fig 6 Case Depth for SBN5 Specimen for 180 minutes

Optical microscope testing for the treated specimen.SBN1 - 60mins the thickness is 36microns.The treated specimenSBN2 for 80mins thickness varies from 44-46 microns similarly for SBN3 SBN4 SBN5 thickness varies 58-61, 62-66, 70-72 microns. As the time prolongs the Case depth for treated specimens increases thereby increase in the wear resistance and strength

3. HARDNESS RESULTS – VICKERS TEST

Micro Hardness Measurements

Vickers hardness measurements were made to assess the influence of the nitrogen on the superficial hardness of the nitride specimens. The micro hardness at the surface of the nitride layers of the specimens were measured for all the nitrided specimens.

Specimen	Case Depth	Hardness Value
Untreated	Nil	380 VHN
SBN 1	36µm	992.5 VHN
SBN 2	44.67µm	1151 VHN
SBN 3	58.33µm	1324.5 VHN
SBN 4	64.33µm	1418.25 VHN
SBN 5	70.67µm	1519 VHN

Table 1 – Hardness & Case Depth Values for Various Nitrided Specimens

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4. SCANNING ELECTRON MICROSCOPE RESULTS (SEM)

Scanning Electron Microscope for Untreated Specimen

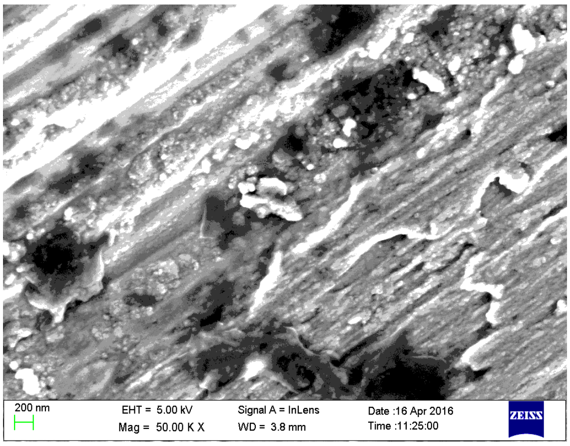

Fig 1 Scanning Electron Microscope for Untreated Specimen

Scanning Electron Microscope for SBN2 80 minutes Specimen

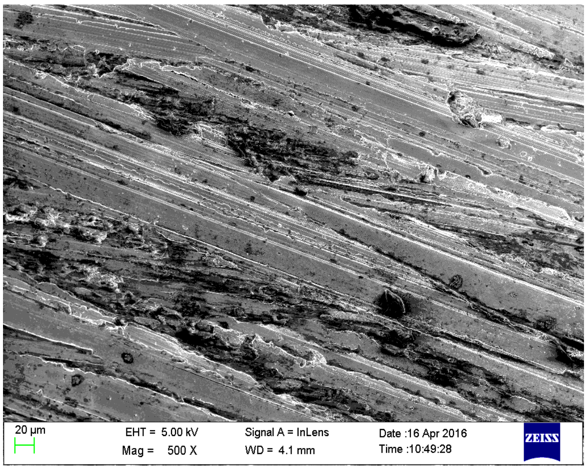

Fig 2 Scanning Electron Microscope for SBN2 80 minutes Specimen

Scanning Electron Microscope for SBN3 120 minutes Specimen

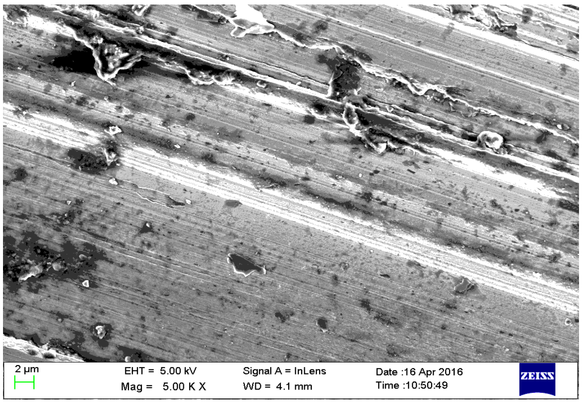

Fig 3 Scanning Electron Microscope for SBN3 120 minutes Specimen

Scanning Electron Microscope for SBN4 150 minutes Specimen

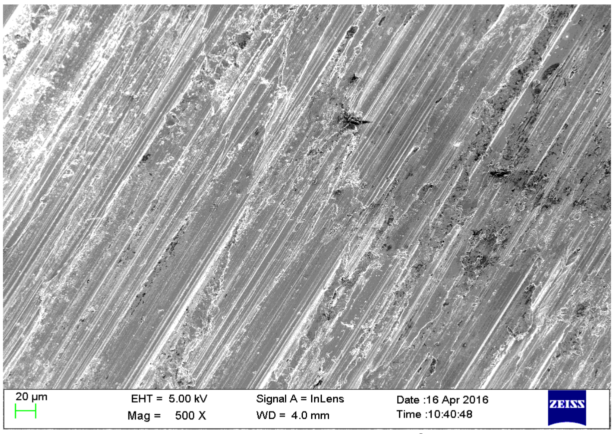

Fig 4 Scanning Electron Microscope for SBN4 150 minutes Specimen

Scanning Electron Microscope for SBN1 180 minutes Specimen

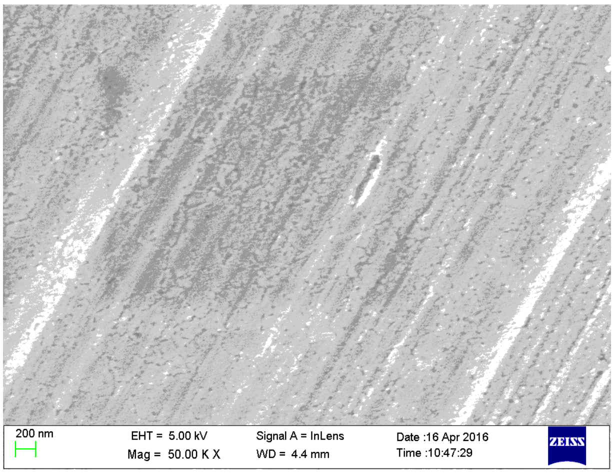

Fig 5 Scanning Electron Microscope for SBN5 180 minutes Specimen

In SEM analysis, salt bath nitridedspecimens reveals very minute microetch pits. They are visualized in the compound layer indicating the uneven distribution of nitrides. In plasma specimen, no wear was found. There is no peel of material, when compared to the other nitrided specimens, where as in untreated specimen, more peel of material occurs.Also in salt bath nitrided samples, some cracks werefound. This is due to the load acting over the specimen, sliding speed and variance sliding distance

5. CONCLUSION

By analyzing salt bath nitriding 316L specimens at different timing by different testing methods, it is concludes that

1. As the time for treatment increases the case depth also increases. In salt bath nitriding process it is from 36, 44, 58, 64, 70 Microns which is nitrided at 60, 80, 120, 150, 180 minutes respectively.
2. From the wear studies we can find that SBN5 specimen has a very good wear resistance when compared to other nitrided samples. The hardness of the material is expanded up to 500% by this procedure.
3. In the case of salt bath nitriding, SBN5 has a good wear resistance, when compared to other three specimens.

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This could be due to the presence of hard compound layer of maximum thickness of 70 microns at the surface.

4. The combination action of strong adhesion, abrasion and severe plastic deformation are the primary reasons for the continuous material loss in the untreated specimens. Whereas the wear on the nitrided specimen in mild form is dominated by oxidation wear resistance and micro abrasion.

6. ACKNOWLEDGEMENT
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