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IMPROVEMENT OF 316L STAINLESS STEEL PROPERTIES BY GAS NITRIDING

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Abstract - *In this paper, 316l Austenitic steel specimens are gas nitrided at different timings. The changes in the surface and microscopic level of the specimens are underwent into different testing for detail view on the specimens and for the structural testing optical microscope and SEM are used, whereas for physical behavior- hardness vecker's test is used. Pin on disc is used to test wear resistance of the specimen before and after the process is conducted. The untreated specimen and treated specimen are compared to determine the best process timing.*

Key Words**: 316L , SEM , Vicker test , Austentic steel Optical microscope .**

1. INTRODUCTION

Stainless steels are the alloys of iron (fe) chromium (cr) with controlled carbon percentage. Generally steels are classified into carbon steels and stainless steel. If the chromium percentage in stainless is more than 11% it is a stainless steel. If it is less than 11% then it is a carbon steels. Mo, N, cr different types of elements are added to steels in resulting different grades of stainless steels

Heat treatment is process of improving the properities of the steels to the greater extent .in this process material are heat to 700-800c are heating cooling rates are varies and holding temp in furnace , with different cooling mediums - types of heat treatment process for steels can be done . Heat treatments majorly used are harding, annealing, normalizing, quenching, tempering etc. Each heat treatment process has different end goals in improving specific characteristics. Generally characteristics improvement by these methods like strength toughness ductility corrosion resistance, wear resistance etc.

1.1 Gas Nitriding

Gas nitriding is a type heat treatment where material external properties are changed without changing the internal properties, by inducing this process, material with high surface finish and strength can be achieved. Nitrogen is introduced into the surface of a solid ferrous alloy by holding the metal at a suitable temperature in contact with a nitrogenous gas, usually ammonia. The nitriding temperature of all steels is between 450 – 550°C. Because of the absence of a quenching requirement with volume changes and the comparatively low temperature employed in this process, nitriding of steels produce less distortion and deformation than in carburizing or in conventional hardening. Certain growth occurs as a result of nitriding but volumetric changes are relatively small

By gas nitriding the austenitic grade stainless steel, a non- magnetic layer as the hardness value of 820-880 VHN and a case depth of about 0.25-0.3mm could be obtained. The ammonia gas dissociates into nitrogen and hydrogen at the part surface. At the instant of dissociation, nitrogen is liberated in atomic form and is absorbed by the material as such whereas the hydrogen becomes the part of atmosphere in the furnace. The depth of hardening and extent of case hardness developed due to gas nitriding depends on several factors such as time temperature schedule of the process, degree of dissociation of ammonia, concentration and nature of nitride forming elements etc. For the same depth of hardening, gas nitriding causes less dissociation of the hardened parts than the liquid nitriding.

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MATERIAL SPECIFICATIONS

Chemical Specification:

Carbon: 0.03%, Manganese: 1.93%, Silicon: 0.56%, Sulphur : 0.017%, Phosphorous : 0.021%, Nickel: 12.24%, Chromium: 17.94%, Molybdenum: 2.06%

2. PREPARATION OF SPECIMEN

- The plate type 316 L grade stainless steel were cut into small pieces of length 30mm, diameter 6 mm, with the help of wire cut EDM processes disc of 316 L material is used as the disc, with 50mm diameter and 8mm thickness.
- Extra chips or unwanted materials are removed by using grinding with the different grade emery papers.

- Specimens are holded at suitable temperature 450-550 degrees in closed furnaces chamber with nitrogen gas like ammonia.
- The two specimens are nitride at different times that is 28 ,56 hours

3. PIN ON DISC

The untest specimen and two tested specimens under goes pin on disc wear test. The speed of rotation of disc is 1000 rpm. Each specimen is tested for 3mins.

WEAR TRACK READINGS

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	GN1	5.28	5.08	0.2	2.5
3	GN2	5.29	5.1	0.19	2.37

As the time of process increase the weight loss of the specimens significantly decreased. The volume wear is decreased from 6.25 to 2.37.

UT - untested specimen

GN1 - tested specimen for 28 hours

GN2 – tested specimen for 56 hours.

In the pin on disc when weight loss after testing , it is observed it's decrease rate very high , but from GN1 to GN2 the weight loss is very low. The rate of wear loss of the material surface for different timings specimen decreases. The volume wear loss also follows similar as weight loss.

3.1 OPTICAL MICROSCOPE

Three specimens are analyzed using optical microscope.

1. As the material is untreated there is no formation of layer on the specimen. In this specimen, It has zero microns case study

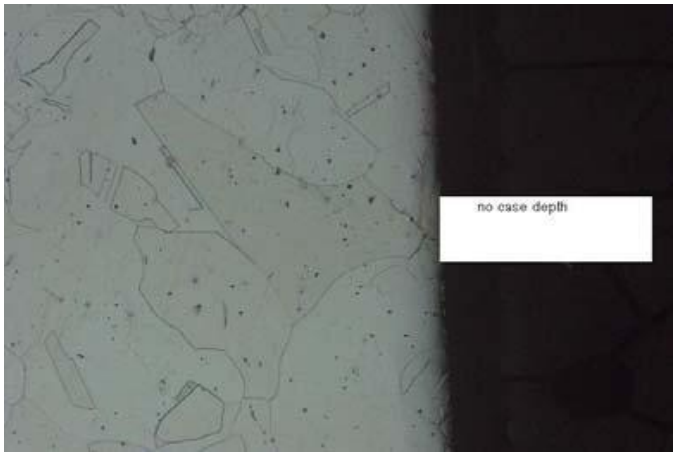

Fig 1 . case depth of untreated specimen

The specimen is untreated so there is no case depth of layer formed .

2. In this, the specimen is treated for 28hrs , so the specimen's case is 12.43-11.14 microns.

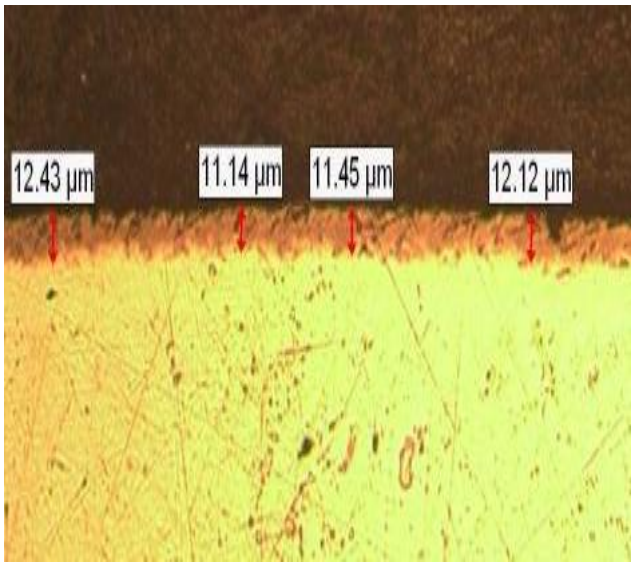

Fig 2. Case depth of GN1 specimen -28hrs

As specimen is treated, the case depth on the surface of the specimen is formed , the case depth of the specimen varies from the 11 to 12 micron results to avg. of 11.785 microns.

3. The specimen is treated for 56hrs, the specimen forms thicker layer on the specimen's surface . The specimen case depth is 32.42-31.07 microns

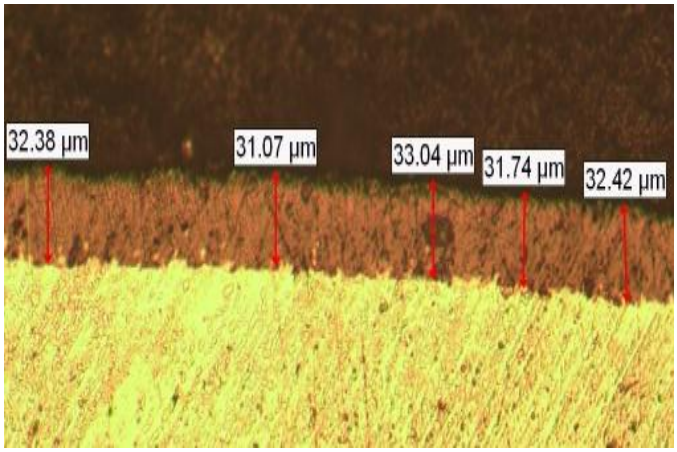

Fig 3. Case depth of the GN2 specimen -56hours

The specimen's case depth even increases as the time increases. The average case depth on the surface results to 32.11 microns.
Thus this indicates that, the specimen treatment time increase the case depth also increases.

3.2 SEM

Three specimens are analyzed using SEM

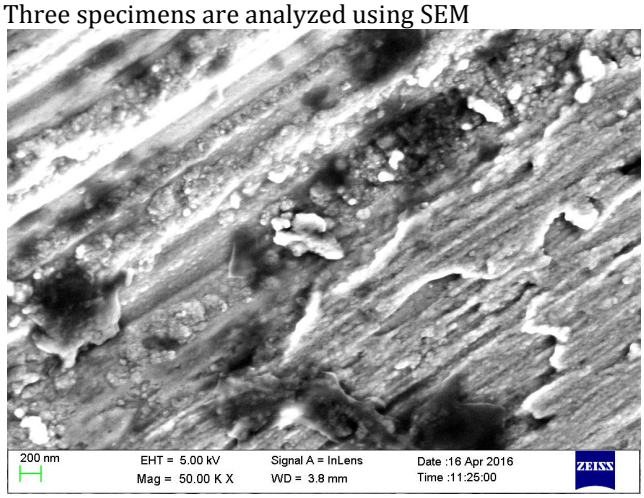

FIG 4 SEM IMAGES OF UNTREATED SPECIMEN

UT specimen has high peel of material, the material is distributed even as shown in the fig4. when we compare with tested specimens.

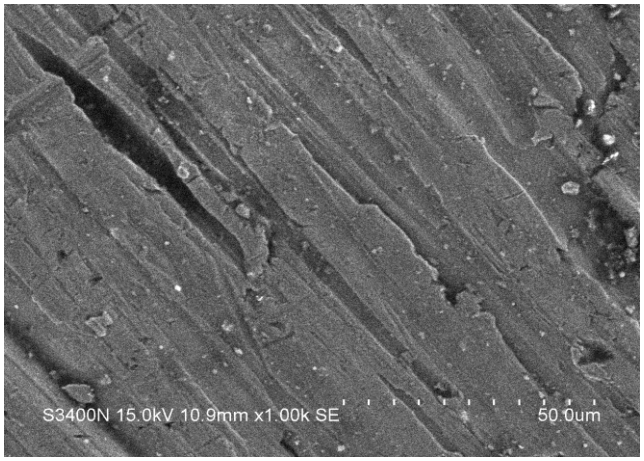

FIG5. GN1 NITRIDED SPECIMEN 28HOURS

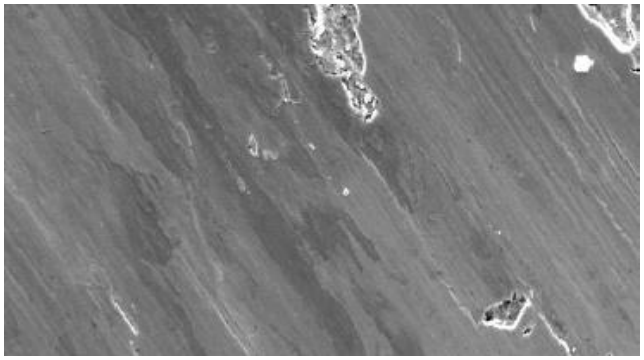

FIG6. GN2 NITRIDED SPECIMEN 56HOURS

In SEM analysis, gas nitride specimens reveals very minute microetch pits. They are visualized in the compound layer indicating the uneven distribution of nitrides. There is no peel of material, when compared to the other two nitrided specimens. In gas nitride specimens, hard crack is viewed on the specimen. The peel of material is high in untreated specimens when compared with gas nitrided specimens.
As it is observed the testing timings increases the specimen surface gets better finish.

3.3 VICKER'S TEST

Specimen	Case Depth	Hardness Value
Untreated	Nil	283 VHN
GN 1	11.785 µm	1080 VHN
GN 2	40.137 µm	1162 VHN

The three specimens undergoes vicker's test, To determine the hardness of the specimen. As the untreated specimen doesn't has case depth, when the specimen treated there is a drastically increase in its hardness. Even when GN1 and GN2 is compared there is increase in the hardness is less because of lesser case depth difference.

4. CONCLUSIONS

As gas nitriding process performed on specimens. It is concluded that

1. With increase of Heat Treatment time (28 to 56 hrs), the case depth results 11 to 32 microns.
2. Due to the layer formation, the materials wear resistance has improved drastically and the material wear loss is decreased more than 60 %. i.e 6.25 to 2.37cubic cm
3. Due to inclusion on nitrogen into specimen's surface, hardness improvement is over 350%.
4. As the nitriding time increases the material properties improves and with increase in treatment time the materials surface is free from the peels.

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