Assessment of Properties on AISI 316LN Austenitic Stainless Steel Material under Low Temperature Liquid Nitriding Processes

Ram.Subbiah, S.Satheesh, Shoan C.Sunny, G.Kishor, K.Fahad, R.Rajavel

Abstract* - *Austenitic stainless steels have been widely used in highly corrosive environments for power generation, chemical, fertilizer, marine, and food and petrochemical reactors. These materials are well known for their good corrosion resistance and mechanical properties like strength etc. However, because of its low hardness and wear resistance their applications are greatly limited. Nevertheless, the performance of these alloys can improved further for both aqueous and high temperature applications and environments by case hardening techniques like carburizing, nitriding and so on. These surface hardening processes offer high corrosion resistance in addition to, improved hardness and wear resistance. In the present study, the effect of gas nitriding on the properties like micro hardness, corrosion resistance and wear resistance of type AISI 316LN grade austenitic stainless steels were investigated. The salt bath nitriding was carried out at a temperature of 5000C for durations of 60, 90 and 120 minutes with a post oxidation process for a period of 30 minutes and named as SBN1, SBN2, SBN3 respectively. The resultant inter metallic phases were analyzed with optical microscope and micro hardness tester for micro hardness, micro structural changes, nature and compositions of the diffused elements. It has been found that the matrix element interacted with alloying elements and formed a 'ξ ' phase or 's' phase consisting of hard complex Fe-Cr nitrides. These phases showed significant influence on the properties. From the experiment results, it was observed that gas nitriding increases the micro hardness to a considerable amount. A maximum of 1410Hv could be obtained on the austenitic grade stainless steel specimens, which were investigated among the various specimens, in order to improve the wear resistance. The untreated specimens were compared with the nitride specimen.. The reason for the increase in the micro hardness could be attributed to the presence of the Mo and the other alloying elements in the solid solution. The value of hardness at the surface level increases with the diffusion time up to a certain level. Beyond this, limit further increase in diffusion duration does not have any impact on the surface hardness. To evaluate the effect of post-oxidation on nitrided specimen's corrosion and tribological properties were determined. From the results, it was observed that post- oxidation has no significant effect on the hardness but improves the corrosion resistance in comparison with non-oxidized specimen in a larger factor. Also it was observed that the change in the properties was due to the formation iron oxide layer on the specimen and especially during the subsequent treatment in the oxidizing bath. From the micro structural analysis of the nitrided specimens, the case depths were observed to be about 20 -50 microns (μm).

Keywords: stainless steels, nitriding, micro hardness, corrosion resistance, microstructure

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I. INTRODUCTION

Salt bath surface treatments has been used widely for various industrial applications for many years, since the technology is able to be applied in mass production. Nitriding is a thermo chemical treatment which involves the diffusional addition of nitrogen to the surface of ferrous metals.The treatment involves the resistance to scuffing through the development of a compound layer at the surface consisting of nitrided layer.

The treated components also exhibit the enhanced fatigue properties on account of the diffusion zone where nitrogen is held in solid solution beneath the compound layer. Nitriding is therefore applied advantageously to textile machinery components, water pump parts, timing gears and a number of automotive parts which undergo sliding rolling. Gears used in industrial applications require a hard, wear resistant case. The principal methods of case hardening gears are carburizing, nitriding, flame hardening and induction hardening. Research works were carried out in a low temperature, non polluting salt bath treatments which are superior to traditional treatments.

Liquid or salt bath nitriding is carried out in a molten salt bath in a temperature of 450^0C-500^0C. Salt bath containing cyanides, cyanates and mixture of sodium -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.

II. EXPERIMENT PROCEDURE

The stainless steel specimens examined were prepared to the following forms. Polished cylindrical specimens measuring – 3 No's with 10mm diameter, 30 mm long were used for metallography examination. Specimens for wear testing machine were produced in accordance with the falex pin on disc machine.

2.1 Treatments

One disc material of austenitic stainless steel which was nitrided to the saturated limit and three pin specimens were nitrided to various time parameters. Prior to all treatments, specimens were cleaned ultrasonically, rinsed and dried, with care taken to avoid further finger contact. Before nitriding, the specimens were additionally sand blasted and just prior to treatment, pickled in 10% sulphuric acid for 10 minutes. The specimens were preheated to 450^0C, immersed in a salt bath for 60 minutes, 90 minutes, 120 minutes and named as SBN1, SBN2, SBN3 respectively.

2.2 Wear Testing

Using a standard falex machine, with the test pin rotating at 800 rpm, a constant load of 15 kg was applied for a period of 2.5 minutes under dry conditions. The wear rate was

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calculated by determining the weight loss or if the specimen seized, the time to seizure was recorded.

2.3 Hardness Profile

Comparative hardness profiles for the different grades of stainless steels and the various nitriding treatments were investigated. Salt bath nitriding imparted a good surface hardness with values as high as 1410H_v for the AISI steel.

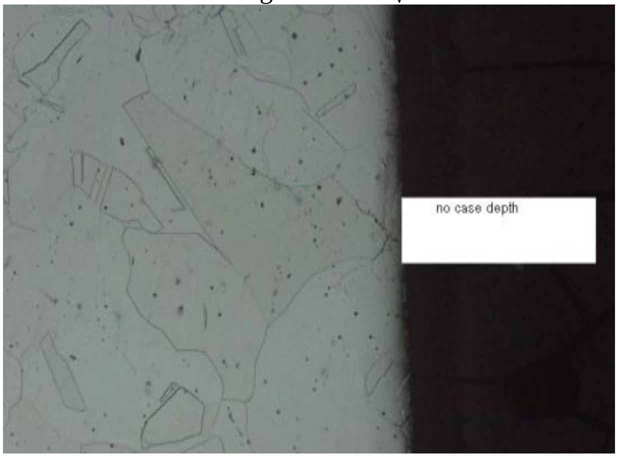

Figure 2.1 Untreated Specimen

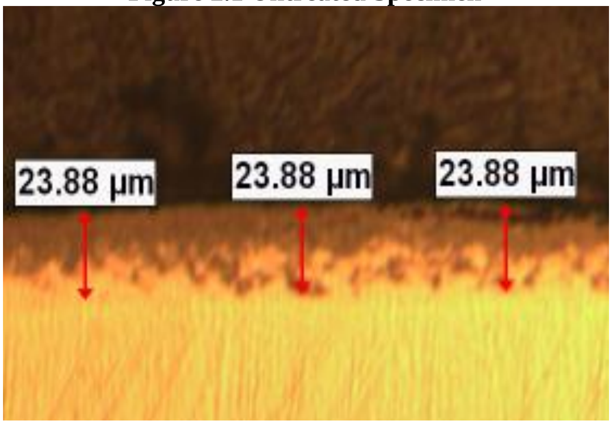

Figure 2.2 SBN1 Specimen

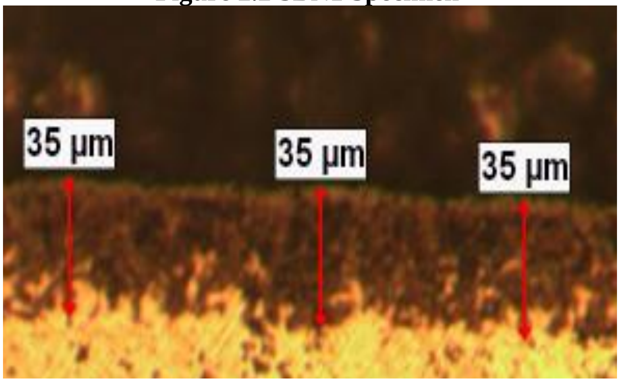

Figure 2.3 SBN2 Specimen

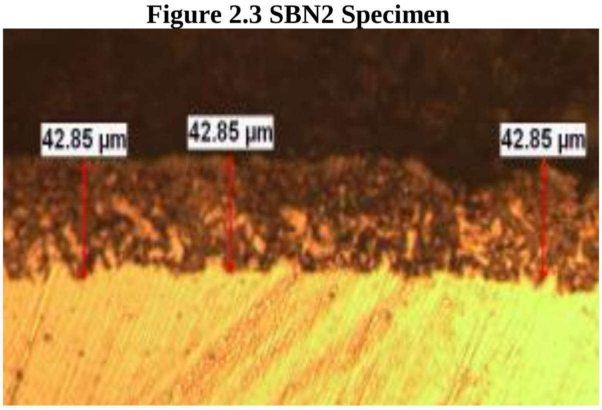

Figure 2.4 SBN3 Specimen

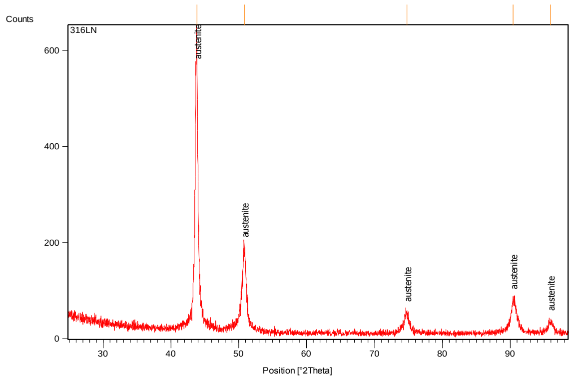

Figure 2.5XRD for Untreated Sample

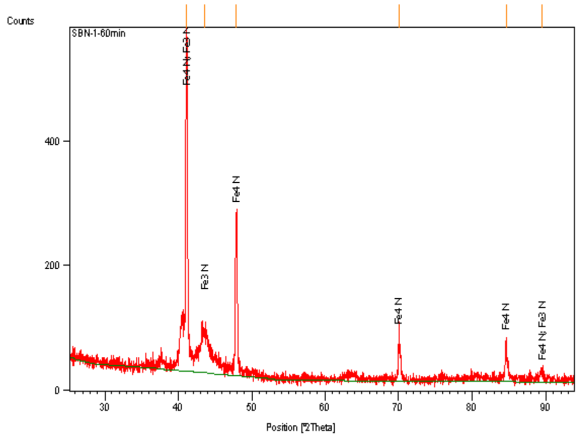

Figure 2.6 XRD for SBN1 Specimen

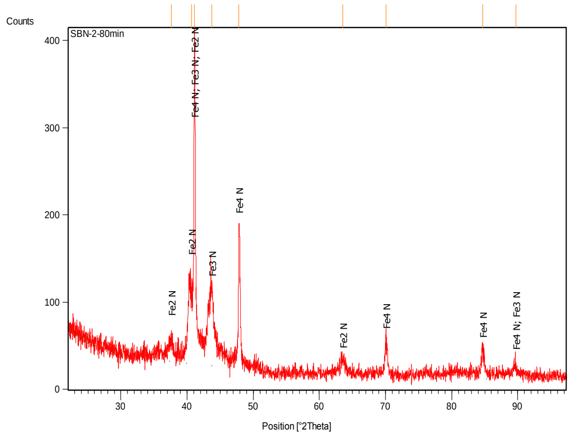

Figure 2.7 XRD for SBN2 Specimen

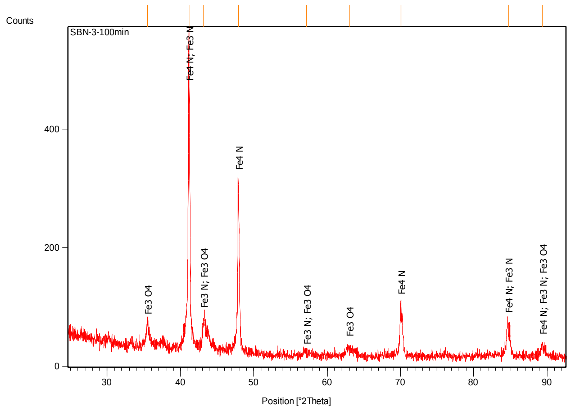

Figure 2.8 XRD for SBN3 Specimen

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III. RESULTS

From the figure 2.1, it was found that no case depth was found in an untreated specimen. The other salt bath nitrided specimens showed the case depth of 23.88, 35 and 42.85 microns shown in figure 2.2, 2.3, 2.4 . Also in an untreated specimen, the XRD results showed the presence of austenite structure in figure 2.5. Whereas in other specimens, the presence of iron nitrides on the surface of the material, that confirms that the material has been surface hardened and improves the wear and corrosion resistance shown in figure 2.6, 2.7, 2.8. Microscopy study showed the surface layers produced after nitriding stainless steel to be different from those observed on other nitride stainless steel materials.

IV. CONCLUSIONS

As would be expected, the specimens salt bath nitrided at higher temperatures exhibit deeper nitrided cases than those treated at the low temperature, despite the use of prolonged nitriding times in the latter instance. The diffusivity of nitrogen in the FCC matrix of austenitic stainless steel is very low and the alloying elements are not mobile enough to combine with the nitrogen to form the nitrides readily. However, stainless steel salt bath nitride at this temperature, has a surface hardness as high as $1410H_v$. Sputtering is not only one of the possible mechanisms for the enhanced rate of nitriding at low temperatures; it also promotes cleaning of the surface, removing the passive oxide film on the stainless steel and avoiding costly mechanical or chemical depassivation treatment necessary prior to most conventional nitriding process. This low temperature salt bath nitriding imparts better corrosion resistance than the other nitriding methods. It is generally believed that the passivity untreated stainless steel is due to the protective surface which consists of chromium oxide. Nitriding results in the precipitator chromium nitrides, depleting the matrix of chromium hence of a passive surface oxide layer.

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