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Experimental Investigation on Hardness of Gas Implanted AISI 316LN Austenitic Stainless Steel

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Abstract- The superiority of austenitic stainless steels lies in its good weldability and great resistance to stress corrosion and pitting, because of its higher chromium, molybdenum and nitrogen contents, when compared to general stainless steels. However, some of its applications are limited by very poor wear behavior, Gas nitriding is a very effective treatment for producing wear resistant and hard surface layers on the stainless steels without compromising the corrosion resistance. In this work, AISI 316LN stainless steels samples were gas nitrided at three different timing parameters 8 hrs, 40 hrs and 72hrs under a pressure of 500Pa, in order to verify the influence of temperature on the morphology, wear of the modified surface layers. The gas nitrided samples were analyzed by means of various metallographic tests like Optical microscope, X-Ray diffraction. Wear tests were conducted on a pin on disc machine. For the samples which was nitrided, chromium nitrides were formed on the surface of the layers.

Keywords: wear behavior, wear resistance, gas nitriding, metallography

I. INTRODUCTION

The Austenitic stainless steels are widely used in many industrial fields because of their very high general corrosion resistance: nevertheless, their low hardness and wear resistance can limit the number of possible industrial applications. Gas nitriding is also referred to as ion nitriding, is a thermo chemical treatment that improves the wear and corrosion resistance of the product being nitrided. Austenitic stainless steel samples were nitrided at 550^0C. The intense precipitation of chromium and iron nitrides in the diffusion zone, are formed during the nitriding cycle. The precipitation of chromium nitrides increases the hardness and promotes compressive residual stresses at the surface but impairs severely the corrosion resistance. Nowadays, many innovative technologies have been utilized to perform low temperature nitriding treatments and produce surface modified layers avoiding the precipitation of large amount of chromium nitrides. By applying gas nitriding at low temperature, an austenite homogenous solid solution, having high nitrogen concentration with no chromium nitride precipitations is formed. This modified layer is named as super saturated or expanded as austenite. The aim of this research is to evaluate the effect of temperature of ammonia gas post oxidation on the microstructure, tribological behavior of gas nitrided stainless steel by means of optical microscope & X-ray diffraction.

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II. EXPERIMENT PROCEDURE

The stainless steels examined were prepared the following forms. Polished cylindrical specimens measuring 10mm diameter, 20 mm long were used for metallography examination.

2.1 Treatments

One disc material of austenitic stainless steel which was gas nitrided to the saturated limit and three pin specimens were gas 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 550^0C, immersed in a salt bath for 8 hours, 40 hours and 72 hours 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.

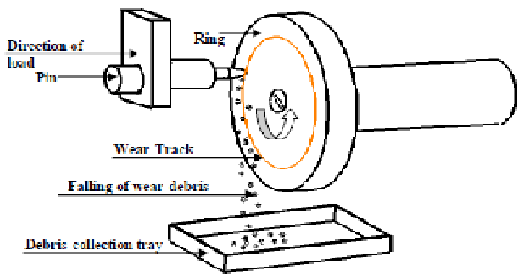

Figure2 – Pin on Disc Machine Used

2.3 Hardness Profile

Comparative hardness profiles for the different grades of stainless steels and the various nitriding treatments were investigated. Gas nitriding imparted a good surface hardness.

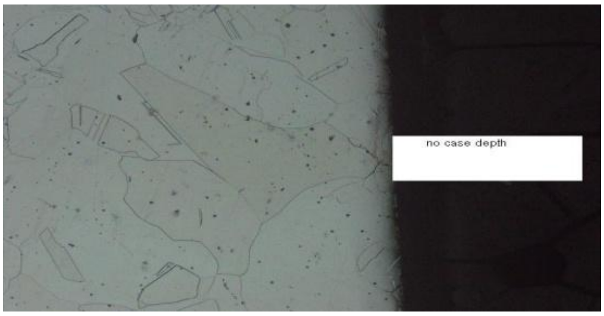

Figure 2.1 – Untreated Specimen

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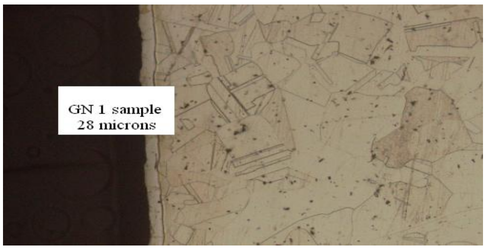

Figure 2.2 – GN 1 Specimen

Figure 2.3 – GN 2 Specimen

Figure 2.4. – GN 3 Specimen

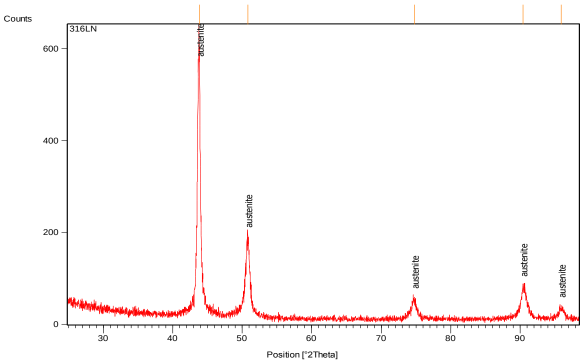

Fig 2.5XRD for Untreated Sample

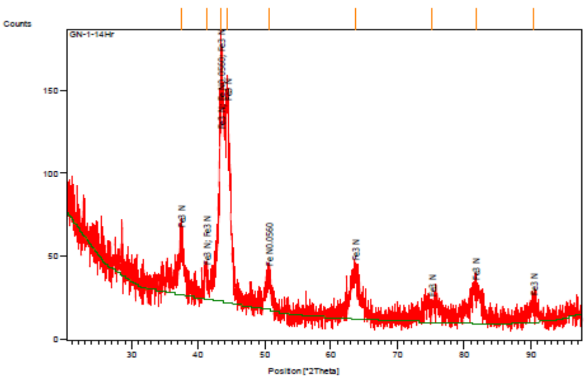

Fig 2.6 XRD for GN1 Sample

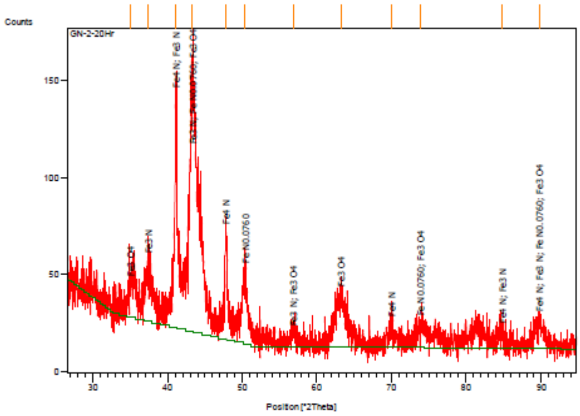

Fig 2.7 XRD for GN2 Sample

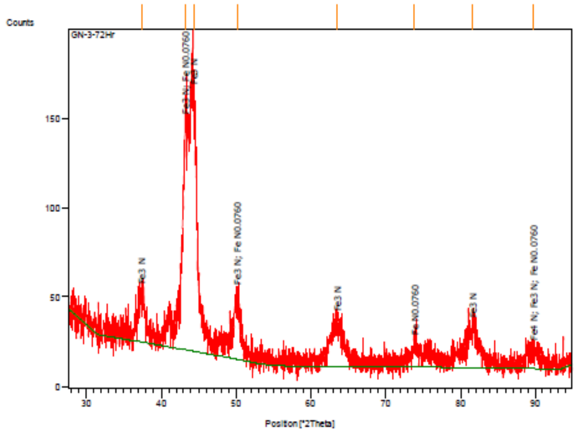

Fig 2.8 XRD for GN3 Sample

From the figure 2.1, 2.2, 2.3, 2.4 it was seen that, there was no case depth in an untreated specimen. Whereas in nitrided specimen, it was found to be 28 microns, 36 microns and 49 microns respectively. From the figure 2.5, 2.6, 2.7, 2.8, it was seen that austenitic phase structure was found in the untreated specimen. Whereas in other specimen, it was found that the formation of new components like raoldite, siderazot, iron nitride. The hardness of the untreated specimen was found to be 330 $H_{V,}$ whereas, the hardness of the gas nitrided specimen was found to be 1110 $H_{V,}$ 1233 $H_{V,}$ 1305 H_V respectively.

III. RESULTS

Microscopy study showed the surface layers produced after nitriding stainless steel to be different from those observed on other nitride stainless steel materials. Three distinct layers were found clearly on the AISI316LN grade stainless steel material. The first layers was found to be austenite together with FCC austenite phase, the second layer was found to be austenite, ferrite and chromium nitride and the third layer was found to be FCC structure corresponding to the austenite. As the time of nitriding increases, wear loss, volume wear loss decreases. XRD results showed the presence of iron nitride components.

IV. CONCLUSIONS

As would be expected, the specimens gas 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

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very low and the alloying elements are not mobile enough to combine with the nitrogen to form the nitrides readily. However, stainless steel gas nitrided at this temperature, has a surface hardness as high as $1305H_v$. 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 gas nitriding imparts better corrosion resistance than the other nitriding.

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