저온 플라즈마침탄처리된 316L 스테인레스 스틸의 플라즈마 후질화 처리시 표면특성에 미치는 가스조성의 영향

The effects of post nitriding on the AISI 316 stainless steel after Plasma carburizing at various gas compositions

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Abstract:

In this experiment, post-nitriding treatment has been performed at 400°C on AISI 316 stainless steel which is plasma carburized previously at 430°C for 15 hours. Plasma nitriding was implemented on AISI 316 stainless steel at various gas compositions (25% N2, 50% N2 and 75% N2) for 4 hours. Additionally, during post nitriding Ar gas was used with H2 and N2 to observe the improvement of treatment. After treatment, the behavior of the hybrid layer was investigated by optical microscopy, X-ray diffraction, and micro-hardness testing. Potentiodynamic polarization test was also used to evaluate the corrosion resistance of the samples. Meanwhile, it was found that the surface hardness increased with increasing the nitrogen gas content. Also small percentage of Ar gas was introduced in the post nitriding process which improved the hardness of the hardened layer but reduces the corrosion resistance compared with the carburized sample. The experiment revealed that AISI 316L stainless steel showed better hardness and excellent corrosion resistance compared with the carburized sample, when 75% N2 gas was used during the post nitriding treatment. Also addition of Ar gas during post nitriding treatment were degraded the corrosion resistance of the sample compared with the carburized sample.

1. Introduction:

At present austenitic stainless steels are the most widely used corrosion-resistant materials in various sectors of industries, due to their excellent chemical and metallurgical properties. However, the use of stainless steels in the manufacture of mechanical components is hindered due to their low hardness and low corrosion resistance. Attempts have been made during the past decades to engineer the surfaces of this type of materials so as to improve their surface hardness and corrosion resistance. Low temperature plasma carburizing was carried out at temperature between 400 to 520°C for several hours with the presence of gas containing carbon which produces a carbon enriched expanded austenite layer. On the other hand low temperature plasma nitriding was implemented at lower temperatures (below 450°C) for several hours which will bring forth a precipitation free nitrogen-enriched expanded austenite layer [1-3]. As we know even though the carburized layer is much thicker than the nitrided layer, it has low hardness compared with nitrided layer. Therefore, to improve the hardness and corrosion resistance of the stainless steel we investigated the effects of post nitriding at various gas contents in our experiments. Also the effect of Ar gas during post nitriding was investigated.

2. Main Body:

Figure 1 shows the X-ray diffraction patterns post nitrided carburized stainless steels at various gas compositions. In all the post nitrided samples dual phase nitrogen enriched expanded austenite (γN) formed after post nitriding. Also it is clear from the XRD pattern that the 2 theta values obtained from the post nitrided samples are shifted towards lower Bragg angles with wider peaks compared than the untreated surface [4]. Besides introducing Ar gas during post nitriding helps to improve the crystal quality of the expanded austenite which can be understood by the sharp peaks.

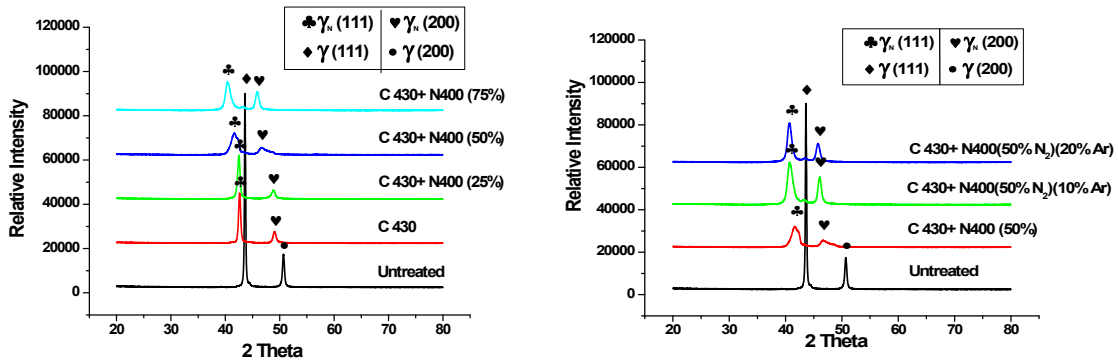

Fig. 1: XRD pattern of carburized and post nitrided AISI 316L stainless steel at various gas compositions.

Figure 2 represents the microstructures of the post nitrided samples at various gas compositions after plasma carburizing. As the nitrogen content increase the nitrogen enriched expanded austenite layer (γN) also increased. Also addition of Ar during nitriding helps to enhance the thickness of γN layer.

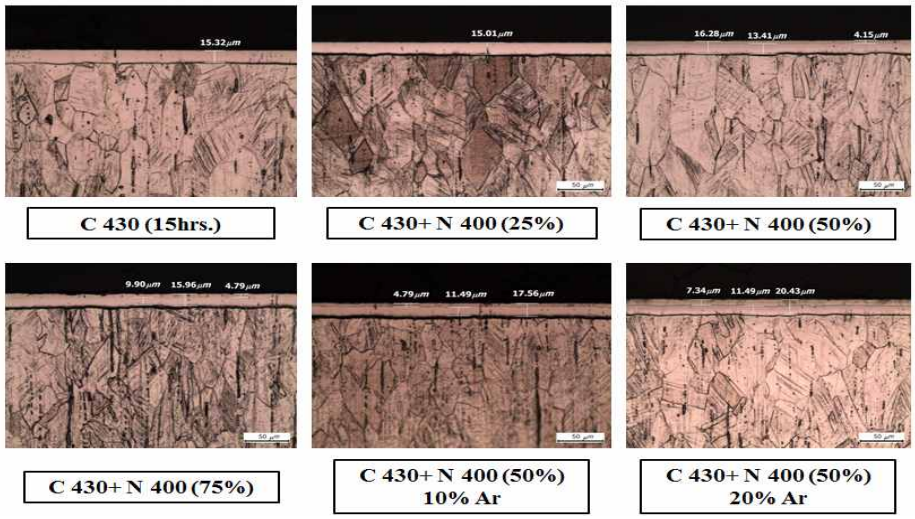

Fig. 2: Optical micrographs of cross-sections of Carburized + Nitrided (C+N) AISI 316L stainless steel with various gas composition during Nitriding

Figure 3 represents the anodic polarization curves of AISI 316 stainless steels for untreated, plasma carburized and post nitrided samples in 3.5% NaCl solution. The Potentiodynamic polarization result shows that carburized post nitrided at 75% nitrogen content has the highest potential and lower current density compared with the carburized steel. It indicates the specimen has excellent corrosion resistance than the other samples. On the other hand, introducing Ar gas during post nitriding treatment deteriorated the corrosion resistance of the carburized stainless steel.

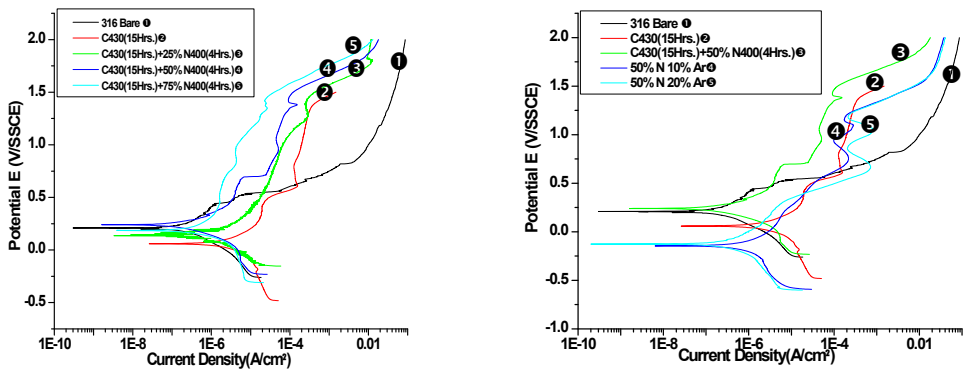

Fig. 3: Anodic Potentiodynamic polarization curves at various gas compositions during post nitriding

3. Conclusion:

i) All of treated sample showed the formation of expanded austenite (γN) without precipitation.
ii) The specimens post nitrided with 75% N2 content showed a much enhanced corrosion resistance in terms of lower corrosion current density and a higher pitting potential as compared to the carburized steel due to the formation of NH4+ (N + 4H+ + 3e- à NH4+) which increasing the passivation ability and retarding the corrosion rate . But a little drop of corrosion resistance was observed due to the introducing Ar gas in the post nitriding.

References:

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