Chapter 17

Hardness of Duplex Treated Stainless Steel: Influence of the Architecture and Composition of Films

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ABSTRACT

This chapter describes how the aim of duplex surface engineering includes chronological application of two surface modification technologies for the production of a surface, with collective properties. Duplex treatment of nitriding and carbonitriding of austenitic stainless steel is of high technical importance owing to its capability to increase hardness, corrosion and wear resistance of treated surface. Duplex treatment has been utilized to enhance the surface mechanical properties of austenitic stainless steel (AISI 304). The microstructure of nitrided surface indicates the development of nitride phases, Fe₄N, Fe₂N, CrN, Cr₂N and γ₈ whereas, duplex treated films shows the formation of FeC, Fe₃C, Fe₇C₃, Cr₃C₂, Cr₇C₃, Cr₆C₃ along with nitride phases like Fe₄N. Both nitrided and duplex treated samples show the formation of cauliflower like grains. Surface micro hardness of treated substrates has been dependent on the variation of crystallite size and increased by 1.26 times the hardness of nitrided sample and 4.60 times the hardness of the untreated substrates.

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INTRODUCTION

Surface hardening of austenitic Stainless Steel (S.S) has been a topic of current research work (Tschiptschin, 2017, Hossary, 2009). S.S material has enhanced oxidation temperature, elevated corrosion and adhesion to substrate but with low wear resistance and surface hardness. These weak properties make them worthless in various applications where good wear resistance is required. These weaknesses can be overcome by improving the surface properties of materials through structuring or coatings (nitriding, carburizing and carbonitriding). Surface treatment can enhance the tribological, mechanical and optical properties of different materials as well as their life time.

SURFACE HARDENING TECHNIQUES

Nitriding and carburizing are two of the best processes, used to increase the surface hardness of some metallic materials without affecting their bulk properties. Nitriding is a surface hardening technique used to enhance the surface corrosion resistance and to improve the surface hardness, wear resistance and fatigue life time of the treated materials.

The plasma nitriding also termed as ion nitriding, is accepted as a cathodic process escorted by bombardment of positive ions. In case of pulsed DC glow discharge the cathode will serve as target and will be bombarded with positive ions, causing the sputtering of the target material, e.g. Fe in S.S. The sputtered Fe atoms will react with the nitrogen atoms and will form the nitrides of Fe i.e., FeN. These nitrides can get deposited on the target surface but as being unstable elements so get further reactions with iron atoms until they form a stable Fe₄N product.

Atomic Nitrogen (N) can diffuse in the target material and forms nitride layer (Figure 1).

Figure 1 shows different steps for the formation of nitride film on the substrate surface. The cathode that is serving as a target is sputtered due to presence of bombarding nitrogen ions e.g. Fe. These sputtered atoms will react in plasma and form FeN. These nitrides will further react with the target (e.g. Fe) atoms and will form Fe₂N, Fe₃N and finally to the stable product (Fe₄N). The atomic nitrogen that is released in all this kind of reactions will diffuse through the target and will cause nitriding of the substrate surface. During plasma nitriding, the material surface gets saturated with the nitrogen that’s why plasma nitriding is much faster than other conventional nitriding techniques. This process can be controlled by selecting the suitable parameters like nitriding time, distance between the electrodes, gas pressures and concentrations etc.

Carburizing

Carburizing is achieved by introducing an extra amount of carbon into the surface treated layer. Plasma carburizing is similar to plasma nitriding process. Plasma assisted carburizing is more advantageous to conventional carburizing techniques as we can get more uniform film in less process time (Bogaert, 2002).

Carbonitriding

Carbonitriding is one more method for surface hardening of material. It is basically a combination of plasma carburizing and nitriding process. It can be carried out in presence of mixture of two gases i.e.