UNIVERSITI TEKNOLOGI MARA

THE STUDY ON EXPANDED AUSTENITE FORMATION OF DUPLEX STAINLESS STEELS TREATED BY LOW TEMPERATURE CARBURIZING IN A TUBE FURNACE ATMOSPHERE

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ABSTRACT

Duplex stainless steels (DSS) are a class of technologically important materials widely used in various sectors of industry. The problem associated with the poor tribological properties of these materials has recently been tackled by many investigators. Surface engineering has proven to be a useful method for increasing the hardness and wear resistance of stainless steel without compromising their corrosion resistance. Low temperature thermochemical carburizing technique has been developed thicker hardened layer on the surface of duplex stainless steels to achieve combined improvement in hardness and wear resistance. The resultant carburized layer is free from chromium carbide precipitates and contains with austenite phase supersaturated with carbon. An attempt was conducted in various process parameters by adding 3 - 5% CH_4 and mix N_2 with in tube furnace atmosphere at temperature 450°C, 500°C and 550°C for 7 h and 14h. Structure and properties of the carburized layer were investigated by various tests such as X-ray diffraction (XRD), scanning electron microscopy (SEM), optical microscope and testing for microhardness and wear to reveal the character of produces thin layers. The surface hardness and wear resistance of the carburized layer was significantly increased compared to untreated one. The carburized layer is contains with austenite phase supersaturated with carbon and free from chromium carbide precipitates. However, by increasing treatment temperature until 550°C with 5% CH_4, it can lead to the formation of chromium carbide precipitates in the carbon enriched layer, and thus deteriorate the quality of the specimens in terms on corrosion resistance. The carburizing treatment produced thicker and harder layer at 14 h compared to 7h treatment; the maximum hardness was about $703.0HV_{0.025}$ compare to untreated DSS at $212.5HV_{0.025}$. The carburizing treatment specimens gave high wear resistance which corresponded to high hardness values. Therefore, in this study it can be concluded that these two parameters have a main role in producing expanded austenite and chromium nitride. The potential application for this carburized surface treatment on DSS may use for piping and fitting parts in chemical and petrochemical where improvement in hardness and wear resistance.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Thermochemical surface treatment conducted at low temperature is a valuable method to improve the tribological performance of duplex stainless steels without affecting the corrosion behavior. This is achieved by the formation of a supersaturated solution of carbon or nitrogen in austenite, usually called *expanded austenite*, which confers significant hardening, increased tribological performance, and corrosion resistance compares to the untreated substrate. Expanded austenite (EA) development on stainless steel (SS) has been studied for many years principally motivated by the possibility of giving the surface higher wear resistance and hardening without introducing substantial worsening in their corrosion behavior [1, 4]. For the DSS 2205, the austenitic grains are also transformed to carbon expanded austenite (γ_C) while ferritic grains are first transformed to austenite, due to carbon diffusion and then to carbon expanded austenite (γ_C) [5].

1.2 PROBLEM STATEMENT

Duplex Stainless Steels are widely used in oil and gas industries, tanks applications and in desalination for their excellent resistance. Although duplex stainless steel is widely used in many applications, but there are still poor understandings of certain aspects such as their responses to low hardness and wear performance. Consequently, surface treatments for stainless steels are an interesting alternative way to improve the surface hardness and wear resistance[1]. Thermochemical treatment is done with nitrogen and/or carbon gases, which translate the treatment into nitriding, carburising and nitrocarburising respectively.

Typically, thermochemical carburizing treatment is done for various grades of stainless steels, surface treatment above 550°C creates a reaction of precipitation between carbons with chromium that producing carbide which promotes corrosion to the steel. Few attempts have been made successfully to increase the hardness of