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Original Article

Characterization of plasma nitrided layers produced on sintered iron

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ABSTRACT

Plasma nitriding is a thermo-physical-chemical treatment process, which promotes surface hardening, caused by interstitial diffusion of atomic nitrogen into metallic alloys. In this work, this process was employed in the surface modification of a sintered ferrous alloy. Scanning electron microscopy (SEM), X-ray diffraction (XRD) analyses, and wear and microhardness tests were performed on the samples submitted to ferrox treatment and plasma nitriding carried out under different conditions of time and temperature. The results showed that the nitride layer thickness is higher for all nitrided samples than for ferrox treated samples, and this layer thickness increases with nitriding time and temperature, and temperature is a more significant variable. The XRD analysis showed that the nitrided layer, for all samples, near the surface consists in a mixture of γ'-Fe_4N and ε-Fe_3N phases. Both wear resistance and microhardness increase with nitriding time and temperature, and temperature influences both the characteristics the most.

1. Introduction

Many thermal treatments have been used to improve the mechanical properties of material surfaces, such as hardness and wear resistances. Nitriding is a commonly used surface treatment for obtaining these improvements due to the facility in its use, relatively low cost, and good ability to improve surface hardness and resistance to wear and corrosion [1]. Among the three different types of nitriding processes, liquid, gas, and plasma (or ion), the latter can be considered the best one because it presents positive characteristics such as a precise control of the surface layers, low energy and gas consumptions, not generating environmental pollution and allowing thermal treatments at low temperatures (below 500 °C) [1].

Ion nitriding is a thermal-physical-chemical treatment process that provokes surface hardening by interstitial diffusion of atomic nitrogen into both ferrous and non-ferrous metallic

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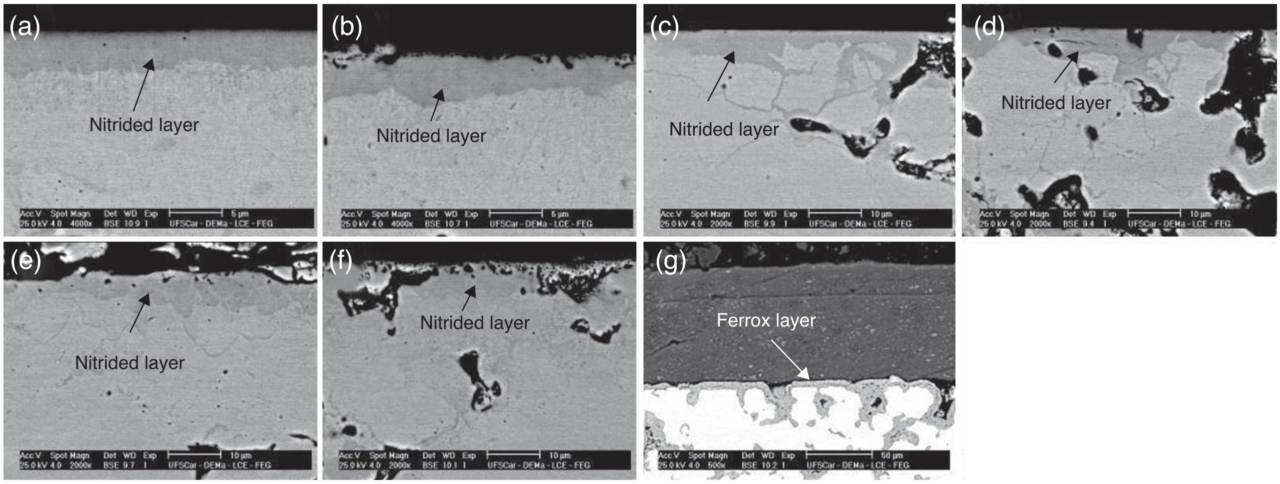

Fig. 1 – SEM micrographs of the plasma nitrided samples, and sample submitted to the ferrox treatment.

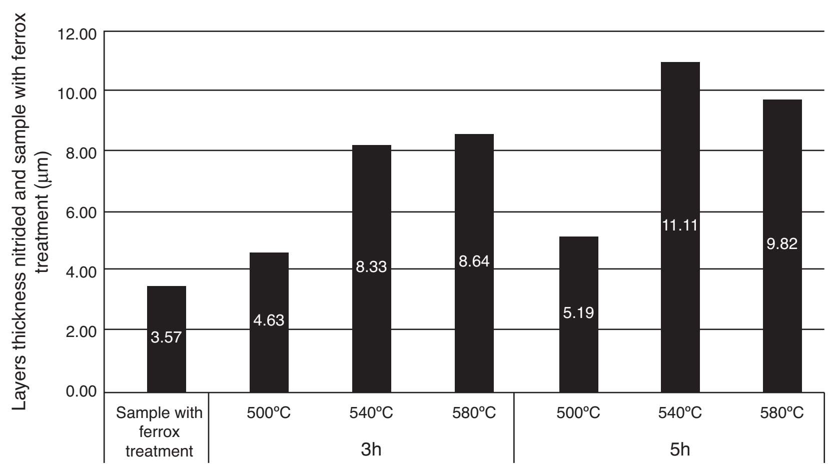

Fig. 2 – Thickness values for the plasma nitrided samples, untreated sample, and sample submitted to the ferrox treatment.

surfaces [2]. This process causes the formation of a case layer, which may comprise an oxide layer, a compound layer, and a diffusion zone [3,4]. In the case of ferrous alloys, the compound layer, also called white layer, is constituted of mainly γ'-Fe_4N, ε-Fe_3N, and possibly Fe_2N [5–10]. The diffusion zone (or diffusion layer) is formed between the compound layer and the matrix, and consists of nitrides formed with not only iron but also high affinity metals such as aluminum, chromium, vanadium, and molybdenum [11]. It is very important to control the nitriding parameters in order to obtain the best performance of nitrided components used in different engineering applications [11]. The composition and thickness of the nitrided layers are directly related to the treatment temperature, pressure, and time, as well as the composition of the base material [12–14].

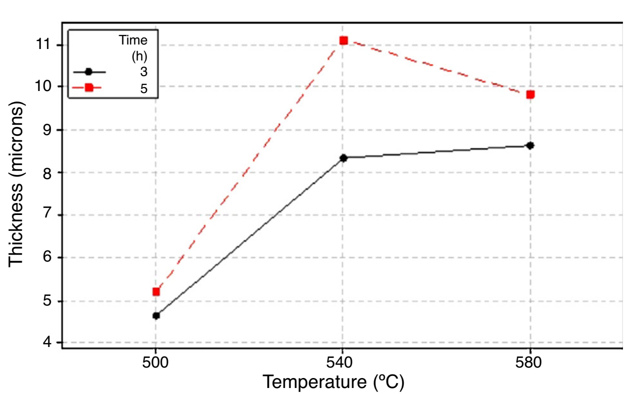

Fig. 3 – Thickness as a function of the nitriding parameters (temperature and time).

Table 1 – Chemical composition (wt.%) of the sintered iron sample.

Element	wt.%
Carbon combined	0.20–0.40
Copper	1.75–2.25
Sulfur	0.14–0.22
Iron	Remainder