Contact fatigue behavior of plasma nitrided or nitrocarburized AISI 316L stainless steel

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The usage of coatings and surface engineered components is increasing and is driven by the need for improved hardness, corrosion, wear and fatigue resistance. Austenitic stainless steels are the most important family of stainless steels with respect to both the number and types of applications. Plasma nitriding and nitrocarburizing of austenitic stainless steels can produce layers composed by a phase called expanded austenite, "S-phase or γ_N". This interesting phase is supersaturated with respect to carbon and/or nitrogen and is characterized by high hardness and wear resistance. AISI 316L samples were plasma nitrided or nitrocarburized at 400, 450 and 500°C for 5h. Monotonic and cyclic indentation tests were conducted in a servohidraulic Instron 8511 with spherical indentation. Monotonic indentation was performed from 100N until the appearance of circular cracks around the impression defining the monotonic critical load. Fatigue testing was carried out by applying fractions of the monotonic critical load for the emergence of circular cracks after 10^4 cycles. The cyclic loading was imposed by means of a sinusoidal waveform at a frequency of 15 Hz and load ratio of 0.1. The residual imprint radius and the damage evolution were analyzed by optical microscopy. The layer thickness was found to increase with treatment temperature. However, as carbon diffuses faster than nitrogen in gamma iron, plasma nitrocarburizing produced thicker layers than nitriding with respect to the three studied temperatures. X-ray diffraction analysis indicates that, for both nitriding and nitrocarburizing, at 400°C a homogeneous S-phase layer is produced. At 450°C the precipitation of chromium carbonitrides and/or nitrides is observed and at 500°C a dark chromium compound layer is produced over the S-phase. For spherical indentation under monotonic or cyclic loading the damage feature corresponds to the appearance of circular cracks at the surface of the coating and plastic yielding is required for such event. The critical load for the emergence of these cracks under monotonic and cyclic loading was found to decrease as treatment temperature increase for both nitriding and nitrocarburizing; and damage emergence is sensitive to cyclic loading. As temperature is risen from 400 to 500°C the layer thickness and surface hardness increase and the coated set behaves more likely a ceramic becoming more fragile, which in turn reduces the fatigue sensitivity. Thus low temperature plasma treating besides producing wear and corrosion resistant layers also improves the fatigue behavior.

Keywords: Nitriding, Nitrocarburizing, Stainless steel, Spherical indentation, Fatigue.

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