Duplex surface treatments combining surface mechanical attrition treatment (SMAT) and low temperature plasma nitriding

Mahdi Chemkhi*[1], Delphine Retraint[1], Arjen Roos[1], Guillaume Montay[1], and Clémence Demangel[2]

[1]University of Technology of Troyes (UTT) – Charles Delaunay Institute, LASMIS, UMR STMR CNRS 6279, University of Technology of Troyes – 12 rue Marie curie, University of Technology of Troyes, 10010 Troyes, France

[2]Regional Centre of Innovation and Technology Transfer (CRITT-MDTS) – CRITT-MDTS, Charleville-Mézières – 3 bd J. Delautre, 08000 Charleville-Mézières, France

Abstract

SMAT and plasma nitriding are two surface treatments that enhance the mechanical properties of surface layers by inducing superficial nanostructures and the formation of hard phases, respectively [1-2]. The idea of this work is to combine SMAT with nitriding: SMAT provides a superficial nanostructure with nanosized grains and a high dislocation density and thus creates a large volume fraction of grain boundaries and defects; during subsequent nitriding these "fast" diffusion pathways enhance atomic nitrogen diffusion. However, contradictory views can be found in the literature: in some cases mechanical attrition pretreatment creates oxide barriers hindering nitrogen incorporation [3].
Therefore, the aim of this investigation is to characterise and to discuss the microstructure evolution of an austenitic stainless steel AISI 316 - ASTM F138 subjected to surface mechanical attrition treatment followed by low temperature plasma nitriding. In addition, a polishing step (after SMAT and before nitriding) was introduced to examine the effect and the interaction of the contamination induced by SMAT in the surface [4] on the nitrogen diffusion.

The treated samples were characterized using several observations (Scanning electron microscopy (SEM), cross-sectional optical micrographs, micro-hardness profiles and X-ray diffraction). They show that polishing away a very thin layer after SMAT and before nitriding significantly improves nitrogen diffusion into the substrate, yielding a 50% thicker nitrided layer with respect to nitrided only. The thermal stability of the nanostructure induced by SMAT was analysed by Transmission Electron Microscopy (TEM). Furthermore, additional chemical analyses by Energy Dispersive X-ray spectrometry (EDS) were performed to try to understand the effect of SMAT on the nitrogen diffusion.

Finally, the residual stress profiles of each treated sample were measured. A combined system of blind-hole drilling and digital speckle pattern interferometry [5] was used to measure the in-depth residual stresses.

*Speaker

References

K. Lu, J. Lu, Nanostructured surface layer on metallic materials induced by surface mechanical attrition treatment, Mat. Sci. Eng. A375–377 (2004) 38–45.

Z.L. Zhang, T. Bell, Structured and corrosion resistance of plasma nitrided stainless steel, Surf. Eng. 1(2) (1985) 131–136.

F. Cemin, F.G. Echeverrigaray, A.C. Rovani, C.L.G. Amorim, R.L.O. Basso, I.J.R. Baumvol, C.A. Figueroa, Mat. Sci. Eng. A527 (2010) 3206–3209.

L. Waltz, D. Retraint, A. Roos, C. Garnier, P. Olier, Surf. Coat. Tech. 205 (2011) 4608–4613.

F. V. Dîaz, G. H. Kaufmann, G.E Galizzi., Optics and Lasers Engng 33 (2000), 39-48.

Keywords: Plasma nitriding, nanocrystalline materials, SMAT, austenitic steels, residual stress.