Study of stirred layers on 316L steel created by friction stir processing

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1. Experiments

Recently, friction stir processes (FSP) have been used to create superficial nanostructured layers on different materials (aluminium alloys, titanium alloys or steels). From an industrial point of view, this technique enables a rapid treatment of complex surfaces using traditional machining tools. The thermo-mechanically transformed structures created by FSP exhibit very interesting properties like high hardness or an enhanced tribological behaviour. The present investigation was carried out on samples of a commercial 316L ASTM 2 grain size, with 180 $HV_{0.025}$ Vickers hardness and 630 MPa tensile strength. The tool was a 10 mm diameter zirconium oxide cylinder, without any pin like shown in Fig.1. A 4-axis numerically controlled milling center, model Gambin50C was adapted adding Kistler force measuring and control devices.

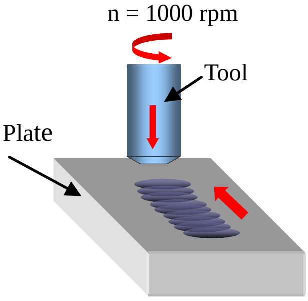

Figure 1 : Schematic illustration of the basic principle of FSP

If all tests were performed using a rotational speed of 2000 rpm, the translational speed and axial force were varied between 20-80 mm/min and 900-1800 N respectively, in order to determine the influence of process conditions on the performance in terms of size, structure and hardness of transformed layers.

2. Results

Significant changes in the 316L microstructure were obtained depending in the FSP conditions. Fig. 2 illustrates a typical cross-section of the stirred 316L steel obtained in the present investigations. The base material exhibits the typical austenitic microstructure that characterizes this material and the stirred layer is made of fine grains like shown in Fig.2.(a). The thickness of the modified layers varies between 270~350±20 µm depending on FSP parameters.

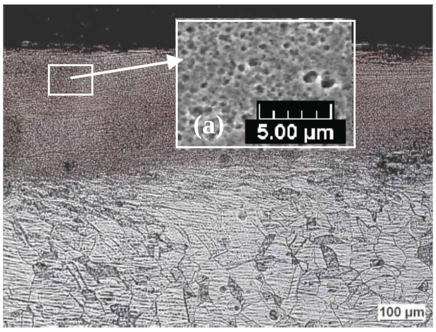

Figure 2: Typical cross-section of the stirred 316L steel (MO and SEM)

The hardness of transformed layers increases compared to the initial value and lies around 290 $HV_{0.025}$ ±20 without significant variations between various samples.

X-rays diffraction as well as GOEDS analyses have been performed in order to characterize the stirred structure and observe possible composition evolution.

3. Conclusion

In this study, the FSP of an austenitic stainless steel has been evaluated. The treated layers have been characterized in terms of hardness and microstructure and these results have been related to the FSP operational parameters. The influence of the processing tool geometry and material has been studied as well as the effect of a cooling system.

A material response map has been plotted to present the occurrence of the various microstructures as a function of the processing parameters.