Effect of Surface Mechanical Attrition Treatment (SMAT) on 316L stainless steels and its behaviour in high cycle fatigue

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Ultrasonic shot peening consists in fixing a sample into a shots containing chamber having its bottom surface vibrating. The shots bounce in all directions against the walls of the chamber, therefore, the sample experiences severe plastic deformation at its surface, resulting in the formation of gradients in microstructure (grain size, dislocation density, twins and phases) and residual stresses. Such mechanical surface treatment is often used to delay crack initiation and to slow down crack propagation by the presence of residual stresses. The objective of this study is to investigate the crack propagation mechanism near the threshold in the complex gradient induced by SMAT on 316L austenitic stainless steels.

SEM coupled with XRD technique was used to characterise phases, microstructure and residual stresses gradients whereas optical microscopy and contact measurements helped to characterise the surface defects and roughness. Fatigue tests have been performed in air at room temperature at 10Hz on a servo-hydraulic machine. Untreated mirror polished and SMATed cylindrical samples have been tested at R=0.1 and R=-1 and their fracture surfaces were analysed accordingly.

At R=-1, self-heating of the specimens was observed and measured on their surface using infrared camera. Nevertheless, it was seen that for both untreated and SMATed specimens, self-heating is negligible (<10°C) for the lowest stress amplitudes. Also, the SMATed specimens exhibited a higher fatigue limit. At R=0.1, no self-heating of the tested samples was detected and no obvious increase in fatigue limit was observed for SMATed samples compared to the untreated ones.

The effect of SMAT on fatigue resistance of 316L stainless steel at high cycle fatigue showed a great dependency on the load ratio. More investigations are needed to quantify this dependency with respect to the microstructure and residual stresses gradient as well as their evolution.