

ABSTRACT

Austenitic stainless steels are widely used in the chemical, petrochemical and food-processing industries due to their excellent corrosion resistance and good mechanical properties. However, due to their inherent austenitic structure, they have relatively low hardness, as well as poor wear resistance and short fatigue life. Thermochemical surface treatments are used to improve the wear resistance, hardness and fatigue life. Austenitic stainless steels are difficult to carburise due to the tenacious Cr_2O_3 layer on the surface, although plasma and gas carburising have proven to be very effective. However, this investigation sought to understand the effect of high carburising temperature on the mechanical properties of AISI 316L steel, without the removal of the tenacious Cr_2O_3 surface layer.

Pack carburising with 60% BaCO_3 , 30% activated carbon and 10% sodium chloride was done on AISI 316L austenitic stainless steel at 450°C, 550°C, 650°C, 700°C and 750°C for 24 hours. Tensile, impact, hardness testing and fatigue tests were done and optical microscopy, SEM and XRD were used to characterise the specimens.

The ultimate tensile strength (UTS) of the as-received samples was 647 ± 4 MPa. The values for samples carburised at 450°C and 550°C were 651 ± 5.5 MPa and 651 ± 3.6 MPa with no significant differences. Samples tested at 650°C, 700°C and 750°C showed decreasing tensile strength (638 ± 3.5 - 603 ± 2.5 MPa). The hardnesses of treated samples at 450°C and 550°C were similar to the as-received, ranging between 248HV_{0.5} and 254HV_{0.5}. Hardnesses of samples carburised at 650°C, 700°C and 750°C decreased from the surface to the core, with limited carbide precipitation within the core, which had similar values to the as-received.

The number of cycles to failure of the as-received sample was 59298 ± 2520 and was similar to the carburised samples at 450-650°C (ranging from 61455 ± 15076 - 51819 ± 5257). A significant reduction in fatigue strength was observed for samples carburised at 700°C (25387 ± 595) and 750°C (7146 ± 318), which was due to the effect of carbon intake of the samples.

The elongation for as-received material was $48.5 \pm 0.4\%$, and the reduction in area was $76.6 \pm 0.97\%$. These values decreased with increasing carburising temperatures from 450°C to

750°C. The decrease in ductility was attributed to uptake of carbon, causing surface hardening and minor carbide precipitation in the core. X-ray diffraction of the carburised samples showed a shift in γ peaks compared to the as-received samples, which was attributed to the carbon intake. Samples carburised at 450°C and 650°C had austenite grains, twin boundaries and slip lines within the grains. The frequency of the defects increased with increasing carburising temperature. The twins were more predominant at the surface and less so towards the core of the steel. The hardness increase was more effected by the carbon increase. There was limited carbide precipitation and a very thin observable carburised case. The results showed that this type of pack carburising of austenitic stainless steel is not suitable for improving the properties of AISI 316L steel.