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The Role of Multivariant Twinning on J-integral Value in Commercially Pure Titanium

Vivek Kumar Sahu[a], Nilesh P. Gurao[a]

[a]*Department of Materials Science and Engineering, Indian Institute of Technology Kanpur, Kanpur-208016, U.P. India*

Email Address: vsahu@iitk.ac.in

The present investigation shows the effect of multivariant twinning on J-integral value in commercially pure titanium. In order to achieve this goal, three-point bend samples in two different orientations i.e. c-axis nearly perpendicular (TD-RD) and nearly parallel (RD-ND) to loading axis in commercially pure titanium having split-TD basal texture, were machined and tested in mode-I. J-integral values were calculated using digital image correlation and observed that TD-RD (288 ± 13 kJ/m^2) has more than fourfold of RD-ND (60 ± 6 kJ/m^2) sample. 2D DIC strain evolution suggested that e_{xx} strain of TD-RD was much higher than RD-ND samples. Microstructural characterization using EBSD at notch tip indicated abundant multivariant twins of $\{10\bar{1}2\}$ extension type I, $\{11\bar{2}1\}$ extension type II and $\{11\bar{2}2\}$ contraction type I with high geometrically necessary dislocation (GND) density for TD-RD than RD-ND having weaker twinning and lesser GND. Higher GND density at the crack tip for TD-RD than RD-ND suggested very high plastic deformation before the crack propagation led to high J-integral value. Fractography of RD-ND showed more fluted voids, where c-axis parallel to the crack propagation and it was caused by dominant prismatic slip. Thus, the multivariant twinning and high GND density cause more plastic deformation and delay the crack propagation, consequently, enhance the fracture toughness of titanium.

Keywords: J-integral, digital image correlation, commercially pure titanium