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MECHANISMS FOR IMPROVING THE FATIGUE LIFE OF TINI ALLOYS ASSOCIATED WITH ELECTRON-BEAM SURFACE MODIFICATION *

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The study results of the influence of surface electron-beam treatments on the fatigue characteristics of an TiNi shape memory alloy (SMA) are presented in the report. Surface melting modes were used for processing by a pulsed low-energy high-current electron beam (LEHCEB) with electron energy densities E_S = 1.5, 2.7, and 3.7 J/cm^2 at different numbers of pulses n = 5 and 15. Cyclic tensile tests were carried out in the low-cycle fatigue mode on a servo-hydraulic testing machine Biss UTM 150 (Biss, India) with cycle asymmetry R=0.1 at a maximum load of 160 MPa and a frequency of 20 Hz. The study of the fatigue fracture surfaces of the LEHCEB's modified TiNi substrates was carried out with use a scanning electron microscope (SEM) EVO 50 (Zeiss, Germany).

It is shown that LEHCEB treatment of the TiNi surface led to an increase in the fatigue life of TiNi substrates by almost 1.5-2 times, compared with non-irradiated TiNi substrates, which is due to the effective cleaning of sample surfaces using LEHCEBs from particles/inclusions, as the main sources of fatigue microcracks on the surface. The highest result is observed after LEHCEB treatments at E_S = 1.5 and 3.7 J/cm^2 with the number of pulses n = 5, which is due to the formation of residual compressive stresses in the modified surface layer, which prevent the initiation of defects from the surface of the sample and their propagation into the internal volume.

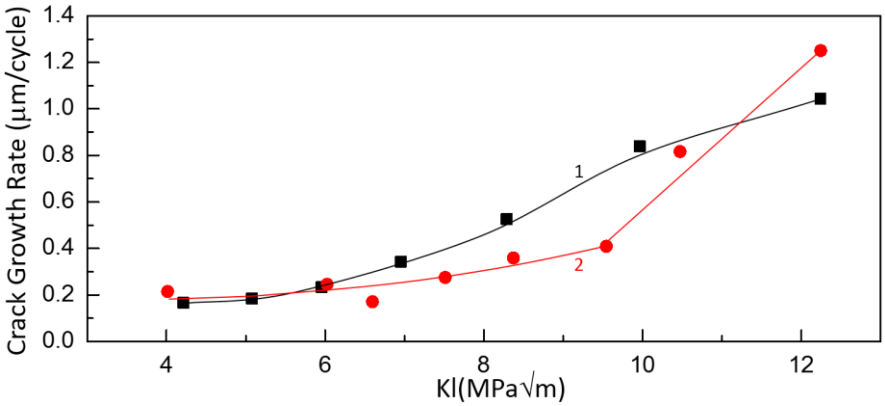

Fig.1. Dependences of fatigue crack growth rates on the maximum stress intensity factor before (1) and after (2) LEHCEB treatments of TiNi substrates.

Regularities of formation and propagation of fatigue cracks before and after LEHCEB treatment of TiNi substrates are studied. The influence of these treatments on the fatigue crack growth rates are estimated. It was found that LEHCEB modification leads to an increase in the average number of cycles <Nstart> of the beginning of fatigue crack formation by more than $\Delta N \approx 2000$. More over the fatigue crack growth rate in irradiated TiNi substrates at the first stages of formation and propagation of a fatigue crack is 4–10 times lower than this rate in non-irradiated samples. At the same time, the stages of critical destruction and the sizes of fracture zones before and after LEHCEB irradiation differ little from each other.

The conclusion is substantiated that LEHCEB surface modification plays a critical role in the first stages of the process of fatigue accumulation of defects, effectively preventing the onset of this process. The main reasons for this result are the structure of the modified layer and the residual stresses inside it and below, to a depth of ~100 μm, induced by LEHCEB treatment.

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