ENHANCEMENT OF FRACTURE RESISTANCE BY CRACK DEVIATION VIA SHAPE MEMORY ALLOY AGENTS

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Introduction of compressive residual stresses allows delaying the failure nucleation and crack propagation in materials. This involves a mature practice in surface treatment, while few works were dedicated to bulk materials. In the framework of metal matrix composites, shape memory alloys provide a possibility to generate internal stresses in the bulk metallic matrix and thus to enhance the fracture resistance, according to numerical predictions [1].

The present work aims at improving the fracture resistance in aluminum via crack deviation that results from internal residual stresses. Shape memory alloy (NiTi) particles are integrated into the aluminum matrix (Al1050) by friction stir processing [2]. The shape memory effect is triggered by a pre-straining and a heat treatment to generate residual stresses in the vicinity of each NiTi particle. High resolution TEM characterization indicates a good bonding between the matrix and the enhancement agents. *In-situ* uniaxial tensile tests and single edge notch tension tests are carried out in a scanning electron microscope to assess the fracture properties. Comparisons are performed between the Al/NiTi composite (refer to as Al/NiTi) and the friction stir processed pure aluminum subjected to the same pre-straining process (refer to as FSPed Al). It is found that the Al/NiTi involves a higher fracture strength than the FSPed Al, and that higher NiTi fraction leads to larger enhancement. The *in-situ* monitoring reveals a deviated crack path in the Al/NiTi, in contrast to a straight fracture path in the FSPed Al. Moreover, the fracture mode switches from mode I “bath-tub” to slant fracture when the NiTi particles are present. Albeit the higher strength in the Al/NiTi is accompanied by a lower fracture strain - the well-known strength-ductility trade-off, the total elongations are almost the same in both the composite and the pure aluminum. In that respect, the fracture dissipation in the Al/NiTi is expected to be higher than the FSPed Al, given that the Al/NiTi involves a higher external work but a lower plastic dissipation. The quantitative fracture toughness measurement will be carried out with double edged notched tension tests in future investigations.

References

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