CMM-SolMech 2022 conference

S12 Plasticity, damage and fracture mechanics

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ID 48: *Double surface model of the intermittent plastic flow in ductile materials at cryogenic temperatures* – R. Schmidt, B. Skoczeń

ID 79: *Application of unified mechanics theory to constitutive modeling of gigacycle fatigue* (poster) – H. Wei Lee, H. Fakhri, R. Ranade, H. Egner, A. Lipski, M. Piotrowski, S. Mroziński, N. B. Jamal, C. L. Rao

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ID 256: *Viscoplastic consistency model for concrete with non-associated flow rule* – A. Winnicki, A. Wosatko

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MODELING OF DEFORMATION AND FRACTURE OF METAL-CERAMIC MICROCANTILEVER BEAMS IN BENDING

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In this paper a combined experimental and computational study of the deformation and fracture of microcantilever specimens made of chromium(rhenium)-alumina Metal-Matrix Composite (MMC) is presented, with a particular focus on the failure properties of the metal-ceramic interfaces [1].
In two-phase ductile-brittle materials reinforced with ceramic particles, the interface between the matrix and the reinforcement plays a dominant role in the overall material response to mechanical loading. Hence, the interfacial strength and fracture toughness are among the factors of primary importance in producing stronger and tougher MMCs. Micromechanical testing techniques are being more and more used to investigate the mechanical properties at the microscale, which are of primary importance for modeling. However, determination of both the interfacial strength and fracture toughness is still a challenging task. In this research we attempt to solve the problem in question by proposing an inverse numerical analysis of the results from micromechanical tests to infer the properties at the microscale. More specifically the micro force-displacement curves and deformation patterns from the bending tests are used as input data in the finite element model predicting the micro specimen behavior with a sufficient accuracy. The most essential outcome of this model is an estimation of the cohesive strength and fracture energy of the interface.
In general terms this work contributes to a better understanding of the local deformation and fracture behavior of Cr(Re)/Al2O3 MMC manufactured by powder metallurgy. The specific targets achieved encompass: (i) in-situ experimental identification of the deformation and failure modes of the FIB-milled micro cantilevers loaded by a nanoindenter, and (ii) numerical simulation of the bending experiments to predict the cohesive strength and fracture energy of the interface between Al2O3 particles and Cr(Re) matrix on the microscale.
It is shown that the dominant fracture mode of the chromium(rhenium)-alumina composite under investigation is brittle interfacial mixed-mode cracking that is quite sensitive to the amount of ceramic reinforcement in cross-sections near the specimen's fixed end. Interestingly, higher maximum forces are exhibited by specimens with more Cr(Re)/Al2O3 interfaces in that region. An extensive parametric study demonstrates that the cohesive strength and fracture energy of the interface are estimated to be 0.63 MPa and 50 J/m2, respectively.

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[1] Węglewski W., Bochenek K., Pitchai P., Bolzon G., Konetschnik R., Sartory B., Ebner R., Kiener D., Basista M., Experimental and numerical investigation of the deformation and fracture mode of micro cantilever beams made of Cr(Re)/Al2O3 Metal-Matrix Composite, Metallurgical and Materials Transactions A DOI: 10.1007/s11661-020-05687-3, Vol.51, No.5, pp.2377-2390, 2020.