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MECHANICAL BEHAVIOR OF GUM METAL UNDER TENSION AT VARIOUS STRAIN RATES – FULL-FIELD DEFORMATION MEASUREMENTS AND SIMULATIONS

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ABSTRACT - Recently, a class of multifunctional β titanium alloys called Gum Metal have drawn increasing attention because of their unique performance [1]. Their superior properties, caused by an activity of unconventional deformation mechanisms, include low Young's modulus combined with high strength, large range of nonlinear reversible deformation and high plastic deformability without hardening. In this work, mechanical behavior of Gum Metal was investigated by conducting tensile tests at various strain rates and applying 2-dimensional digital image correlation (DIC). Stress-strain curves were analyzed using selected lengths of virtual extensometer (VE) placed in the strain localization area. Evolution of the Hencky strain and deformation rate tensor fields was analyzed for various strain rates at selected stages of Gum Metal loading. The analysis demonstrated that for lower strain rates the deformation is macroscopically uniform up to the large average strain level whereas for higher strain rates the strain localization occurs at the smaller average strain level during the process and takes place in the smaller area. It was shown that for all strain rates applied maximal values of Hencky strain immediately before rupture of Gum Metal samples were similar for each strain rate, and the maximal values of deformation rate tensor were two orders higher when compared to average strain rate values. The experimental outcomes were compared with a hyperelastic-viscoplastic model of Gum Metal formulated in the large strain framework [2]. The free energy function, postulated in the model, consisted of the hyperelastic and viscoplastic components. Original extension of the Neo-Hooke model with a power law component was proposed for hyperelasticity. It enabled to describe a relatively large nonlinear elastic regime observed for the alloy. Viscoplastic strain follows the Perzyna-type law with an overstress function. The model was implemented into the finite element method. Good accordance of the simulation results and the available experimental data is obtained.

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