UNIAXIAL COMPRESSION BEHAVIOUR OF POROUS COPPER: EXPERIMENTS AND MODELLING

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The yielding behavior of porous metallic materials has been fairly well studied. However, the data on post-yield flow behavior is rather scarce. In the current study, porous copper samples with a wide range of porosity (2% - 25%) are prepared by suitably changing the process parameters of Spark Plasma Sintering (SPS) process. Uniaxial compression tests are performed on the porous samples with different initial porosities to experimentally determine the evolution of porosity and flow stress and thereby understand the post-yield hardening behavior. A simple analytical model is developed for evolution of porosity and flow stress during uniaxial compression based on the Gurson model. A unique linear relationship was observed for normalized porosity (porosity / initial porosity) with strain and normalized flow stress (flow stress / flow stress of matrix) with porosity as shown in Fig. 1. The model predictions are in good agreement with the experimental results and Finite Element Analysis (FEA) results over a wide range of porosity and strain.
Furthermore, a new model for strain hardening rate (θ) is developed which explains the significant strain hardening observed in the uniaxial compression tests as shown below.

$$\theta = \theta_M (1-q_1 f) + \sigma_M q_1 f_0 a$$

where, θ_M is strain hardening rate of the matrix, σ_M is the flow stress of the matrix, f is porosity, f_0 is initial porosity, q_1 and a are constants.
The observed strain hardening rate of the porous samples depends not only on the strain hardening rate of the matrix material but also on the extent of pore closure during compression. While the relative contribution of the strain hardening rate of the matrix largely dominates the observed response, the contribution due to pore closure is significant for samples with high initial porosity, especially at higher values of strain.

The Gurson model parameters for the current material system and porosity range will also be presented along with a discussion on the applicability of the Gurson model for the current range of porosity.

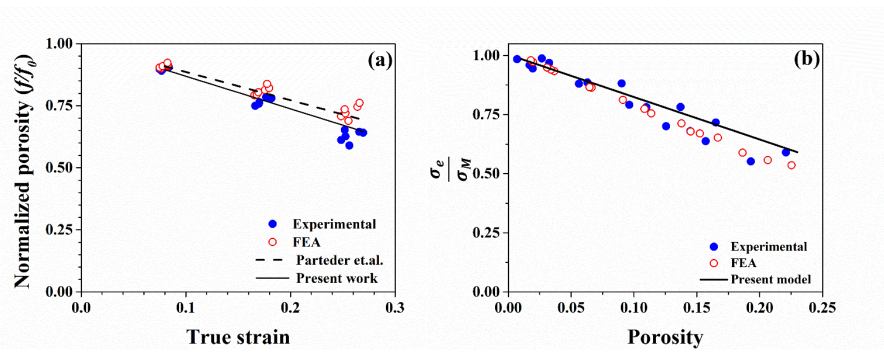

Fig. 1: (a) Comparison of experimental, FEA and theoretical results for normalized porosity (f/f_o) during compression (b) Variation in normalized flow stress (σ_e/σ_M) with porosity, comparison between experimental data, FEA predictions and theoretical analysis