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Material optimisation for creep testing by additively manufactured composite cantilevers

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The bending of cantilevers is an alternate technique for extraction of power-law creep parameters of materials. Digital image correlation (DIC) allows extraction of multiple “stress-strain rate” pairs using a single cantilever by exploiting the varying strain field across the thickness and length of the sample. DIC and Finite element analysis (FEA) show, that in bending, creep deformation in T22 (2.25Cr-1Mo) steels is localized to ~20% of the beam volume near the constrained end for power law exponents ~ 4-5. Therefore, fabrication of composite cantilevers is proposed as an alternative for minimising volume of material for testing. The composite consists of a creeping portion and an additively extended non-creeping portion. The creeping portion remains at the constrained end while the non-creeping part extends to the loading end. Validation of the approach was established by testing T22 steel cantilevers at 600°C, which formed the creeping portion. The non-creeping portion was an additively deposited Inconel-718. The optimisation process involved varying T22 steel length, ‘*a’,* while keeping total sample length, ‘*L*’, constant. High-temperature DIC (600°C) was used to measure creep for varying *a*/*L* ratios. An excellent match between monolithic and composite beam creep behaviour was observed. Microstructural analysis of the 85-100 µm interface between T22 and Inconel-718, augmented with DIC, showed that even at *a/L* of 0.2, the shear strains at the interface were only ~ 0.5% and that these strains did not alter the creep rates measured in the steel further away. FEA of the bi-material beam suggests that additional stresses are developed at the interface owing to the abrupt change in the gradient of curvature between the creeping and elastic segments.

Keywords: Bending Creep, High-Temperature Testing, Digital Image Correlation