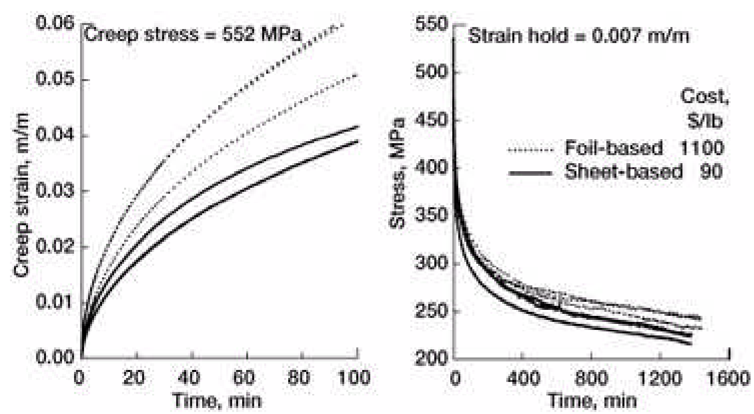
Deformation Behaviors of HIPped Foil Compared With Those of Sheet Titanium Alloys

Micromechanics-based modeling of composite material behaviors requires an accurate assessment of the constituent properties and behaviors. For the specific case of continuous-fiber-reinforced metal matrix composites (MMC's) manufactured from a foil/fiber/foil process, much emphasis has been placed on characterizing foil-based matrix materials that have been fabricated in the same way as the composite. Such materials are believed to yield mechanical properties and behaviors that are representative of the matrix constituent within the composite (in situ matrix). Therefore, these materials are desired for micromechanics modeling input. Unfortunately, such foils are extremely expensive to fabricate and procure because of the labor-intensive rolling process needed to produce them. As a potential solution to this problem that would maintain appropriately representative in situ properties, the matrix constituent could be characterized with sheet-based materials, which are considerably less expensive to manufacture than foils, are more readily procured, and result in fewer plies to obtain a desired panel thickness. The critical question is, however, does the consolidated sheet material exhibit the same properties and behaviors as do the consolidated foils? Researchers at NASA Lewis Research Center's Life Prediction Branch completed a detailed experimental investigation to answer this question for three titanium alloys commonly used in metal matrix composite form.



Creep and stress relaxation behavior of HIPped foil and sheet Ti-6-4 matrix at 427 °C (800 °F).

The experimental investigation compared the 427 °C (800 °F) mechanical properties and deformation behaviors of three HIPped (Hot Isostatic Pressed) foil and HIPped sheet titanium matrix materials commonly used in silicon-carbide- (SiC-) reinforced titanium composites. The alloys investigated were Ti-15V-3Cr-3Al-3Sn (Ti-15-3), Ti-15Mo-3Nb-3Al-0.2Si (Ti-21S), and Ti-6Al-4V (Ti-6-4). Elastic properties, creep deformation, and stress relaxation were examined along with the microstructural features before and after deformation. Differences in behavior were judged on the basis of statistical significance, where both a univariate analysis of variance (ANOVA) and a multivariate analysis of variance (MANOVA) were used and a two-parameter Norton-Bailey power law relationship was employed. In general, the HIPped foil and sheet were found to be significantly different in creep and stress relaxation at the 95-percent confidence level, with the only exceptions being Ti-15-3 in creep and Ti-21S in stress relaxation. Influencing this conclusion was the fact that the behaviors for any one alloy/product-form combination tended to be tightly grouped and exhibited relatively low sample-to-sample functional deviations. Of the three alloys, only the Ti-15-3 differed significantly within the microstructure in comparison to the foil and sheet forms. Furthermore, this was the only alloy to exhibit differences between the pre- and post-deformation states. This resulted from the metastable condition of the Ti-15-3 (even after a stabilization heat treatment). At 427 °C (800 °F), this alloy tends to experience a notable degree of deformation-assisted α-Ti precipitation within the β matrix. Although the strictly interpreted statistical analysis indicated that the foils and sheets exhibited significantly different behaviors, often a more practical engineering assessment and interpretation of the behaviors suggested that the sheet material could, in fact, be substituted for the foil, depending on the intended application of the data.

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