XL ZJAZD DELEGATÓW PTMTS
XII KONFERENCJA Nowe Kierunki Rozwoju Mechaniki IX SYMPOZJON Kompozyty. Konstrukcje Warstwowe

Zbigniew L. KOWALEWSKI[1]
Ved Prakash DUBEY[1]
Mateusz KOPEC[1]

ASSESSMENT OF INITIAL AND SUBSEQUENT YIELD SURFACES OF TI-CU BIMETALLIC STRUCTURE AFTER PRE-DEFORMATION INTRODUCED BY COMPLEX LOADING

1. Abstract

Investigating of the material properties and physical mechanisms responsible for plastic deformation caused by complex loading is crucial for bimetallic structures. These materials are a type of functionally graded multi-material structures designed to combine diverse material properties within the same framework while optimizing manufacturing costs. In the present work, the initial yield surface and its subsequent evolution were determined for a Ti-Cu bimetal based on the definition of yield stress for 0.01% plastic offset strain. The subsequent yield surfaces were determined after introducing monotonic axial tension and axial tension-cyclic torsion pre-deformation up to 1% permanent axial strain. It was found, that the determined initial yield surface was close to the Huber-Mises locus. Furthermore, subsequent yield surfaces were determined to assess a hardening/softening effect in the loading direction applied. Interestingly, only the monotonic tension caused a significant enhancement of the tensile yield strength as the monotonic tension associated with cyclic torsion caused its reduction. On the other hand, the sizes of subsequent yield surfaces reflecting pre-deformation were reduced in the axial compression direction.

2. Introduction

The main objective in the design of structural metals is to manufacture high-strength materials characterized by improved the yield and ultimate strengths. Both these mechanical parameters immensely rely on the primary mechanisms of plastic deformation and evolving microstructure under loading conditions taken into account. In recent years, bimetals or two-phased nano-layered metals have been extensively investigated due to tremendous opportunities to replace costly and rare metals used in the industrial applications (Chen et al., 2022). Bimetals demonstrated higher strength and mechanical stability as compared to their component metals at extreme temperature and pressure environments. This unique behaviour of bimetals cannot be explained by a simple volumetric average properties of the component metals. Thus, the authors systematically investigated the mechanical properties of Ti-Cu bimetal in this paper through uniaxial tension and combined monotonic tension-cyclic torsion. Yield surfaces of Ti-Cu bimetal, both in its as-received state and after pre-deformed conditions resulting from monotonic tension and various combinations of monotonic tension and cyclic torsion, were reported. Yield surfaces were determined using thin-walled tubular specimens loaded along sequential proportional paths, where the yield point was defined by a designated plastic offset strain. Additionally, the texture evolution of samples due to plastic pre-

[1] Instytut Podstawowych Problemów Techniki Polskiej Akademii Nauk, Zakład Mechaniki Doświadczalnej

deformation was analysed. This study may provide potential implications on the physical mechanism accountable for plastic deformation and the evolution of yield surfaces in HCP/FCC bimetallic structures.

3. Results and discussion

As shown in Figure 1a, a clear tendency of decreasing tensile stress can be observed when tension is combined with cyclic torsional loading and gradual increase of the cyclic strain amplitude. Also, an increase of the frequency resulted in decrease of the tensile stress. Such decrease in tensile stress can be attributed to the introduction of shear stress components. Figure 1b provides a comprehensive visualization of the initial yield surface evolution in the axial-shear stress space, following various level of pre-deformation of the Ti-Cu bimetal. It was observed, that each yield surface has a distinct shape and the size of subsequent yield surfaces decreases in the compressive direction, which is the opposite of that representing the tensile pre-deformation of bimetal. The yield surface of bimetal after 1% monotonic tension pre-deformation exhibited the largest dimensions. By examining Figure 1b, it becomes evident that monotonic tension pre-deformation leads to the kinematic hardening in the same direction as that used during pre-deformation. Furthermore, combined monotonic tension-cyclic torsion pre-deformation leads to the kinematic softening in all directions and it becomes more prominent with the increase of torsional strain amplitude.

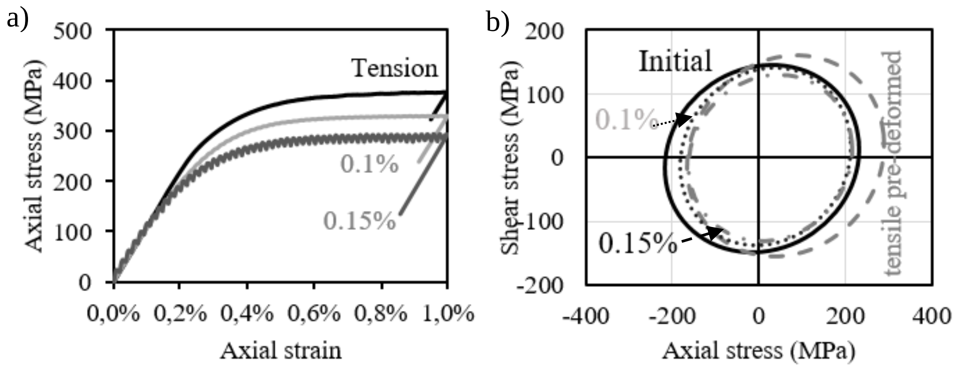

Figure 1. Material characteristics of Ti-Cu bimetal subjected to: monotonic tension only and simultaneous application of monotonic tension with cyclic torsion with strain amplitude equal to: 0.1% and 0.15% at frequency of 0.5 Hz (a) and evolution of the initial yield surface of Ti-Cu bimetal due to such pre-deformation (b).

Literature

[1] DUBEY VP., KOPEC M., ŁAZIŃSKA M., KOWALEWSKI Z.L., Yield surface identification of CP-Ti and its evolution reflecting pre-deformation under complex loading, International Journal of Plasticity, 2023, Vol.167, pp.1-21, 2023.

This work has been supported by the National Science Centre through the Grant No 2019/35/B/ST8/03151.