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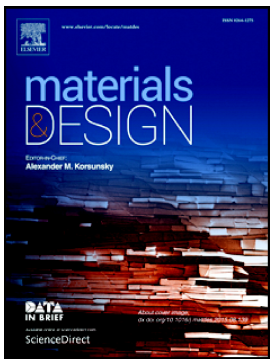

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Extrapolation based constitutive modeling of flow stress of titanium alloy sheet under hot-working condition

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Abstract

Due to the limitation of stress-strain range obtained by tension tests, constitutive models of sheet metal generally cannot accurately describe the large deformation behaviors involved in forming process under hot-working condition. Thus, extrapolation and constitutive modeling of flow stress is critical in sheet metal forming process. In this study, the flow behaviors of a titanium alloy sheet in hot-working process were investigated via hot tension tests under different conditions. The strain at necking onset is found having a minimum value of 0.11, which limits accurately describing the large deformation behaviors involved in forming process. While the flow stress shows work hardening and flow softening behaviors with temperature and strain rate and further behaves the temperature and strain rate sensitivities. Considering the limited stress-strain range, an extrapolation model was proposed considering the work hardening and flow softening behaviors. The model parameters were attained through finite element (FE) based inverse method, and the flow stress at large strain was thus obtained. With the extrapolated stress, a constitutive model was developed considering the flow stress characteristics with quantitative analysis. The results show that this model serves a feasible approach to describing the flow behaviors of titanium alloy under hot-working conditions with large deformation.

Keywords: Titanium alloy sheet; Hot-working condition; Flow stress extrapolation; Constitutive model; Finite element simulation.

1. Introduction

Sheet metal forming has been widely used in many industrial clusters including automotive, aerospace, and medical to manufacture light-weight components [1-3]. Generally, the process is conducted at room temperature. However, for some sheet metals such as titanium and magnesium alloys, the process is conducted in hot-working conditions for the poor formability of the materials at room temperature [4-6]. While under hot-working conditions, the deformation shows the complex deformation behaviors and the working parameters including deformation degree, strain rate and temperature change [7-10]. To accurately describe the deformation behaviors, constitutive modeling of sheet metal under