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Thermal-Mechanical Coupled Manufacturing Simulation in Heterogeneous Materials

A. El Amri [a] [*], M. El Yakhloufi Haddou [a], A. Khamlichi [b]

[a] *Department of Physics, Faculty of Sciences at Tetouan, Tetouan 93030, Morocco.*

[b] *Departments TITM, National School of Applied Sciences, Tetouan 93030, Morocco.*

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Abstract

This work is aimed to investigate on thermal and thermo-mechanical behaviour of 6061 Aluminium alloy. The main target of the present investigation is to apply a numerical procedure to assess the thermo-mechanical damage. Finite element analyses of the notched tensile specimens at high temperature have been carried out using ABAQUS Software. The objective was to study the combined effects of thermal and mechanical loads on the strength and ductility of the material. The performance of the proposed model is in general good and it is believed that the presented results and experimental–numerical calibration procedure can be used in practical finite-element simulation.

Keywords: Continuum Damage Models; Manufacturing; Thermal and Mechanical Damage; Finite Element Analysis.

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1. Introduction

The Finite element modeling (FEM) has been widely introduced into the design of manufacturing products because of its high efficiency in predicting several problems and major defects occurring in sheet metal forming manufacturing process like necking. In order to predict those defects within a virtual manufacturing system [1-2], One of the most widely used models is continuum damage. The tensile strength, the yield strength and Young's modulus depend the temperature because Young's modulus of some tempered steels increases slightly at mid temperatures before decreasing at high temperature on mechanical properties is linked to transformations of the material structure due to various processes that inelastic deformation can occur more easily at elevated temperatures, so more plastic deformation and creep occur in the plastic zone of a fatigue crack [3, 4]. The damage parameter is not incorporated into the constitutive equation and it is assumed that presence of voids does not significantly alter the behavior of the material. The von Mises criterion is most frequently used as yield criterion in uncoupled models, Damage parameter is incorporated into constitutive equation and crack growth simulation is automatically performed using a complete deterioration of elements in front of the crack tip [5].

To describe the phenomenon of initiation and growth of cavities and micro cracks induced by large deformation in metals and called "ductile damage", within the framework of continuum damage models, either phenomenological or micromechanically based, have been developed. In recent years, several different formulations for a variety of materials and processes have been presented, such as elastic-brittle [6, 7], brittle, creep, fatigue and creep-fatigue [8-13], among others. However, initially, the development and application of damage models was focused on ductile fracture.

Ductile fracture process is controlled by nucleation, growth and coalescence of micro voids, so it is natural to link material fracture behavior to the parameters that describe the evolution of micro voids rather than conventional global fracture parameters [14].

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[*] Corresponding author: abdelouahid26@gmail.com