PREDICTION OF DUCTILE FRACTURE STRAINS IN UPSETTING PROCESSES

By
Mostafa Khaled Megahed Ali Hassan

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Mechanical Design and Production Engineering

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Under the Supervision of

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Title of Thesis:

PREDICTION OF DUCTILE FRACTURE STRAINS IN UPSETTING PROCESSES

Key Words:

Ductile fracture; porous metal plasticity; finite element analysis, forming limit diagram at fracture, upsetting process.

Summary:

Forgeability and workability are measures of the plastic deformation limit that workpieces can undergo under bulk-forming processes. Upsetting tests for different axisymmetric specimens are usually used to construct the forming limit diagram at fracture (FLDF). The objective of the present work is to predict the FLDF for upsetting processes using coupled and Uncoupled DF approaches and relating the friction conditions and specimen dimensions to the critical height reduction of blocks. Numerical simulations are performed to determine the stress and strain distribution at the locations of crack formation. Two FE models are adopted after validating the results against published data; one considers voided materials while the other does not. It has been found that the coupled DF approach is in principle capable of predicting analytically the failure in upsetting processes. For uncoupled DF approach, an average value of the critical parameter (Cavg) in the out-of-plane shear and hydrostatic integrals has to be assigned from experiments to predict a semi empirically bilinear forming limit diagram at fracture FLDF. The fitting expression developed from the parametric study gives results close to the results obtained numerically with an error less than 9.69 %.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Mostafa Khaled Megahed Ali Hassan Date: …/…/2020

Signature:

Dedication

I dedicate this work to all interested and knowledge eager folks.

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I would like to thank all the people who contributed in some way to the work described in this thesis. First, I thank my academic advisor, Dr. Chahinaz for her time, effort and patience.

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Nomenclature

C_{v_o} , C_v	Initial and current Void volume fraction
q_1, q_2, q_3	Tvergaard adjusting parameters
C	Critical damaged parameter of uncoupled integrals
$\bar{\varepsilon}$	Equivalent strain
$\bar{\varepsilon}_e$	Effective strain for the matrix
$\bar{\varepsilon}_e$	Equivalent elastic strain
$\bar{\varepsilon}_p$	Equivalent plastic strain
$\bar{\varepsilon}_f$	Equivalent strain at failure
ε_v^p	Volumetric plastic strain
$\varepsilon_{1,2,3}$	Principal strains from maximum to minimum
$\varepsilon_\theta, \varepsilon_z$	Tangential and axial strain
σ_{ij}	Stress terms in the stress tensor
σ_m	Hydro static stress
$\bar{\sigma}$	Macroscopic von-Mises flow stress
$\bar{\sigma}_M$	Equivalent stress for the matrix
$\sigma_{1,2,3}$	Principal stresses from maximum to minimum
σ_θ, σ_z	Tangential and axial stress
C^e	Elasticity matrix
λ	Plastic multiplier
λ_{1i}, λ_1	Initial and current void aspect ratio
λ_{2i}, λ_2	Initial and current unit cell aspect ratio
$\frac{b_1}{b_2}$	Ligament size ratio
n	Strain hardening exponent
D	Shear damage
g_θ	Lode angle dependence function
θ_l	Lode angle
τ_{13}	Out of plane shear stress
μ	Coefficient of friction
E	Modulus of elasticity

υ	Poisson's ratio
H/D	Height to diameter ratio