Forming limit curves analysis of aluminum alloy considering the through-thickness normal stress, anisotropic yield functions and strain rate

S.M. Mirfalah Nasiri, A. Basti, R. Hashemi

www.elsevier.com/locate/ijmecsci

PII: S0020-7403(16)30178-3
DOI: http://dx.doi.org/10.1016/j.ijmecsci.2016.08.011
Reference: MS3391

To appear in: *International Journal of Mechanical Sciences*

Received date: 8 April 2016
Revised date: 29 July 2016
Accepted date: 22 August 2016

Cite this article as: S.M. Mirfalah Nasiri, A. Basti and R. Hashemi, Forming limi curves analysis of aluminum alloy considering the through-thickness norma stress, anisotropic yield functions and strain rate, *International Journal o Mechanical Sciences,* http://dx.doi.org/10.1016/j.ijmecsci.2016.08.011

Forming limit curves analysis of aluminum alloy considering the through-thickness normal stress, anisotropic yield functions and strain rate

S.M. Mirfalah Nasiri[1], A. Basti[1*], R. Hashemi[2]

[1]*Department of Mechanical Engineering, University of Guilan, Rasht, Iran*

[2]*School of Mechanical Engineering, Iran University of Science and Technology, Tehran, Iran*

[*]Corresponding author. Tel. /fax: +98 13 33690276. *E-mail address*: basti@guilan.ac.ir (A.Basti).

Abstract

Based on three anisotropic yield functions including Karafillis-Boyce (K-B), Yld96 and Yld2011, directional normalized uniaxial yield stresses, directional r-value and forming limit curve (FLC) for AA3104-H19 aluminum alloy under plane stress condition are numerically investigated in this article. Moreover, considering the through-thickness normal stress effect the forming limit diagram (FLD), stress-based forming limit diagram (FLSD) and extended forming limit stress diagram (XFLSD) is also studied theoretically based on Yld2011 yield criterion and modified Marciniak–Kuczynski (M-K) model. The nonlinear equations set are solved through employing Newton-Raphson numerical method to calculate limiting strains. The anisotropic plastic behavior and FLC of AA3104-H19 predicted by Yld2011 yield criterion are in good agreement with experimental data and are more accurate than those of K-B and Yld96 yield functions. In addition, according to FLD, the formability of sheet metal increases by applying the through-thickness normal stress. The effects of strain rate at quasi-static condition and temperature are theoretically investigated on the FLD of AA3104 aluminum alloy. The positive temperature sensitivity and negative strain rate sensitivity are observed of FLD of AA3104.

Keywords:

Forming Limit Curve, Through-Thickness Normal Stress, Yld2011 Yield Function, Anisotropic Aluminum Alloy, Strain Rate Sensitivity.

Nomenclature

ψ	Yield function
Y	Yield stress
S	Isotropic plasticity equivalent (IPE) stress tensor
σ	Chauchy stress tensor
L	Linear-transformation tensor
a	Material coefficient in the K-B, Yld96 and Yld2011 criteria