Constitutive response of AA6013-T6 aluminum alloy sheet in tensile and shear loading

Taamjeed Rahmaan*, Cliff Butcher, and Michael J. Worswick

University of Waterloo
200 University Ave W, Waterloo, ON N2L 3G1, Canada
E-mail: rahmaan@uwaterloo.ca

ABSTRACT

High strength aluminum alloys are currently of great interest in the automotive industry due to their superior strength-to-weight ratio. In the present work, AA6013-T6 aluminium alloy sheet is characterized from low (10^{-3} s^{-1}) to high (10^{3} s^{-1}) strain rate under both tensile and shear loading. A tensile split-Hopkinson bar and hydraulic intermediate strain rate apparatus are used for the high (10^{3} s^{-1}) and intermediate (10^{1}-10^{2} s^{-1}) rate experiments, respectively. Material anisotropy is characterized in terms of the differences in stress-strain response and Lankford coefficient (or r–value). The effect of strain rate on both the stress-strain and anisotropy characteristics is examined. Room temperature experiments are performed at quasi-static (10^{-3} and 10^{-2} s^{-1}) strain rates on the selected sheet metal alloy. The stress-strain behaviour is found to be similar along all sheet orientations tested (0°, 15°, 30°, 45°, 60°, 75°, and 90° with respect to the rolling direction). The effect of strain rate on stress-strain response and r–values is found to be relatively low. The shear deformation behaviour and fracture characteristics of the two sheet metal alloys are compared with the tensile data. A conversion of the shear stress to an equivalent stress using the von–Mises yield criterion provided excellent agreement with the results from tensile tests. Unlike the tensile test, the shear test is not limited by the onset of necking so the equivalent stress is determined over a larger range of strain. The quasi-static hardening behaviour to large strains was fit using a Hockett–Sherby [1] constitutive model. The calibrated anisotropic yield criterion was able to capture the material anisotropy with good agreement with the measured data. An anisotropic constitutive model was developed that can be used in future high strain rate applications such as vehicle crash simulations.

REFERENCES

[1] J.E. Hockett and O.D Sherby, *Large strain deformation of polycrystalline metals at low homologous temperatures*, Journal of Mechanics and Physics of Solids, Vol. 23, Issue 2, pp. 87-98, (1975).