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FRICTION MODEL IN EQUAL CHANNEL ANGULAR EXTRUSION SUBJECTED TO BACK PRESSURE

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1 Introduction

Equal channel angular extrusion (ECAE) is a forming process where a lubricated billet is extruded through angled twin channels. The process is a promising tool to refine the grain structure of structural materials with consequent improvement of its mechanical properties. As a result, many numerical studies by Finite Element Method (FEM) on ECAE were published on the subject but the majority neglects frictional effects. Nevertheless, friction plays a crucial role in the extrusion since it affects directly the deformation behavior. Consequently, to design the ECAE system precisely, it is imperative to estimate accurately the frictional effects. This study proposes an alternative approach to model the friction in ECAE with back pressure.

2 Finite Element Analysis

Figures 1a and 1b depicts the finite element (FE) model and the material properties employed in this study. The penalty method and the Coulomb friction model with truncated shear stress were employed to model the contact and friction on the interface between the billet and the die. The truncated stress is expressed as $\tau_{max} = \sigma_{y_o}/\sqrt{3}$ where σ_{y_o} is the Mises yield stress (for copper σ_{y_o} = 70 MPa). The FE model employed adaptive mesh refinement using the arbitrary Lagrangian-Eulerian (ALE) method to avoid the the numerical instabilities generated by the severe mesh distortion. Finally, the FE model was validated against an experiment with the same conditions as its numerical counterpart.

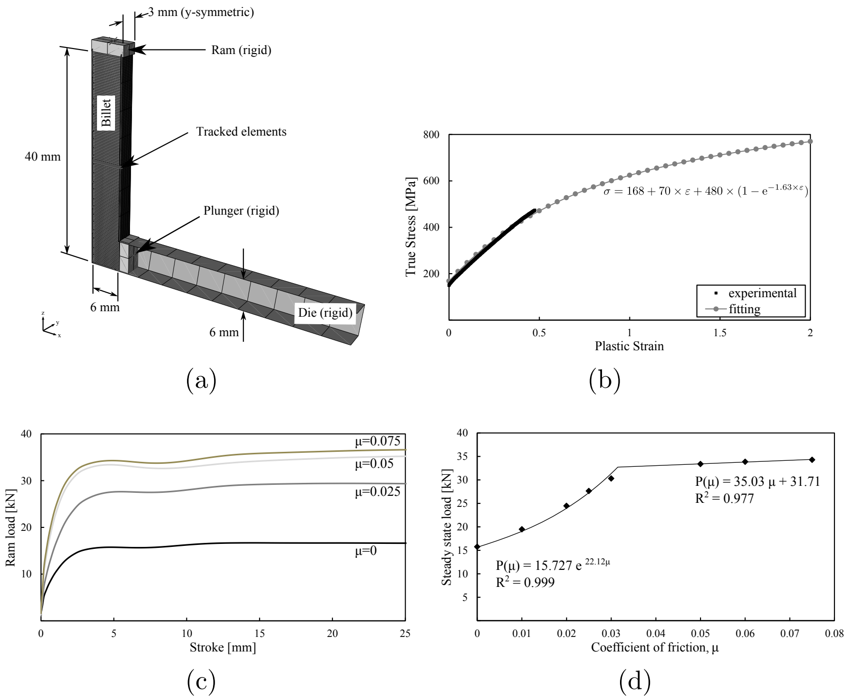

Figure 1: (a) The FE model, and (b) the material properties for Cu, (c) the pressing load, and (d) the steady state load versus coefficient of friction (back pressure of 176.056 MPa).

3 Results and Discussion

Figure 1c depicts the pressing load curves for a selected range of coefficient of friction. Local maximum are identified for each case using the beginning of the steady state (stroke of 5 millimeters) for the plastic strain distribution. Figure 1d illustrates the relation between this maximum and the coefficient of friction. Thus, using the experimental data acquired in this study and the fitting function, the coefficient of friction is estimated as $\mu = 0.021$ (Smolyakov et al. [1] experimentally determine $\mu = 0.02$).

4 Conclusion

The FEA indicates that the pressing load can be employed to estimate the coefficient of friction during a single pass ECAE of pure copper with back pressure. This method is a crucial step towards appropriate design of the ECAE system.

REFERENCES

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