Investigation of friction conditions in metal forming processes: A computational study validated by Ring Compression Tests and extrusion experiments

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ABSTRACT

Metal forming processes usually involve large friction forces which develop at the die-work-piece interface, and as a result greatly limits tool life expectancy and product surface quality [1,2]. Adequate determination of the friction condition is important to enable optimization of the forming process. Several experimental methods have been developed for quantitative evaluation of friction in metal forming. The most accepted method in the last few decades is the ring compression test (RCT) [3], in which a ring is plastically compressed between two flat dies. The dimensional changes of the inner diameter provide quantitative knowledge of the friction coefficient (μ) at the die-workpiece interface. Nevertheless, due to the inhomogeneous deformation, numerical analysis is necessary in order to determine μ . It is customary to assume that the friction characteristics extracted from the RCT are appropriate for describing the friction conditions in more complex plastic forming processes such as extrusion but this assumption is still debated among researchers.

In order to investigate the above assumption, the current study incorporates several experimental methods (using Al1100 with graphite-based lubricants) in conjunction with verified and validated computational models:

1. Compression tests of cylindrical specimens were used to determine the material flow stress for different temperatures and loading rates.
2. RCTs were conducted at several temperatures and loading rates and used to extract the dependence of friction coefficient μ on temperature and loading velocity.
3. Hot hollow extrusion experiments were performed at various temperatures and extrusion ratios.

The computational models were used to examine the thermo-mechanical fields which develop during the different processes with emphasis on the effect of friction conditions. The thermo-mechanical fields were correlated with resulting microstructure in the RCTs. The friction characteristics obtained using the RCTs were implemented in the extrusion experiments and conclusions regarding the effectiveness of the RCT method in predicting friction conditions in more complex forming processes will be presented.

REFERENCES

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