Influence of the microstructure of copper on the friction coefficient under very high pressure: application to the ECAP process

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Severe plastic deformation (SPD) processes are used to obtain ultra-fined grains materials under low motion speed rates. This study focuses on equal channel angular pressing (ECAP). To characterize the friction coefficient between the sample and the matrices of the ECAP process, an original tribometer which allows up to 30 mm sliding length has been designed. The used material are specimens cut out of samples of commercially pure copper subjected to ECAP (one and four passes). These tests allow us to highlight the influence of the number of passes on the friction coefficient.

Keywords: Severe Plastic Deformation, Equal Channel Angular Pressing, Copper, High Pressure Friction

1. Introduction

The understanding of the tribological properties of materials in metal forming is an important issue especially in SPD processes. In these processes, material is subjected to high severe plastic deformation under low motion speed rates in order to obtain ultra-fined grain material [1]. Some SPD processes require a high friction coefficient to drive the material like in High Pressure Torsion. On another side, friction can be non-beneficial like in Equal-Channel Angular Pressing (ECAP) for which it opposes the motion of the material billet.

In ECAP a metal sample is subjected to an intense plastic straining through simple shear without corresponding change in its cross-sectional dimensions. One of the main parameters of modeling is the friction coefficient between the sample and the matrices. In these works, the friction coefficient is often used as a fitting parameter to match with the experimental tests [2]. The purpose is to collect data on the friction coefficient in order to develop a friction law which could be used in modeling.

2. Methods

In order to characterize the friction coefficient a first tribometer device has been designed by Pougis et al. [3]. It allows to measure friction coefficients for several couples of materials in representative conditions of the ECAP process but for only one millimeter of sliding.

This study focuses on a new tribometer device with a sliding length up to 30mm. The main material of the study is commercially pure copper, which is commonly used in ECAP process [4].

For this study two square-section samples of commercially pure copper have been subjected to ECAP with respectively one and four passes following the route C [5]. One raw sample of copper is also used as a reference. Out of these three copper samples, several specimens have been cut by spark-machining to fit into the new tribometer device. Friction tests were carried out for a contact pressure up to 1 GPa and a sliding velocity of 5 mm/min. These tests will allow us to notice the influence of the number of passes on the dry friction coefficient.

3. Discussion

Friction coefficient evolution shows for 20mm sliding length three distinct zones. The first zone is similar of results published by Pougis et al. [3] for one millimeter while the two others show transient and steady-state behaviours of the friction coefficient. Investigations of sliding surfaces of matrices combined with microstructure analysis of worn parts of the pin allowed us to suggest assumptions about mechanical behavior observed during testing.

4. References

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