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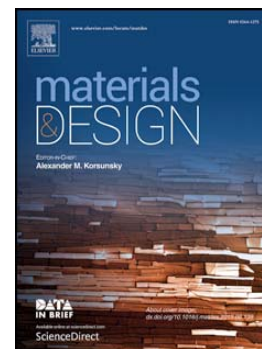
A simple model for material's strengthening under high pressure torsion

S. Khoddam, P.D. Hodgson, A. Zarei-Hanzaki, L. Yan Foon

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A SIMPLE MODEL FOR MATERIAL'S STRENGTHENING UNDER HIGH PRESSURE TORSIONS. Khoddam^{a*}, P. D. Hodgson^a, A. Zarei-Hanzaki^b and L. Yan Foon^c^a Institute for Frontier Materials, Deakin University, Geelong, Victoria, Australia, 3216^b School of Metallurgy and Material Engineering, University of Tehran, Tehran, Iran^c Curtin University, Sarawak, Malaysia

* Corresponding author Phone: +61 3 5227 1102, Fax: 03 5227 1103, E-mail address: shahin@deakin.edu.au

ABSTRACT

Constrained high pressure torsion (CHPT) is a promising route to fabricate ultra-fine structured bulk and powder materials. It was recently proposed as a mechanical test for large strains. Only a few models are available on "friction induced deformation" during CHPT. A number of closed form models were derived in this work to estimate a sticking friction condition during CHPT. The models also correlate CHPT's torque-twist-pressure response and its constitutive parameters. To verify the accuracy of the derivations, the response for Armco iron samples were estimated under three different pressures of 1.9, 3.8 and 7.5GP and compared with experimental data. Contribution of frictional power dissipated at the specimen's circumferential surface were evaluated and compared with the total deformation power.

Key words: high pressure torsion; sticking friction; extended deformation

1. INTRODUCTION

Severe plastic deformation (SPD) refers to the processing of metals under a combination of extensive hydrostatic pressure and large strains [1]. This produces ultra-fine grained material with a very high dislocation density and modifies properties of the original material. Several new SPD techniques have been developed recently including accumulative roll bonding (ARB) [2], equal channel angular extrusion (ECAE) [3], high pressure torsion (HPT) [4], twist extrusion [5] and axisymmetric forward spiral extrusion [6].

Un-constrained and (semi)constrained modes of high pressure torsion, (semi)CHPT, are widely used by several researchers. A CHPT, allows establishing an effective back-pressure, reduces bulging effect and decreases surface defect. The constrained mode, in its ideal sense, is not practical due to the brittle nature of the punches and the manufacturing errors. A semi-constrained version of HPT has been commonly employed in the existing literature to minimize the implementation problems. Analytically, the constrained mode is reasonably close to the semi-constraint mode. Both semi-constrained and constrained modes are considered in this article. CHPT has been viewed [7] as the realisation of an ideal torsion test in which the fracture of the sample is being postponed indefinitely due to the presence of high hydrostatic pressure. Such a

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