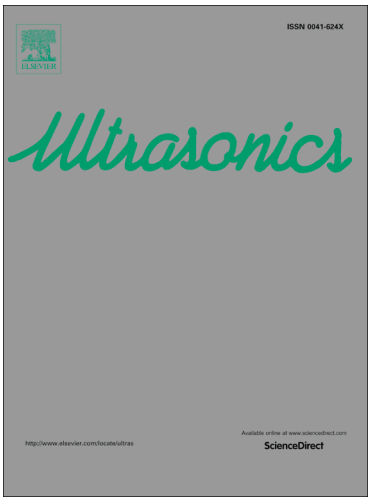

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Shen Liu, Xiaobiao Shan, Kai Guo, Yuancai Yang, Tao Xie

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Experimental Study on Titanium Wire Drawing with Ultrasonic Vibration

Shen Liu [1], Xiaobiao Shan [1], Kai Guo [2], Yuancai Yang [1] and Tao Xie [1,*]

[1] School of Mechatronics Engineering, Harbin Institute of Technology, Harbin 150001, China
[2] Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Sciences, Suzhou 215163, China
* Correspondence: xietao@hit.edu.cn; Tel.: +86-451-8641-7891; Fax: +86-451-8641-6119

Abstract

Titanium and its alloys have been widely used in aerospace and biomedical industries, however, they are classified as difficult-to-machine materials. In this paper, ultrasonic vibration is imposed on the die to overcome the difficulties during conventional titanium wire drawing processes at the room temperature. Numerical simulations were performed to investigate the variation of axial stress within the contacting region and study the change of the drawing stress with several factors in terms of the longitudinal amplitude and frequency of the applied ultrasonic vibration, the diameter reduction ratio, and the drawing force. An experimental testing equipment was established to measure the drawing torque and rotational velocity of the coiler drum during the wire drawing process. The result indicates the drawing force increases with the growth of the drawing velocity and the reduction ratio, whether with or without vibrations. Application of either form of ultrasonic vibrations contributes to the further decrease of the drawing force, especially the longitudinal vibration with larger amplitude. SEM was employed to detect the surface morphology of the processed wires drawn under the three circumstances. The surface quality of the drawn wires with ultrasonic vibrations was apparently improved compared with those using conventional method. In addition, the longitudinal and torsional composite vibration was more effective for surface quality improvement than pure longitudinal vibration, however, at the cost of weakened drawing force reduction effect.

Keywords: wire drawing; power ultrasonic; titanium wire; metal forming;

1. Introduction

Titanium and its alloys have been widely used in aerospace, automotive, chemical and biomedical industrials where high strength, lightweight, good corrosion and heat resistance, and excellent tissue compatibility are required. However, they are also termed as ‘difficult to machine’ materials due to high yield stress to tensile strength (Y/T) ratio, work hardening, low heat conductivity, high adhesive affinity to the tools, and spring-back effect [1][2]. Unlike most metallic wires, titanium wires are generally drawn at elevated temperature, involving complicated surface treatment and multiple vacuum annealing, because of their high mechanical resistance [3]. Conventional cold drawing procedure would further decrease the plasticity and workability of the processed wires, resulting in high breakage ratio and poor surface finish, therefore, is not feasible [4]. Superimposing ultrasonic vibration on the wire drawing tools, which contributes to lubricant condition improvement and metal softening, seems to provide a solution to these problems [5][6].