Accepted Manuscript

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PII: S0141-6359(17)30445-2

DOI: 10.1016/j.precisioneng.2018.05.006

Reference: PRE 6776

To appear in: *Precision Engineering*

Received Date: 25 July 2017

Revised Date: 12 May 2018

Accepted Date: 18 May 2018

Please cite this article as: Soleimanimehr H, Nategh MJ, Najafabadi AF, Zarnani A, The analysis of the Timoshenko transverse vibrations of workpiece in the ultrasonic vibration-assisted turning process and investigation of the machining error caused by this vibration, *Precision Engineering* (2018), doi: 10.1016/j.precisioneng.2018.05.006.

The Analysis of the Timoshenko Transverse Vibrations of workpiece in the Ultrasonic Vibration-Assisted Turning Process and investigation of the Machining Error Caused by This Vibration

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Abstract

Deformation of workpiece causes diametrical error in the turning process. In order to analyze the diametrical error, a model of elastic deformation of workpiece is required. In this article, an efficient elastic deformation model is developed by using of transverse vibration analysis of Timoshenko workpiece method. It is assumed that the workpiece is only held in one side with the chuck in lathe machine. The obtained results illustrated that in the ultrasonic vibration assisted turning process, diametrical error in workpiece after machining was about 35% less than the conventional machining method. Furthermore, by comparing different vibration analysis methods, it was observed that in the same experimental condition, there is a small difference in diametrical error between Euler-Bernoulli and Timoshenko methods and it is about 0.3 percent. The results of Timoshenko method are closer to experimental results compared with the Euler-Bernoulli method.

Keywords: deformation; ultrasonic assisted turning; Timoshenko transverse vibrations; conventional turning; diametrical error.

1. Introduction

Elastic deformation of workpiece under the machining forces leads to diametrical error. This phenomenon in the turning process, especially in long workpieces is obvious. The factors that influence the final properties of the machined workpiece have been investigated in numerous articles. Liu Zhan Qiang [1] used finite difference analysis for calculating the deformations of multi-diameter workpieces by considering turning parameters like the cutting force, workpiece material, shape dimensions and the kind of clamping. A.-V. Phan et al. [2] reported an improved model for predicting diametrical errors in turning cantilever multi-diameter bars. C.K. Chen and Y.M. Tsao [3] studied the stability of flexible and rigid workpieces during turning operation. In this study the relationship between the critical chip width and the cutter spindle speed was investigated under a range of cutting and workpiece conditions. It was also shown that the critical chip width of