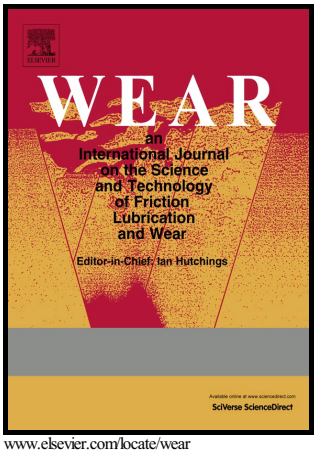

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A theoretical and experimental investigation of material removal characteristics and surface generation in bonnet polishing

Zhong-Chen Cao[1], Chi Fai Cheung*[1] and Xing Zhao[1,2]

1. Partner State Key Laboratory of Ultra-precision Machining Technology, Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

2. Institute of Modern Optics, Key Laboratory of Optical Information Science and Technology Nankai University, Ministry of Education of China, Tianjin, China

*Corresponding author.

Abstract

This paper presents a theoretical and experimental investigation which attempts to provide a better scientific understanding of the material removal characteristics and surface generation in bonnet polishing. The experimental results reveal that the material removal is shared by the polishing pad and the abrasives trapped in the pad-workpiece interface, and the abrasive wear is dominated significantly by plastic removal mode of abrasive particles, while the material removal caused by the polishing pad should be mitigated in order to obtain super mirror finished surfaces. The surface generation is found to be a linearly cumulative effect of dwell time together with the constant material removal rate under the identical polishing condition. Hence, a multi-scale material removal model and a surface generation model have been built based on the contact mechanics, kinematics theory, abrasive wear mechanism, as well as the relative and cumulative removal process of surface generation in bonnet polishing. The models are verified through a series of spot and pattern polishing experiments. Based on the results of spot polishing experiments, the multi-scale material removal model is found to predict well for the material removal characteristics under various polishing conditions. The simulated patterns by the surface generation model are found to agree well with the measured patterns in the pattern polishing experiments which substantiate that the relative and cumulative removal process is a key surface generation mechanism in bonnet polishing.

Keywords: Ultra-precision machining, Bonnet Polishing, Surface Generation, Modelling, Contact Mechanics, Multi-scale Materials Removal

* Corresponding author.

Benny C.F. Cheung, Tel: (852)27667905, Fax: (852)23625267, email: Benny.Cheung@polyu.edu.hk

1. Introduction

Bonnet polishing is a computer controlled sub-aperture polishing process that actively controls the position and orientation of a spinning, inflated, membrane tool (the 'bonnet') as it sweeps through the polished surfaces [1] (see Fig. 1). It is essential for achieving the ever increasing tolerances and demands for high-precision applications such as optical [2], biomedical [3], and automotive