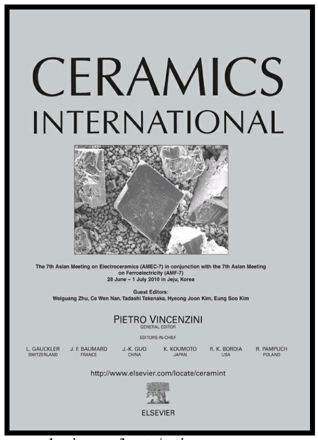
Author's Accepted Manuscript



www.elsevier.com/locate/ceri

Smoothed Particle Hydrodynamics Simulation and Experimental Analysis of SiC Ceramic Grinding Mechanism

Yao Liu, Beizhi Li, Chongjun Wu, Lingfei Kong, Yihao Zheng

PII: S0272-8842(18)30853-8
DOI: https://doi.org/10.1016/j.ceramint.2018.03.278
Reference: CERI17915

To appear in: *Ceramics International*

Received date: 27 November 2017
Revised date: 7 March 2018
Accepted date: 31 March 2018

Cite this article as: Yao Liu, Beizhi Li, Chongjun Wu, Lingfei Kong and Yihao Zheng, Smoothed Particle Hydrodynamics Simulation and Experimental Analysis of SiC Ceramic Grinding Mechanism, *Ceramics International,* https://doi.org/10.1016/j.ceramint.2018.03.278

Smoothed Particle Hydrodynamics Simulation and Experimental Analysis of SiC Ceramic Grinding Mechanism

Yao Liu[1,2], Beizhi Li[1,*], Chongjun Wu[1], Lingfei Kong[2,3], Yihao Zheng[2]

[1]*Department of Mechanical engineering, Donghua University, Shanghai 201620, China*

[2]*Department of Mechanical engineering, University of Michigan, Ann Arbor, MI 201620, USA*

[3]*Department of Mechanical Engineering, Xi'an University of Technology, Xi'an710048, Shaanxi, China*

Abstract

Crack induced surface/subsurface damage in grinding limits the application of SiC ceramic in industry. A single-grain scratching simulation based on the smoothed particle hydrodynamics (SPH) has been employed to analyze the SiC grinding mechanism, including the material removal process, crack initiation and propagation, ground surface roughness, and scratching force. The simulation results show that the material removal process goes through the pure ductile mode, brittle assisted ductile mode, and brittle mode with stress increases as the depth of cut increases. The high wheel speed with high strain rate can elevate facture toughness of the SiC and promote the transformation of deep and narrow longitudinal crack in the subsurface into the shallow and wide transverse crack in the surface, which can prevent the subsurface damage. The critical depth of cut for ductile-brittle transition is about 0.35 μm based on the study of the ground surface crack condition, surface roughness, and maximum scratching force discrepancy in the SPH simulation. The SPH simulation results were indirectly verified by the cylindrical grinding experiments, which shows consistent the critical ductile-brittle transition undeformed chip thickness and similar trend of the ground surface, surface roughness, and grinding force with the SPH scratching simulation.

Keywords: SPH, SiC ceramic, Crack, Surface quality

1. Introduction

Brittle materials, such as engineering ceramic, glass, and silicon, are widely used in industry due to its low density, strong corrosion resistance, wear resistance, high temperature resistance, and excellent chemical inertness [1]. As one of the typical brittle material, SiC ceramic has been widely used in the aerospace, automation, cutting tools, and optical instrument [2]. However, the high hardness, high brittleness, and low fracture toughness of SiC ceramic may induce the surface quality deterioration in the manufacturing process, which is grinding generally. In the grinding, the SiC ceramic material is forced by the abrasive to deform and flow, no crack initiate and the material is removed in the ductile mode at a small depth of cut. When the depth of cut increases to larger than the critical value for crack initiation, the crack occurs and propagates to remove the material in brittle mode. The cracks remaining in surface/subsurface can destroy the strength and result in the failure of the SiC ceramic components in the application process [3, 4]. The technological challenge in SiC ceramic grinding is to achieve crack-free surface/subsurface, which needs to understand the SiC ceramic grinding mechanism.