Modeling of Thermal Barrier Coating Cutting Process Using Discrete Element Method

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ABSTRACT

In this study, the thermal barrier coating (TBCs) cutting process was studied using the discrete element method (DEM). The orthogonal cutting process has been selected to simulate the cutting process. During the cutting process, the coating layer fracture phenomena were simulated. The cutting force is maximum at the beginning of the cutting process, due to the first major piece of TBC broken off from the bulk. Coating fragmentations are in the form of a block, not a particle, which is consistent with the brittle nature of the ceramic coating material. The broken bond number increased with cutting time, due to the increased cutting process.

1. INTRODUCTION

Thermal barrier coatings (TBCs) made of low–thermal conductivity ceramics are being extensively used in hot sections of gas-turbine engines for aircraft propulsion, power generation, and marine propulsion [1]. TBCs provide thermal insulation to metallic substrate components from the hot gas stream. During gas turbine operations, TBCs damage may occur due to either time- and cycle-dependent degradation phenomena or external foreign object damage (FOD) or erosion. Therefore, components with the damaged TBC must either be repaired locally or globally or replaced during engine maintenance [2].

Although there are numerous efforts of developing a good practice of coating removal and repair processes, there is still an urgent need for a physics-based approach to understand the processes. Cutting is the most effective way to process ceramic materials. Different mathematical methods and material models are also used to study the cutting process. A finite element model (FEM) was established to explore the high-speed cutting mechanism. The optimal cutting parameters to achieve ductile cutting was analyzed [3]. If the cutting tool is pressed into the material internally perpendicularly, a “cutting” model can be used to deal with the cutting removal mechanism of nanostructured ceramic coatings. Cutting can be treated as a fracture mechanics process. The input energy is provided, at least in part, by a cutting tool. In terms of cracking, there are three types of cracks. One mode is the normal-opening mode, the other two