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Influences of Particle Impingement Angle and Velocity on Surface Roughness, Erosion Rate, and 3D Surface Morphology of Solid Particle Eroded Ti6Al4V Alloy

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In this study, it is aimed to investigate the effects of particle impingement angle and velocity on the surface roughness, erosion rate, and surface morphology of solid particle eroded Ti6Al4V alloy. Ti6Al4V samples were eroded in erosion test rig under various particle impingement angles (15°, 30°, 45°, 60°, 75° and 90°) and impingement velocities (33 m/s, 50 m/s, and 75 m/s) by using 120 mesh garnet erodent particles. Subsequently, erosion rates and surface roughness values of samples were analyzed and calculated as a function of particle impingement angle and velocity. Moreover, 3D surface morphologies of the eroded samples were prepared by using high definition scanner and image processing programs. Results show that erosion rates, surface roughness values and surface morphologies of Ti6Al4V alloy have been varied significantly depending on the both particle impingement angle and velocity. Erosion rates of Ti6Al4V alloy were decreased with increases in particle impingement angle; on the other hand, the surface roughness values were increased with increases in particle impingement angle. Both erosion rates and surface roughness values were increased with increases in particle impingement velocity. Finally, the surface morphologies of the eroded samples were evaluated deeply. It is concluded that the surface morphology variation of the Ti6Al4V alloy depending on the particle impingement angle and velocity were well correlated with the erosion rates and the surface roughness values.

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1. Introduction

Titanium alloys (specifically Ti6Al4V alloy) have been extensively used in aerospace applications due to their good mechanical, chemical and physical properties such as high strength to weight ratio, high toughness, low density, and high working temperature. Yet, they present relatively poor wear resistance owing to their poor tribological properties [1–5]. Titanium alloys used in aerospace applications (specifically turbine blades) exposed to sand/dust due to environmental conditions (especially dust/sand storms in deserts) are subjected to solid particle erosion.

Solid particle erosion is a process which occurs by progressive removal of material from the surfaces of the target material due to repeated impact of erodent particles [6–8]. It has been reported that solid particle erosion causes severe damages in various engineering applications [6–10]. Hence, many researchers have investigated the solid particle erosion behavior of various engineering materials for last decades [1–10]. The studies have specifically focused on aerospace applications due to vulnerability of aircraft structures working in dusty environments. It is understood that deterioration of the material properties due to solid particle erosion is inevitable, if the aircraft structures have to operate in dusty environments and exposed to the impact of the particles. Therefore, it is vitally important to examine solid particle erosion behavior of aircraft materials.

In this study, solid particle erosion behavior of Ti6Al4V alloy have been examined in detail by using various characterization methods. It is aimed to investigate the effects of the particle impingement angle and the velocity on the surface roughness, the erosion rate and the surface morphology of the solid particle eroded Ti6Al4V alloy.

2. Materials and methods

Ti6Al4V alloy used in this study was supplied by TIMET (Titanium & Medical & Mining Company, Turkey) in the form of 100 × 100 cm^2 sheets (thickness of 3 mm). The samples were cut to sheets of 40 × 40 mm^2 by using a guillotine shear. Chemical composition, mechanical and physical properties of the samples are given in Table I.

TABLE I

Chemical composition, mechanical and physical properties of Ti6Al4V samples.

Titanium alloy	Ti-6Al-4V
ASTM GRADE (UNS NO.)	Grade 5 (R56400)
Chemical composition (wt%) (max. values unless range is shown)	
0.08C; 0.25Fe; 0.05N; 0.20O; 5.50–6.75Al; 3.5–4.5V; 0.0150H	
Mechanical properties	
ultimate strength	896 MPa
yield strength	827 MPa
nominal hardness	33 HRC
Physical properties	
density	4.43 g/cm^3
melting point approximate	1650 °C

The erosion test rig used in this study and SEM photo of garnet particles used in this study are given in Fig. 1. Accelerated particles impacted the specimen, which can be hold at various impingement angles (15°–90°) by ad-