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Effect of Particle Impact Angle, Erodent Particle Size and Acceleration Pressure on the Solid Particle Erosion Behavior of 3003 Aluminum Alloy

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This study aims to examine solid particle erosion behavior of 3003 aluminum alloy. 3003 aluminum alloy samples were eroded in erosion test rig under various particle impingement angles (15°, 30°, 45° and 60°) and acceleration pressures (1.5, 3 and 4 bar) by using 80 mesh and 180 mesh sized erodent particles (garnet). The erosion rates of aluminum alloy samples were calculated depending on the erosion parameters. The erosion rates of the samples have varied dramatically depending on particle impingement angle, acceleration pressure and erodent particle size. The maximum erosion rates were observed at 15° impingement angles at all acceleration pressures and particle sizes. Moreover, erosion rates of the samples were increased with increases in acceleration pressure at all particle impingement angles and particle sizes. On the other hand, erosion rates of the samples decrease with increase in erodent particle sizes. Hence, maximum erosion was observed when the aluminum alloy eroded at 15° impingement angle and 4 bar pressure by using 180 mesh erodent particles. Finally, the eroded surfaces of the samples were analyzed by using scanning electron microscope. The surfaces of the samples were also investigated by using energy dispersive X-ray analysis in scanning electron microscopy studies. Microcutting and microploughing erosion mechanisms were observed at 15° and 30° impingement angles, while deep cavities and valleys formed due to plastic deformation were observed at 45° and 60° impingement angles. Moreover, embedded erodent particles were clearly detected on the surfaces of the samples by energy dispersive X-ray analysis.

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1. Introduction

3003 aluminum alloys have been widely used in many engineering fields due to its relatively low cost, high strength to weight ratio, and high corrosion resistance. They have been replacing conventional materials specifically in automotive industry due to their superior specific properties [1–4]. Solid particle erosion is a process which occurs by progressive removal of material from surfaces of the target material due to repeated impact of erodent particles [5–7]. It has been reported that solid particle erosion causes to damages in various engineering applications specifically in aircraft applications. However, it has been reported that it also plays an important role in automotive applications [8].

Solid particle erosion is a complex process which is affected by many parameters. In literature, researchers have reported that operational parameters such as particle impingement angle, velocity and particle size plays a crucial role on the solid particle erosion behavior of materials [5–7]. Hence, in this study solid particle erosion behavior of 3003 aluminum alloy have been investigated depending on particle impingement angle, acceleration pressure, and erodent particle size. It is aimed to examine the effects of these parameters on the solid particle erosion behavior of aluminum alloys.

2. Materials and methods

3003 aluminum alloy used in this study was supplied by ASSAN Alüminyum (Aluminum Company, Turkey) in the form of 300×200 mm^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 3003 alloy samples are given in Table I.

TABLE I

Chemical composition, mechanical and physical properties of 3003 samples.

Aluminum alloy	3003 H 14
BS EN 485-2:2004	Alloy EN AW-3003 [Al Mn1Cu]
Chemical composition (max. values) [wt%]	
Cu 0.20, Fe 0.70, Si 0.60, Mn 1.50, Mg 0.05, Cr 0.05, Zn 0.10, Ti 0.050	
Mechanical properties	
tensile strength ultimate	152 MPa
tensile strength yield	145 MPa
modulus of elasticity	68.9 GPa
hardness brinell	40
Physical properties	
density	2.73 g/cm^3

The erosion test rig used in this study is illustrated in Fig. 1. SEM photos of garnet particles used in this study are given in Fig. 2. Accelerated particles impacted the specimen, which can be hold at various impingement angles (15°–60°) by adjustable sample holder shown in Fig. 1. Solid particle erosion test parameters are given in Table II.

Moreover, to characterize the morphology of eroded surfaces and to understand material removing mecha-