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The Evaluation of Solid Particle Erosion in Polymethyl Methacrylate by Surface Topography Mapping

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The present work introduces and demonstrates a novel high resolution surface topography method for mapping the distribution of erosive wear in polymethyl methacrylate. The technique is based on grayvalues obtained from eroded sample surfaces and three-dimensional surface topography mapping from these grayvalues. Surface topography maps make it a valuable method for fundamental studies on erosive wear. In the present investigation, a flatbed scanner system has been used for obtaining the surface images of eroded test samples. Polymethyl methacrylate test samples eroded with 80 and 120 mesh alumina particles at 1.5 and 3 bar blast pressures and their surface topography maps compared. Erosive wear is difficult to visualize for its dynamic and complex nature, hence monitoring of erosive wear in industrial applications is rather important. High resolution surface topography method detail capturing capability may improve tribological surface damage characterization of real machine elements. Reduced costs and simplicity two primary outcomes of using a simple flatbed scanner system in non destructive testing of erosive wear.

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1. Introduction

Polymethyl methacrylate (PMMA) is a transparent thermoplastic, often used as a lightweight or shatter-resistant alternative to glass. High transparency characteristic of PMMA makes it a valuable engineering material nowadays and is used in the lenses of exterior lights of automobiles, viewing ports of submersibles and in aircraft as passanger windows or windshields. Especially primary surfaces such as aircraft windshields exposed to impingement of high speed solid particles, they may lose their mechanical and optical transparency properties. The loss of transparency in an aircraft windshield has a crucial effect on outside visibility and flight safety.

Erosive wear of materials occurs by removal of target material from impact zone, due to repeated impacts of erodent, by a micromechanical deformation/fracture process [1–3]. Solid particle erosion phenomenon has a complex characteristic, therefore it is crucial to visualize the damage on target materials surface for evaluation of damage mode. Researchers have been working on developing novel methods for material wear characterization for many years. They have attempted to take advantage of image analysis methods in order to achieve their goals. Nowadays, flatbed scanners, digital cameras and optical microscopes are used as attractive devices in order to set up an image analysis system by researchers [4, 5]. In this study, solid particle erosion behavior of PMMA has been examined in detail by using a novel surface analysis method in order to figure out the effect of abrasive particle size and blast pressure. To achieve this goal, grayvalues were obtained from high resolution scanned images of eroded PMMA samples. It is aimed to visualize the surface topography of eroded PMMA as 3D rendered view.

2. Materials and methods

PMMA sheets commercially named Altuglas CN with a nominal thickness of 10 mm were selected as test materials. The test specimens are prepared in 30 mm × 20 mm by cutting out from PMMA sheets of 200 mm × 200 mm. Table I gives the mechanical and optical properties of PMMA test samples, according to the manufacturer's declaration.

TABLE I

Mechanical and optical properties of PMMA samples.

Mechanical properties	Test method	Units	Value
density	DIN53479		1.19
Poisson ratio to 20 °C			0.39
hardness, shore scale M	ASTM D 785		100
Optical properties	Test method	Units	Value
light transmittance	DIN5036	%	92
refractive index	DIN53491		1.492

The erosion test rig used in this study is illustrated in Fig. 1. Accelerated particles impacted the specimen, which can be hold at various impingement angles (15°–90°) by adjustable sample holder shown in Fig. 1. Solid particle erosion test parameters are given in Table II.

To capture the image of PMMA test specimens, HP Scanjet G2710 flatbed scanner is used. The scanner comprises an opaque cover to hold the subject on top of the glass pane, an illumination source, CCD sensors and software solutions for image processing. The sample to be scanned is placed face down on the glass, the opaque cover is lowered over it to exclude ambient light. The sensor array and light source move across the pane by carriage, reading the entire area. Scanning parameters of PMMA samples and HP Scanjet G2710 flatbed photo