Residual mechanical properties of carbon/polyphenylenesulphide composites after solid particle erosion

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Abstract

The objective of the study is to investigate the residual mechanical properties of cross-ply carbon fibre reinforced polyphenylenesulphide (C-PPS) composites after particle erosion. Angular silica sand particles with the size of 150–200 μm are driven by a static pressure of 1.5, 3 and 4.5 bar and are accelerated along a 50 mm long ceramic nozzle of 5 mm diameter at room temperature. The average velocity of the silica sand at these pressures at the nozzle tip was measured as 20, 40 and 60 m/s with respect to the air pressure. Composite samples clamped on to the specimen holder. The samples on specimen holder were subjected to particle flow at impingement angles between 15° and 90°. Erodent mass flow was measured as 4.25, 6.25 and 9 g/s for average velocities of 20, 40 and 60 m/s, respectively. Wear rates were measured by means of weight loss with an electronic balance with an accuracy of 0.1 mg after 2–30 s of particle erosion. The impingement angle was found to have a significant influence on erosion rate. Composite material showed semi-ductile erosion behaviour, with a maximum erosion rate at impingement angle of 45°. The morphology of eroded surfaces was examined by using scanning electron microscope (SEM). Possible erosion mechanisms were discussed. The erosion behaviour was not only considered as a material loss but also as exposing of repeated impacts by means of particles. Great differences were observed between the initial and post-erosion flexural strength of the material. It was concluded that the minimum residual strength values were determined for the samples eroded at impingement angle of 45°. Also the samples are found having lower residual flexural properties at higher impingement angles.

1. Introduction

Polymer composites have been used for a long time with an increased demand in various engineering fields, particularly in aerospace applications, due to their high specific mechanical properties as compared to the other conventional materials. Also these composites are finding further applications that subjected to solid particle erosion. Examples of such applications can be summarized as; pipe line carrying sand slurries in petroleum refining, helicopter rotor blades, pump impeller blades, high speed vehicles and aircraft operating in desert environments, water turbines, aircraft engine blades, etc. [1–3].

The most important factors influencing the erosion rate of the composite materials can be summarized under four categories. (1) The properties of the target materials (matrix material properties and morphology, reinforcements type, amount and orientation, interface properties between the matrices and reinforcements, etc.). (2) Environment and testing conditions (temperature, chemical interaction of erodent with the target). (3) Operating parameters (angle of impingement, impinging velocity, particle flux – mass per unit time – etc.). (4) The properties of the erodent (size, shape, type, hardness, etc.) [1,3,4]. Evaluation of the particle erosion behaviour of any polymer composite is not easy,