The Scratch Behavior of Accelerated Aged Carbon Fiber Reinforced Epoxy Matrix Composite

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This paper deals with the effect of accelerated aging on the scratch behavior of carbon/epoxy composites. Carbon/epoxy composite is one the most important type used in aircraft structural parts and exposed to drastic service conditions under various temperatures resulted with scratch damage. Four different type of accelerated aging procedure applied and scratch behavior of carbon/epoxy composites were evaluated using coefficient of friction and penetration depth. Scratch damage morphologies of both original and accelerated aged samples were determined by optical and scanning electron microscope.

INTRODUCTION

One of the most outstanding thermosetting resins used in aviation industry is epoxy because of several superior characteristics. Moreover, using reinforcements together with epoxy; improvement of load-bearing, mechanical strength, resistance to wear, and thermal properties can be achieved. Furthermore, some interactions such as processing, easy mixing and wettability between epoxy and reinforcing fibers make it preferable in aviation composite manufacturing [1]. The percentage of using carbon fiber/epoxy composites in aviation industry is increasing nowadays because of their flexibility in design without losing their specific mechanical performance [2]. However, it is evident from the literature that polymer–matrix composites (PMCs) which are used, for example, as aeronautical engineering structures and in other industrial applications may be generally subjected and exposed, in its service life, to different environments usually involving humidity, temperature and mechanical stress [3, 4]. This may affect essentially the mechanical performance of aircraft composite parts and reduce their lifetime. These composites are much more easily damaged in service, for example, by mechanical impacts [5]. Table 1 lists the major sources of service damages by mechanical impacts.

The risk presented by desert and semi-desert areas depend on where they are situated geographically, and whether the aircraft is operating from the area, or is merely stored there. The sand and dust cause erosion and, together with oil and grease, form abrasive mixtures that adhere to surfaces [6]. Abrasive mixture consists of oil and dust particles can penetrate through the surface of carbon fiber-reinforced polymers and decrease the structural integrity by means of matrix damage and fiber breakage. For example, repeated impacts of abrasive particles on the surface of carbon fiber-reinforced aviation composite can cause structural damage [7]. Moreover, scratches occurred as a result of abrasive particles hitting on the surface of aircraft composite at various speeds during service operations such as paint removal or surface preparation can decrease the mechanical strength of composite. Skin defects started with scratches can be followed by delamination and induce interlaminar stresses [8]. Sliding motion of composite structure on a rough surface cause serious damage on load-carrying capacity due to scratches on the surface. Main sources of scratches on an aircraft composite structure are de-icing operations, fueling, cargo operations or interactions with other ground vehicles [8]. Various studies were determined about the decrease of wear resistance due to scratch damage in composites [9–11]. However, understanding scratch damage mechanisms of an aviation carbon reinforced composite at real service conditions and the effect of accelerated aging on scratch resistance has not been reported in detail yet.

Polymer matrix composites are key candidates for the structural components of proposed supersonic transport aircraft. The usage of composites is increasing for primary aircraft structures: the Boeing 777 airframe is about 10% composite (compared to only 3% for the 767) while the F-22 airframe is 30% composite. Future applications are proposing extensive use of composite materials to meet demanding performance requirements. Examples include gas turbine engine structures, reusable launch vehicles (such as the X-33) and supersonic commercial