DESIGN, ANALYSIS, MANUFACTURE, AND TEST OF A CONTINUOUS FIBER REINFORCED THERMOPLASTIC STRINGER WITH LOCAL REINFORCEMENTS

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1. ABSTRACT

Recent developments in the rapid processing of continuous fiber reinforced thermoplastics (CFRTs) allow for the manufacture of structural components to meet cost, performance, and production volume requirements. Compared to thermoset composites CFRTs offer rapid processing cycles, excellent compression after impact, high fracture toughness, improved environmental resistance, improved recyclability, low storage cost, and infinite shelf life. This work describes the design, manufacture, and test of AS4/PEEK stringers. Stringer design includes management of concentrated loads at airframe interfaces through local padup reinforcements within the stringer layup. Padups consist of one or more additional plies of unidirectional material that are strategically placed. The stringer design is further optimized for minimal weight using finite-element analysis and closed form calculations. Fabrication of the stringers includes automated layup of unidirectional prepreg tape into multi-angle laminates with padups, consolidation of the layup to create a solid multi-thickness laminate, stamp-forming the laminate into a final 3D profile, and final trimming. The stringers are tested to validate finite element models. Case study results show a 46% weight savings using local reinforcement padups, compared to a uniform stringer thickness.

2. INTRODUCTION

Continuous fiber reinforced thermoplastics (CFRTs) have long held potential for mass-producing lightweight structural parts. Compared to thermoset composites, CFRTs offer excellent compression after impact (CAI, Figure 1) [1], fracture toughness (Figure 1) [1], improved environmental resistance, recyclability, low storage cost, extensive shelf life, and relatively short processing cycles. Based on these attributes, CFRTs are increasingly being used in aerospace applications. For example, the Gulfstream G650 business jet rudder and elevators utilize CF/PPS thermoplastics [2]. The A340-500/600 and A380 contain 1 ton and 4 tons, respectively, of CFRTs [3] and the Airbus A400M cargo aircraft floor assembly consists of CF/PEEK C-shaped beams and flat panels [4]. Likewise, the extensive use of composites on the Boeing 787 and Airbus A350XWB fuselages has prompted the creation of large numbers of thermoplastic brackets, clips and cleats [5]. There is continued and growing interest in aerospace CFRT parts such as door panels, ribs, stiffeners, brackets, aerodynamic fairings, helmets, trays, and corrugated shapes, among others which are currently manufactured from thermoset composites

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