

FAILURE MODE EFFECT ANALYSIS OF COMPOSITES PREPREG MANUFACTURING PROCESS FOR AIRWORTHINESS CERTIFICATION - A CASE STUDY

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Abstract

Airworthiness certification of aircraft structures requires a holistic approach ranging from material manufacturing process to design evaluation of airframe components. Present day airframe structures find greater applications of composite materials owing to their extraordinary mechanical properties on pro rata weight basis. In case of polymer based composites, the prepreg form of material is preferred for several applications due to matrix efficiency (high fiber-to-volume ratio) and ease of application. As part of composite material certification, the design audit of composite prepreg manufacturing process is carried out to assess the possible failure scenarios. Manufacturing Process Design and Control plays a significant role in satisfactory realization of composite parts right from raw material stage. Process variability/ scatter can lead to large variation in performance of the final product and thus stringent control of process parameters is essential to achieve aero-grade composite structures. This study provides basic understanding of composite prepreg manufacturing process and application of FMEA as a process design tool to detect and assess potential failures with an aim to devise preventive measures for improved process control. The complete process of manufacturing prepreps is divided into three stages viz.: Fabric weaving, Resin formulation and Prepregging operation. FMEA principles are used to identify the predominantly vulnerable operations and to quantify the inherent risk associated. Risk Priority Numbers (RPN) are evaluated for various operations in these three stages. Based on process technology and engineering expertise, suitable corrective and preventive measures are offered according to the potential risk factors and failure types. Emphasis is to prioritize the efforts and attention towards major preventive measures by targeting the least number of factors causing the maximum impact for failures (Pareto principle). Present study substantiates the significance of trained personnel, proper documentation of operating procedures and work instructions along with contamination control as critical factors in eliminating failures in composite prepreg manufacturing process.

Keywords: Airworthiness, Certification, Composites, FMEA, Manufacturing Prepreg, Pareto Analysis