Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure
Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid
Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1

PAPER REF: 7313

RELIABILITY SYSTEM ANALYSIS FOR AIRCRAFT COMPOSITE STRUCTURES

Paola Caracciolo(*)
Airbus Industries, Germany
(*)*Email:* paola.caracciolo@airbus.com

ABSTRACT

The aim of the paper is to bring in a system the variability of materials to create a better understanding and management of safety, risk and reliability of aircraft composite structures. The uncertainty of the structures in engineering, material and environmental engineering will be addressed.

Keywords: system analysis, events, material property, composite structures.

INTRODUCTION

A probabilistic interpretation, of the uncertainties parameters as allowable, impact, environment and moisture effects, helps to reduce incorrect assumptions penalizing the performance of composite materials. The analysis needs to be done using probabilistic approach; it is not possible to do with traditional deterministic methodologies. In the design phase of an aircraft the variability of uncertainties is firstly neglected but successively covered using safety and knock down factors, in order to avoid a failure before ultimate load at service condition. Here the question arises: "How are considered, in the deterministic and probabilistic methods, the uncertainties?"

In general, the uncertainties are characterized by the PDFs, in the probabilistic approach and in the deterministic analysis with safety factors. The main factor to cover most of the uncertainties, that will affect the strength of a structure, is a called "safety factor", and additional knock down factors are used to cover others lack of knowledge. The safety factor, defined in 1930, includes unknown uncertainties and approximations in deterministic analysis (FAA, 1999). The availability of the sources of knowledge can be used to define the statistical representation of variables PDFs. In general, the allowable of the materials represents respectively the 1% and the 10% of the entire data under the probability distribution function with 99% and 90% probability (percentile) of occurrence. The likelihood of material property, environmental condition and ageing are defined with statistical characterization with 95% confidence intervals and the reliability is defined considering the system process. The analysis is done in a stepwise process: definition of events, characterization, quantification and propagation of uncertainties, identification of failure modes under loading conditions to the end evaluation of the failure probability. The probabilistic analysis remains to formulate expressions defining the stress/load on the structure and the resistance to strength/ applied load of the structure.

The uncertainty propagation method is a powerful tool for screening. A system to propagate the uncertainties stochastically, across a chain of coupled analysis can be used to describe the structural problem of failure events. In the present work only some events are considered in the reliability analysis.

RESULTS AND CONCLUSIONS

The problem is addressed to optimize the damage tolerance concept, with a given confidence levels. In a generic method, the allowable are defined considering the lower test 10% where 90% confidence interval will not be breached. The analysis is determined including the external loads, and calculated probabilistic failure using the allowable. In Figure 1 different coefficient of variation (CV) versus the Pf shown the influence of the CV and the deterministic value (Pf=1E-9) represented in bold.

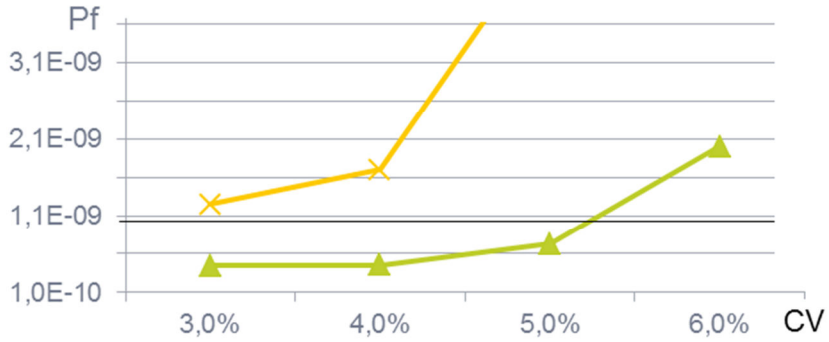

Fig. 1 - Comparison of the Pf with different CV

In the approach the values do not exceed 90% confidence level. It is the reason why additional tests sometimes cannot improve/change the allowable. In fact, in a deterministic analysis, the results are not influenced of the CV the value is defined a priori.

An improvement in the production of the composite and a reduction of defect could help to improve the allowable respecting the safety requirements. A main part of the paper was to evaluate the failure probability and the integrity of a structure, which is not possible with the deterministic way. The study and the hypothesis give's a decision-making to eliminate the knock down and environmental factors.

These worst case assumptions demonstrate to lead to an excessively conservative design. The benefit of probabilistic analysis is the information gained in understanding the interactions, effects, and sensitivities of design variables. The application of the proposed method can help the conservative and arbitrary assumption hidden in the general deterministic approach.

This methodology can be extended to optimize testing for various purposes, and highlight the need to tighten/relax manufacturing tolerances.

REFERENCES

[1] FAA, Analysis of Static certification for composite strucutres, DOC/FAA/AR-99/2 June, 1999.

[2] J. Rouchon, Certification of Aircraft Composite Structures. EUROSAE, 2007.

[3] P. Caracciolo, G. Kuhlmann, Reliability Analysis in Bolted Composite Joints with Shimming material, ICAS Hamburg, (2006).