Environmental Conditioning of Polymer Composites for Aerospace and Non-Aerospace Applications

M. Sendil Murugan*, A. Revathi, S. Navaneetha, Shylaja Srihari and D.V. Venkatasubramanyam
FRP Division, National Aerospace Laboratories (CSIR), Bangalore-560017, INDIA
E-mail: *senthil@nal.res.in

ABSTRACT

Environmental conditioning of polymer composites involves subjecting these material to different conditions like Temperature, Humidity, Altitude, Rain, Fungus, Dust, Salt etc to asses their performance demanded by an application. A conditioning process that simulates the real aging (natural weathering) requires months or even years, which is experimentally unacceptable. Therefore accelerated aging methods have been developed that takes several days or a few weeks. During exposure to various conditions like Thermal Shock, Humidity/Temperature or the combined effect of Altitude, Temperature and Humidity (CATH), the material properties will be affected. This is due to the effect of absorbed moisture in those conditions. This paper brings out the details of qualification tests carried out on prototype Radomes (4Nos) of military Aircraft and representative specimens after painting with an antistatic anti rain erosion paint as per the RCMA approved QTP under the CRI inspection. Some information on the unique Environmental Test Facility available at FRP Division, NAL are also presented. Environmental tests on variety of components (both structural and electronics type of applications) for end user community ranging from inhouse, inter division (ALD, STTD and ACD), premier Defense Establishment (ADRDE, SAC and ADA), public sector units (HAL and BEL) to private industries (Flow tech, SLN Technologies Pvt. Ltd., FLIC Microwave Pvt. Ltd., Spectrum Info Tech Pvt. Ltd., and Data Pattern (India) Pvt. Ltd.).

Keywords: *Polymer, Composites, Environmental, Qualification, Radome, Military, Aircraft.*

1. INTRODUCTION

Polymer composites which are widely used in the aerospace and non aerospace applications having light weight, high strength, cost savings, superior chemical and impact behavior when compared to metal. In order to qualify any material which are used in the above said applications its performance must be assessed not only in terms of mechanical, electrical and chemical properties at normal ambient conditions but also on the effect of harsh and severe service conditions which the component as a whole will experience during its service life. A given property such as strength can some times decline slowly during service life or can be fairly stable for a long time but fall suddenly with no warning before fracture occurs. Thus it is difficult to predict the time scale of environmental degradation. When the composite materials are exposed to environmental condition (Temperature, Humidity, Altitude), which will absorb the moisture to various degree. The absorbed moisture can cause the physical and mechanical properties and therefore long term durability of polymer matrix composites. The absorbed moisture also interfaces the degradation or fracture of the composite material. This degradation interface considerable loss in these properties decreasing the safety of the airborne structures made out of it. To use the full potential of composite material their performance during and after exposure to environmental conditions should me known. Consideration of these problems should lead to the selection of the best possible materials and the best possible design. It is not just a question of avoiding catastrophic failure, but of predicting useful product

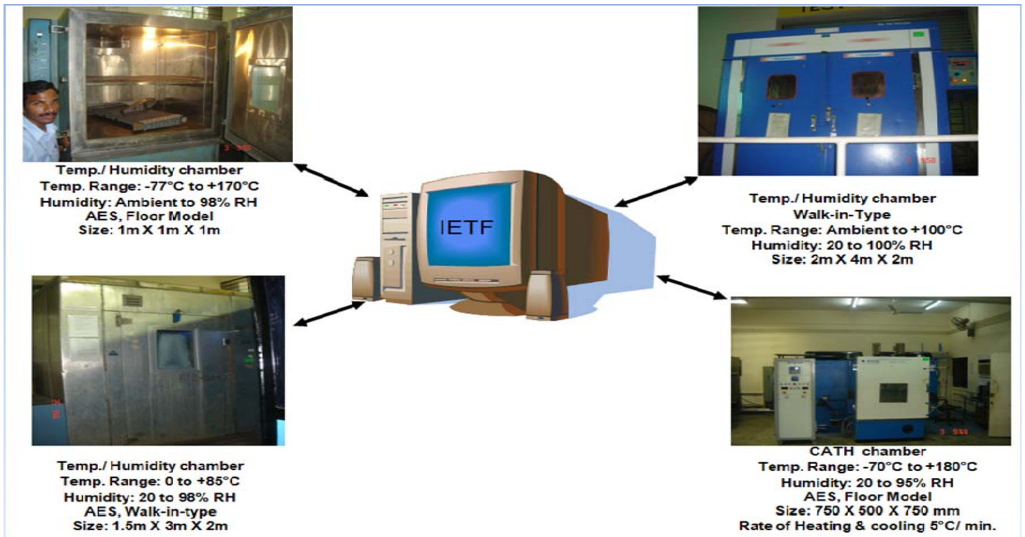

Fig. 1: Unified Computer Facility

lifetimes so as to be able to estimate the true cost effectiveness of these alternative materials. This paper highlights the Environmental Qualification and Certification aspects of indigenously developed radomes for a military Aircraft for Indian Navy.

2. ENVIRONMENTAL TEST FACILITY

The FRP Division over the last three decades carried out extensive R&D Studies and established a unique Environmental Test Facility (ETF). This facility contains different types of simulation chambers which are running round the clock for conditioning of components of inhouse/sponsored projects and Adhoc services. These chambers are interfaced with personal computer through RS232 & 485 converters to monitor their performance. Each chamber is dedicated highly sophisticated microprocessor based programmable controller (Three loops) with user friendly software to control heating, cooling, humidity and vacuum.

A Centralized Computer Controlled Environmental Test Facility is shown in the Fig. 1.

3. EXPERIMENTAL DETAILS

3.1 Radome Features

The fairing (Radome) is a cylindrical dome of 73 mm ID × 102 mm length and is concentric with the antennae with a radial clearance of 0.5 mm. The fairing is fabricated out of Quartz fibre reinforced plastic (QFRP) with C14 epoxy resin system. While the radome's thickness in the electromagnetic window region is 0.85 mm (5 layers of 0.17 mm nominal thickness) the attachment area of the fairing to the bracket is provided with 4.6 mm thickness.

3.2 Material and Fabrication Method

The composite material system used is a high temperature cure resin C-14/hardener K-68 , supplied by M/s. Atul Limited, Gujarath and quartz fabric supplied by M/s. Saint Gobain Qartz S.A., France. Radomes were fabricated by Resin Injection technique and subjected to the cure schedule mentioned in the QTP. The radome is painted with CAAPCOAT Rain Erosion paint of room temperature curing qualified to MIL-C-83231A, Type II, Class A, Composition I to yield a coating thickness of 0.20 to 0.25.

3.3 Qualification Tests

The following tests were conducted on painted 1^{st} radome. Test procedure was as per MIL-STD-810F.

Vibration—Both sinusoidal and random, Mechanical shock, Acceleration.

The following tests were conducted on painted 2^{nd} radome. Test procedure was as per MIL-STD-810F.

High Temperature (120°C/8 Hrs), Thermal Shock (–54°C/1hr and +120°C/1 hr), CATH (Temp: –54°C to +90°C, Humidity: 85% to 95%, Altitude: 11 KM),

(a) High Temperature Test FRPD, NAL

(b) Rain Erosion Test IICT, Hyderabad

(c) Surface Resistivity Test FRPD, NAL

(d) Peel Strength Test FRPD, NAL

(e) Transit Drop Test FRPD, NAL

Fig. 2: Test Facilities at Various Institutes

Humidity (Temp: 30°C to 60°C, Humidity: 85% to 95%), Sand and dust (Temp: 50°C/6 hrs), Transit drop and bench handling (26 drops at a height of 48inches and 4 drops at a height of 4inch at 45° angle).

The following tests were conducted on painted representative specimen. Test procedure was as per MIL-STD-810F, Salt fog (5% salt solution, 24 hrs exposure, drying 24 hrs at temp: 35°C, RH: 90–95%), Fungus (28 days exposure at 29°C/95% RH, condition), Solar radiation (24 hrs exposure at 1.2 KW/m^2), Fluid Contamination test (expose to engine oil at 70°C/8hrs), The following tests were conducted on painted radome sample piece. Test procedure was as per SAE AMS –C-83231A. Rain Erosion (rainfall of 1 inch/hour, droplet size 2 mm, duration: 150 minutes), Peel Strength (not less than 1126 N/m) Surface resistivity (within the range of 0.5–15 mega ohm).

Physical examination and VSWR characteristic measurements were carried out before and after completion of each environmental test. The above tests were carried out at test facilities available at NAL as well as external agencies identified *viz.*, BEL, LRDE, CQAL at Bangalore and IICT Hyderabad. Some highlights of qualification tests carried out at FRPD, NAL and other external agencies were shown in the Fig. 2.

4. CONCLUSIONS

The Radome passed all the environmental tests and paint remained intact, after all the environmental tests. No Physical deterioration of radome was observed after all the tests.

REFERENCES

[1] Qualification Test Procedure (QTP) for TDF Antenna Fairings (Radomes) of TU–142 M Aircraft, Document No. SP 0410, Issue No. 3, Part No. TDF R-01, January 2005.

[2] Qualification Test Report (QTR) for TDF Antenna Fairings (Radomes) of TU–142 M Aircraft, Document No. SP 0516, Issue No. 1, Part No. TDF R-01, August 2005.