

MANUFACTURING PROCESSES OF POLYMER MATRIX COMPOSITE MATERIAL FOR AEROSPACE APPLICATION

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Abstract

The paper focuses extensive use of composites in aerospace application in general and missile programme in particular. In missile programme, namely Trishul, Akash, Nag, Prithvi and in the technology demonstrator Agni, composites have been used for structural, thermostructural, thermal, electromagnetic launch tubes and containers.

Introduction

Composite is an important player in aerospace application especially in the Missile application. In Missile Programme composites have been used for structural, thermostructural, thermal (ablative), electromagnetic launch tubes and containers.

While informing public of the nation, who is familiar with this programme covering 4 weapon systems and 1 technology demonstrator? Trishul missile, Akash - surface to air missile, Nag - Anti Tank missile and Prithvi - surface to surface missile are the weapon systems of our programmes and Agni is the technology demonstrator. In all these 5 missiles, composites are extensively used.

Composites are used in the entire re-entry vehicle structure and also in Agni, the technological demonstrator. In Agni thermo structural components used are different types of composites. The nose cone is made of Carbon-Carbon which is capable of withstanding high re-entry temperature above 2000 K. The other structural components are made of carbon roving epoxy resin and external carbon roving and phenolic resin and filament winding with carbon tow. Control surfaces are made of carbon fabric phenolic prepreps. These also are capable of withstanding little lower temperature around 1200-1300 K.

In Akash, the nose cone radome and composite ablative liner for the booster and sustainer of Ram rocket engine is used.

In the Nag missile, structural part is entirely made out of composites, the various composite parts are made of E-glass roving, CNC filament wound structural components. Straight liner, silica phenolic moulded in autoclave moulding, machined,

bonded and used for ablation. The launch tube of Nag is CNC filament wound E-glass rovings.

Trishul and Prithvi also use various composites hardware.

Prithvi uses composites for Radome which are made from E-glass contour woven socks with phenolic resin and autoclave cured with match die tooling. Composite is also used in the payload section for TAB encasement.

For the launch system a light weight flame deflector using carbon material is being developed. For Trishul Radome, E-glass socks with epoxy resins and over cured method is followed. The ablative systems of Trishul uses ablative liner for rocket motor cases which uses silica phenolic prepregs and subsequently bonded and cured by lay-up in an autoclave.

In order to realise the numerous products in various missiles important state-of-the art technologies had been established and used. One such technology is CNC Filament Winding technology. It required development of Geodesic Filament Winding programme because of its heat shield shape consisting of a cylinder and frustrum of cone. End domes built with sand and PVA ensures continuation of Geodesic path universal of the opens. The winding programme was established using the Tech in and play back technique.

Trishul rocket motor case does not have a full diameter opening and hence the lay-up is to be made in-situ. The lay-up utilises vacuum bag and cured in autoclave.

Resin Transfer Moulding (RTM) :

Process

In RTM process, premixed liquid resin matrix will be introduced into the 'dry reinforcement which are held in the cavity of a matched-die-mould using RTM machine.

Advantages

1. Less cycle time.
2. Good control over resin content.
3. Resin spread out will be uniform.

Components

1. Nose cones/radomes.
2. Laminates with variable resin volume fraction.
3. Repair of rocket motor casings (Akash) by filling the debonded area with liquid resin matrix.

It is the resin transfer moulding technology commonly used for intricate components with mould bonding in-situ in a single shot.

Using this technology, the missile nose cones work as radomes.

A large variety of components of ablative category are prefabricated and bonded to the rocket motor cases, in head-end and nozzle-end regions. The process is inexpensive and utilises a hydraulic press of suitable capacity and matched-die mould with heating arrangements. The raw material used is a glass phenolic.

Press moulding technology has also been used for making the re-entry control surfaces of Agni. It uses a carbon phenolic cloth prepreg and a matched-die-mould used in conjunction of hydraulic press, the component has got complex aerodynamic configuration.

The composite products for missile application fall into 3 broad categories namely : (1) structural products (2) electromagnetic products and (3) ablative products, a specific case of a re-entry which is a thermo-structural item. The re-entry structure used in Agni missile, is in 5 different sections joined together with a nose tip. Each of the sections has a carbon epoxy structural shell surrounded by a carbon phenolic ablative shell of suitable thicknesses designed to withstand the thermo-structural loads predicted. The nose-tip is made from high temperature composites i.e. carbon-carbon composites. CNC Filament Winding with 4-axis control facility is used at CPDC for manufacturing of Nag airframe shells 300mm diameter; 3m in length.

The laboratory has a material testing system of the Instron capacity with a computer aided testing software. It has capability of statistical analysis. This 3 D measuring machine of Carl Zeiss wahe model No1 WMM 800 which has resolution of 1.

Through transmission ultrasonic technique with dry couplant method is used to indicate cumulative defects. Further analysis, if needed, is done by radiography and pulse echo techniques.

Carbon - Carbon Brake disc has been developed and has gone through qualification testing.

Societal Mission

As a spin off from the above technologies, some developmental activities have been taken up for

- a. Wind Turbine generator blade for M.N.Es
- b. Standard Modular F.R.O for Polio affected patients as a joint programme of DST & MOW.