PROCESS OPTIMIZATION OF FRP SANDWICH COMPOSITE STRUCTURE FOR ENGINEERING APPLICATION

SATYA RANJAN DAS, SANJAY CHOUDHRY, VIJAI KUMAR

Central Institute of Plastics Engineering & Technology, Lucknow (U.P.) India
Email: satyaranjands@yahoo.co.in

Abstract- "Composites are the combination of a reinforcement fibre in a thermoset polymer resin matrix, where the reinforcement has an aspect ratio that enables the transfer of loads between fibres, and the fibres are chemically bonded to the resin matrix." FRP (fibre reinforced plastic) Sandwich structure are defined as a three layer type of construction a thick layer known as core and two thin polymer layer known as face . In automobile and aerospace industries FRP composites are used due to numerous advantage like mechanical, chemical, thermal properties and light weight. The mechanical, thermal chemical properties can be optimize by stabilizing the core[1][2]. For this study various raw material characterization done .Aluminium honeycomb used as a Core material (25mm thick) and Epoxy prepreg (layer used as a face sheet material) & PU foam provide housing for core [5]. The experiment conducted according to raw material characterization test report . by autoclave curing At a particular temperature, pressure ,vacuum with respect to time process optimized ,sandwich cured and stabilized. Finally the test conducted According to ASTMD & DIN standard as a result it shows that the stabilized FRP sandwich having excellent mechanical properties compare to core crushing FRP sandwich.

Key words : *FRP Sandwich, Prepreg , Epoxy base adhesive, Core*

INTRODUCTION:

The unrelenting passion of the aerospace & automobile industry to enhance the performance of commercial vehicles & military aircraft is constantly driving the development of improved high performance FRP sandwich composite structure. Composite materials are one such class of materials that play a significant role in current and future aerospace & automobile components. Composite materials are particularly attractive to aviation and aerospace applications because of their exceptional strength and stiffness-to-density ratios and superior mechanical, chemical ,thermal properties. Fibre Reinforced Polymer composite sandwich structure (FRPCSS) formed with the help of fibres, resin, core are bonded together are being referred to as the materials of 21st century because of many advantages. The advantages of FRP sandwich structure over traditional materials are: (1) Superior thermo-mechanical properties such as high strength and stiffness (2) Light weight, (3) Excellent corrosion resistance, (4) magnetic transparency (5) Tailor ability (6) long-term durability under different service environments. Composites can be five times stronger, two to three times stiffer etc, and three to four times lighter than metals such as . In addition, composites are dimensionally stable and lower maintenance than the conventional materials. Composites are a combination of a reinforcement fibre in a thermoset polymer resin matrix, where the reinforcement has an aspect ratio that enables the transfer of loads between fibres, and the fibres are chemically bonded to the resin matrix[7].Composite materials used in commercial aeroplanes typically are produced by combining layers of carbon or glass fibres with epoxy. In recent years, the use of composites expanded to different parts of the aircraft because these materials are typically lighter and more resistant to corrosion than are the metallic materials that have traditionally been used in airplanes

2. EXPERIMENT DETAILS:

2.1 Raw Materials

The FRP composite matrix are epoxy carbon prepreg (G801) and epoxy glass prepreg (Glass 120) manufacture by M/s Les Avenieres, France and marketed by M/s Hexcel, USA .The thermal properties of prepreg are given in Table 1.the epoxy base adhesive Grade FM 73 and Grade FM 490A manufacture and marketed by M/s Cytec engineering material, Arizona. The thermal properties of epoxy base adhesive are given Table 1.

Table 1 : Thermal Characterization Properties of Raw material

Sl. No	**Raw material**	**Onset Temp(°C)**	**Peak Temp(°C)**
1	Epoxy Carbon prepreg Grade G801	141.70	154.23
2	Epoxy glass prepreg Grade Glass 120	143.52	154.44
3	Epoxy base adhesive Grade FM73	123.53	154.63
4	Epoxy base Adhesive Grade FM 490A	140.63	153.39

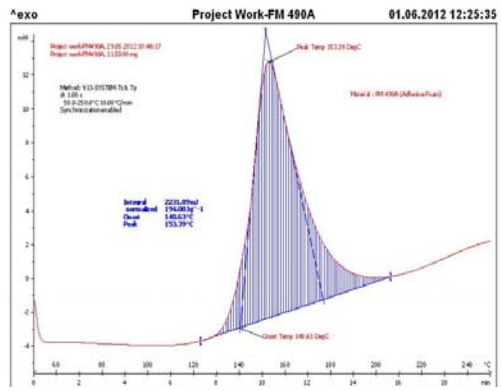


Fig.1 . Epoxy base adhesive Grade FM 490A

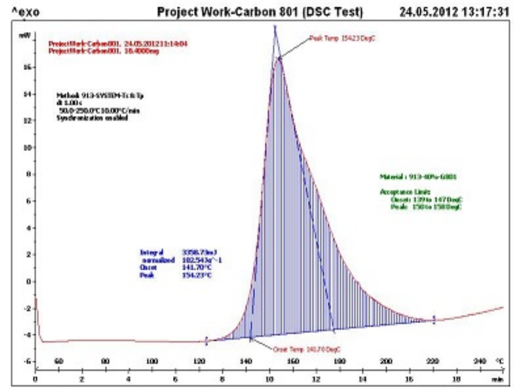


Fig.3.Epoxy Carbon prepreg Grade G801

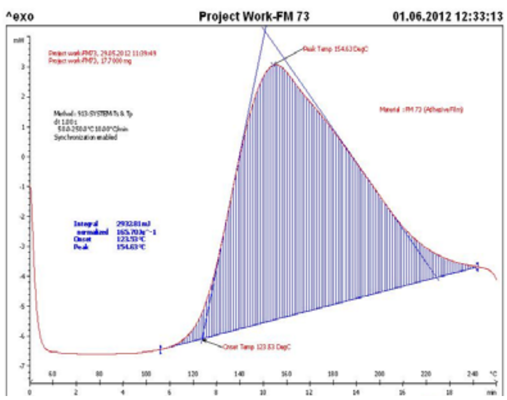


Fig.2. Epoxy base adhesive Grade FM73

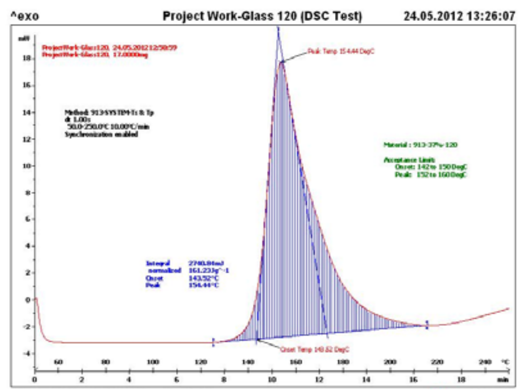


Fig.4. Epoxy base Adhesive Grade FM 490A

3. METHODS :

Two Types of samples were prepared. First, without using any support frame and second by using poly urethane solid foam square frame(fig.5)

Sample With PU solid foam :

A rectangular flat open mould was used for hand lay process. Solid PU Foam Frame was made using four pieces PU solid Foam in a dimension of 260×260×25mm and cured at 135°C +/- 5°C. After curing join the each end of PU solid foam by adhesive to form a square shape. The mould was cleaned using Acetone and lint free cotton cloth to remove contamination. Seven layers of Epoxy Carbon prepreg (G801) was laid as per Prepreg Layup Scheme 45°/90°/45°/90°/45°/90°/45°(Fig.5) Vacuum bag was used on the prepreg stack (Fig.6). Vacuum bag was removed after pre-compaction. one layer of epoxy base adhesive FM73 was laid on the prepreg stack. Square shape PU solid foam was placed on it. Then hexagonal aluminium honeycomb placed on it. Again one layer of epoxy base adhesive (FM73) was laid. layup prepreg scheme-1 for next four layers was 45°/90°/90°/45° and finally one layer of Epoxy glass prepreg Grade Glass 120 was laid . The assembly was applied with vacuum bag for pre-compaction and was Cured in an auto calve at 135˚C.

Sample without PU solid Foam :

A rectangular flat open mould was used for hand layup process. Seven layer of epoxy carbon prepreg (G801) was laid as per prepreg layup scheme 45°/90°/45°/90°/45°/90°/45° .Then vacuum bag was done. one layer of epoxy base adhesive FM73 was laid on the prepreg stack. Hexagonal aluminium honeycomb then placed on it(Fig.8). Again one layer of epoxy base adhesive (FM73) was laid. Layup prepreg scheme for next four layers was 45°/90°/90°/45° and finally one layer of Epoxy glass prepreg Grade Glass 120 was laid. The assembly was applied with vacuum bag for pre-compaction and was Cured in an auto calve at 135˚C.

Fig.5.Prepreg lay up

Fig.5.PU Solid Foam

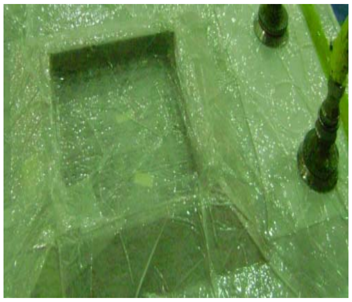


Fig.6.Vaccum bag

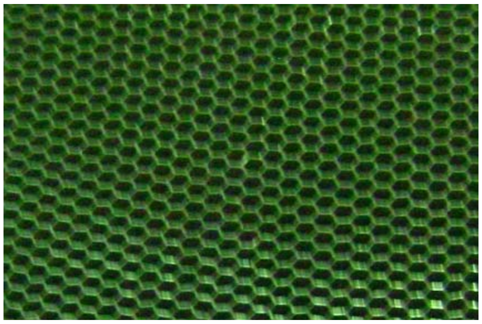


Fig.7. Aluminium honeycomb

Fig.8.Pre compaction

Process optimization : The process was optimized by using Temperature range from 50 to 90 deg. C, Autoclave pressure from 1 bar to 3 bar, vacuum bag pressure 0.05 to 0.10 bar at various stages. Also cooling rate was controlled for during setting.

4. Result and Discussion:

The stabilized core has maximum Inter laminar shear strength properties(Table-2) compare to un-stabilize core (Fig 9) .The properties increased from 39.342Mpa to 65.0068Mpa (Approx 25%).Tensile properties decreases in case of stabilize core(Fig.10) compare to un-stabilize core(Fig.7). The properties decrease from 8.289 Mpa to 6.875 Mpa (Table-2)

The stabilize core has maximum compressive strength compare to un-stabilize core. The properties increased from 13.4 N/mm to 23.9 N/mm (11%)(Table-2). The stabilized core has maximum flexural strength properties compare to un-stabilize core(Fig.9). The properties increased from 825Mpa to 896Mpa (Approx 9%). From the C-scan result it is observed that sample without PU solid foam core crushing took place(Fig.9) Due to core crushing there is a dimensional destruction took place. While the sample which consists PU solid foam not having any core crushing (Fig .10).

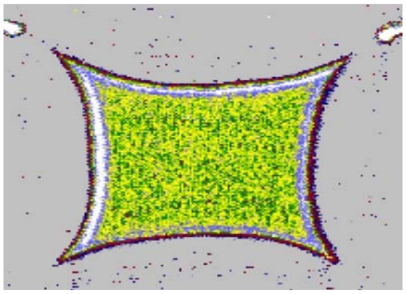
Table-2

Sl no	**SPECIMEN**	**ILSS (MPa)**	**FLEXURAL STRENGTH (MPa)**	**COMPRESSION STRENGTH (N/mm)**	**FTT (MPa)**
1	**Un stabilize Core**	39.342	825	13.4	8.289
2	**Stabilize Core**	65.0068	896	23.9	6.875

Fig.9. Un stabilize core

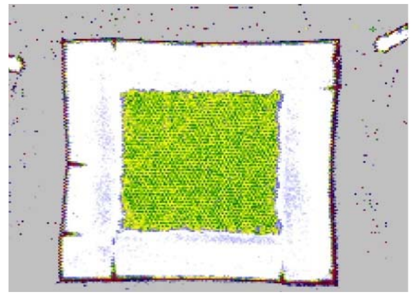
Fig.10.stabilize core with PU solid foam

C



A

B



D

Fig .11. Core crushing

Fig .12. Core crushing absent

A-Prepreg lay up B-Aluminimum honey comb C- Core Crushing D-PU Sold Foam

CONCLUSION:

FRP sandwich composite stabilize with PU Solid foam frame at a temperature of 135°C. By stabilizing the FRP sandwich structure the weight reduce and ILSS, Compressive Strength, flexural strength Increases which is suitable for engineering application . From the above experiment it conclude that due to Pressure, Temperature, Vacuum with respect to Time core crushing occurred as a result mechanical properties decreases in case of un stabilized core.

REFERENCE:

[1]. M. V. Hosur, M. Abdullah, S. Jeelani, "Manufacturing and Low-velocity impact characterization of foam filled 3-D integrated core sandwich composites with hybrid face sheets", Composite Structures, Volume 69, 2005.

[2]. M. V. Hosur, M. Abdullah, S. Jeelani, "Dynamic compression behaviour of integrated core sandwich composites", Materials Science and Engineering, Volume 445-446, 2007.

[3] M. V. Hosur, M. Abdullah, S. Jeelani, "Manufacturing and Low-velocity impact characterization of foam filled 3-D integrated core sandwich composites with hybrid face sheets", Composite Structures, Volume 69, 2005

[4] Street KN, 1971, Proc NPL Conference on *The Properties of Fibre Composites* , Nov 1971, Teddington, UK,(IPC Science & Technology Press, Guildford, Surrey), 36-46

[5] Kim, H.S. and Oh, H.H. (2000). Manufacturing and impact behaviour of syntactic foam, J *Appl poly sci*.

[6] Gupta, N. and Woldesenbet, E. (September, 2001). Stress concentration factor approach to analyze the deformation and fracture behaviour of particulate composites, In: *Proceedings of ASC 16th Annual Conference*. Blacksburg,

[7] Mallick P.K., Composite Engineering Handbook,1997, Marcel Dekker Inc., New York, USA.

[8] Noor, A. K., Burton, W. S., and Bert, C. W., *1996.* Computational models for sandwich panels and shells, *Applied Mechanics Reviews*, Vol.49, No. 3, pp. 155-199

[9] Rose, C. A., Moore D.F., Knight N. F., and Rankin C. C. 2002 Finite element modelling of the buckling response of sandwich panels, *AIAA* 2002, pp1-19.

[10] Shekhar V., effect of Fibre Architecture on Properties of Pultruded Composites, M.S. Thesis, West Virginia University, Morgantown, WV 2007.

[11] Summerscales J., 1998, Microstructural Characterization of Fibre-Reinforced Composites, Woodhead Publishing Ltd., Cambridge, England.

[12] Vadlamani V., Strain Energy Density based Failure Criterion for GFRP Coupons under Tension and Bending, M.S. Thesis, West Virginia University, Morgantown WV 2006.

[13] Vinson J.R., 1999, The Behaviour of Sandwich Structures of Isotropic and Composite

[14] Yuan, W.X and Dave, D.J., 2001. Overall and local buckling of sandwich plates with laminated faceplates, Part II: Analysis, *Computer Methods in Applied Mechanics and Engineering*, Vol. 190, pp. 5215-5231.

[15] Whitney J.M. and knight M., 1980, The Relationship Between Tensile Strength and Flexure Strength in Fibre-reinforced Composites, *Experimental Mechanics*,

[16] Wisnom M.R., 1992, The Relationship between Tensile and Flexural Strength of Unidirectional Composites, *Journal of Composites Materials*, Vol. 26.

[17]Lekhnitskii, S.G., *Elasticity of an Anisotropic Body*, p. 30.

[18] Camponeschi, E.T., Jr., *Compression Response of Thick-Section Composite Materials*,DTRC-SME-90/90, August 1990.

[19] Abdallah, M.G., et al., *A New Test Method for External Hydrostatic Compressive Loading ofComposites in Ring Specimens*, Fourth Annual Thick Composites in Compression WorkshopKnoxville, TN, June 27-28, 1990.

[20] Bode, J.H., *A Uniaxial Compression Test Fixture for Testing Thick-Section Composites*,Fourth Annual Thick Composites in Compression Workshop, Knoxville,

[21] Goeke, E.C., "Comparison of Compression Test Methods for "Thick" Composites," *CompositeMaterials; Testing and Design (Eleventh Volume), ASTM STP 1206*, ed. E.T. Camponeschi,American Society for Testing and Materials, 1993.

[22] *Engineering Materials Handbook, Vol. 1, Composites*, ASM International, 1987.

◈◈◈