Effect of Composite CMDS Structure on Aircraft

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Abstract: **CMDS is extensively used in the mechanical and structural design of an aircraft. Material plays a significant role in CMDS in re-distributing stress and there by effecting fatigue life. In the current thesis CMDS with aluminium and carbon fibre material is considered. It is well know that the combination of aluminium and carbon fibre which makes the composite material helps to reduce the weight of the CMDS compared with aluminium or metals. For the considered composite material, the maximum stress distribution of CMDS with the applied various loads (pressure, point load, uniformly distribute load, bending load.) is determined by using mechanical test.The maximum stress at the edges of CMDS which helps to determine stress concentration, fretting damage, crack initiation, crack growth life.**

Keywords: **square panel, honeycomb core, foam core, nomex core, aluminium core composite materials, CMDS, ECM.**

I. INTRODUCTION

1.1 Electronic counter measure:

An electronic countermeasure (ECM) is an electrical or electronic device designed to trick or deceive radar, sonar or other detection systems, like infrared (IR) or lasers. It may be used both offensively and defensively to deny targeting information to an enemy. The system may make many separate targets appear to the enemy, or make the real target appear to disappear or move about randomly.It is used effectively to protect aircraft from guided missiles. Most air forces use ECM to protect their aircraft from attack. It has also been deployed by military ships and recently on some advanced tanks to fool laser/IR guided missiles. It is frequently coupled with stealth advances so that the ECM systems have an easier job. Offensive ECM often takes the form of jamming. Defensive ECM includes using blip enhancement and jamming of missile terminal homers.

1.2 Radar ECM:

Basic radar ECM strategies are; Radar interference, Target modifications, and Changing the electrical properties of the air.

1.2.1. Communication ECM:

Radio jamming or communications jamming is the deliberate transmission of radio signals that disrupt communications by decreasing the signal-to-noise ratio to the point where the target communications link is either degraded or denied service.

ECM is practiced by nearly all modern military units—land, sea or air. Aircraft, however, are the primary weapons in the ECM battle because they can "see" a larger patch of earth than a sea or land-based unit.Then employed effectively, ECM can keep aircraft from being tracked by search radars, or targeted by surface-to-air missiles or air-to-air missiles.

1.3. Counter Measure Dispensing System:

CMDS is chaff and flare dispensing system; either pilot or RWR activated and used for electronic warfare (EW) purpose. CMDS is on airborne defensive system providing self-protection by passive ECM radar guided anti-aircraft missile and radar guided anti-aircraft artillery. Protection can be achieved by misleading missiles through dispersal of chaff and or flare payloads.

CMDS consists of;

Operating control panel, firing controller, dispenser assembly and safety switch

1.3.1. Operating panel:

The operating panel serves as the CMDS man machine interface through which pilot commands are sent and system status/total inventory displayed. It also incorporates a power switch to route power lines to firing controller.The control panel has all the controls for operating CMDS and is also the primary display surface. The control panel incorporates four push buttons. Switch,dimmer control knob and six alpha numeric display windows.

1.3.2. Firing Controller:

The firing controller is the main electronic assembly controlled by 87c51 microprocessor that receives pilot commands from operating panel through the discrete. And serial lines and transfer them into a sequence of individual activation of electrical squibs. According to the firing program in action; 6 displays and dispenser assembly the dispenser is capable of carrying one more magazine. Magazines are easily and quickly mounted into dispenser.

1.4. Material property of CMDS outer panel:

In constructing and maintaining airframes of aircraft, it is necessary to have through understanding of the characteristics of various structural aircraft metals, such as their strengths, their various uses and their limitations. Repair and maintenance of aircraft require strict adherence to design specifications and proper choice of materials, loss in equipment and human live could become compromised.

Excellence in craftsmanship and proper selection of materials go hand in hand. To be able to select the proper material to be used for a specific job or repair work, the material used in aircraft and their physical properties should be familiar to the technician.

1.5. Composite Materials:

Composite material is a combination of two or more different substances in certain ratios. When they are combined to form single structure, the properties of this completely varies from the raw material.. The individual components remain distinct within the finished structure.Now these composite technology has been improved and Advanced composite materials (ACM's) are characterized by high strength fibers with high stiffness or modulus of elasticity, compared to other materials.

1.5.1. Reasons to Use Composite Material in Aircraft:

Composite materials are widely used in aircraft industry and have allowed engineers to overcome obstacles that have been met when using the materials individually. The constituent materials retain their identities in the composites and do not dissolve or otherwise merge completely into each other. Together the material creates a hybrid material that has improved structural properties. The development of light weight, high temperature resistant composite materials will allow the next generation of high performance, economical aircraft designs to materialize. Usages of such materials will reduce fuel consumption, improve efficiency and reduce direct operating costs of aircrafts. Composite material can be formed into various shapes and if desired the fibers can be wound tightly to increase strength.

1.5.2. Honeycomb Core:

Honeycomb core is material form. It is a series of hexagonal cells nested together to form panels similar in appearance to a cross section slice of a bee hive. Honeycomb core can be made from both metallic and non-metallic materials. This core is usually used for sandwich construction. The core has very little or no stiffness in plane of sandwich panel but has infinite stiffness in normal direction to the plane.

II. RELATED WORKS

2.1.1Honeycomb Composite:

Honey comb composite fabrication consists of core in the middle and number of faces above and below the core. Since the core is placed between the films of fibers, this structure is called as the sandwich panel. Here we use honeycomb structure as the core and carbon fibers as the faces. Core is the inner, light weight metallic or non-metallic face sheets bonded to top and bottom side of the core to for sandwich panel. Sandwich panel consist of two light weight core material. Selection of material is very important to maintain the weight to strength ratio and cost. Different types of cores available and used are: Foam core, Nomexcore, Aluminum core

2.1.2 Design Methodology

First level of designing the honeycomb composite structure manually includes the selection of materials, proper heat treat treatments for those materials, lamination of layers and curing. If we consider the design of honeycomb core in solid works, first level or preliminary analysis of this design uses the tools that have to be simple to design the Hexagonal cell structure and then extrude.

2.1.3 Problem definition

To perform an accurate analysis first we should define the structural loads, geometry, support conditions, and materials properties. The result of analysis typically includes deformation, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure.

2.1.4 Material Selection

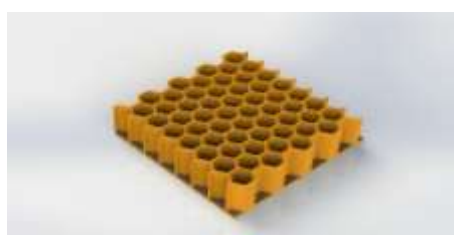
Our main objective is to obtain the high strength with lightweight materials. So we used the following materials to fabricate the honeycomb structures.

2.1.4.1. Types of cell configuration: There are mainly three types of cell configuration they are, hexagonal cell, over expanded cell (ox core), flex cell.

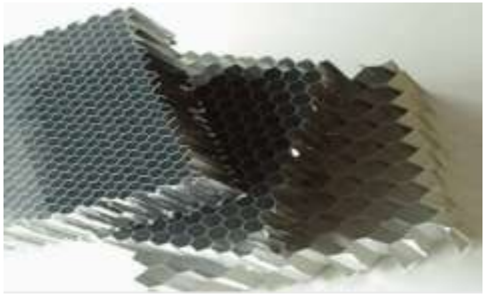
2.1.4.2. Hexagonal Core: - hexagonal core is made up of hexagonal cells and is used for flat panels. Used for flat panels. Which seen in components like floor board.

2.1.4.3. OX Core: - ox core is made up of the over expanding in (W-direction) cell configuration which helps to bend and form the contour in one direction i.e L-direction. Used for single curvature. Which seen in components like ALH tail boom.

2.1.4.4. Flex Core: - flex core is made of cell configuration which helps the core to bend in all L and W direction for compound surfaces without bending the cell. Used for compound curvature.



a) nomex honeycomb



b) aluminium honeycomb

c) nomex flex core

d) aluminium flex core

2.2 Lamination of Layers:

2.2.1 Experiment 1:

From beginning there was an idea to perform lamination step using a grooved plastic mould and vacuum for impregnation of fiber glass with epoxy resin.

2.2.1.1 Mould: Material: POM (Polyoxymethylene), Dimensions:66.5 *15 * 4 (cm), Description: 5 grooves, each 1.5 * 0.8 * 1 (cm) I cross- section

Fig: 2.2.1.1 POM mould for experimental lamination of a layer for honeycomb

2.2.1.2 Materials for Lamination:

Matrix material: fiberglass, 20×66.5cm

Resin : epoxy,

2.2.1.3 additional materials: Release agent, Aerofix, to place fibers into the grooves, Peel, ply, for good secondary bonding, release film, flow mat, plastic film, vacuum tape, elastic tubes and plastic valve.

2.2.1.4 Equipment's: Vacuum pump, Full curing time: 24 hours

Fig 2.2.1.4 Vacuum impregnation of fiber glass with epoxy resin

2.3. Building of honeycomb structure:

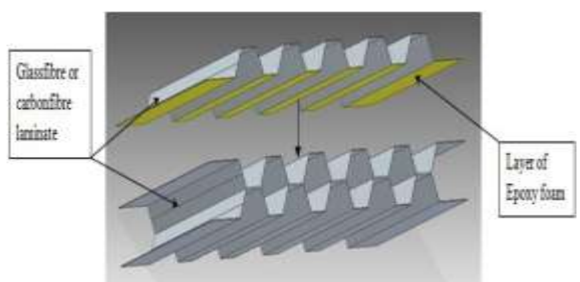


Fig 2.3.1 joining of honeycomb layers

Fig 2.3.2 carbon honeycomb core

The stripes received after the previous stage were to be glued together in order to get honeycomb core. At least two very important issues were to be considered there: choice of an adhesive and the way of gluing.So it was decided to use epoxy foam as an adhesive, because it was available, easy to use, light and suitable for the chosen method of gluing. The honeycomb was constructed as follows. First stripe was taken and placed vertically on its longer side next to some stable flat vertical surface.

Fig2.2.3 penetration

Fig2.2.4 final composite honeycomb core

Second stripe was dipped into the epoxy foam and attached to the first one. It was repeated until allstripes of the same material and size were attached to each other. At the end of the construction the last stripe was supported by some weight with a flat verticalsurface.After that the construction was covered with a plastic film and there was a weight placed on the top of it. In twenty four hours honeycomb cores were solid and ready for next stages of processing. Finally four honeycomb cores were built using that adhesive and gluing method.

2.4. Constructing of Composite Honeycomb Panel:

When the honeycomb cores are ready, honeycomb sandwich panel can be constructed then. That constructing process consists of two following steps:

- Lamination of skins
- Gluing of the skins and core together

2.4.1. Lamination of skins:

Skins for the panels were prepared using vacuum resin infusion process. Choice of matrix materials was not very significant for this experiment, so available materials were chosen for creation of the skins. Matrix materials: carbon fiber, carbon fiber/Kevlar mixture.Resin: epoxy. In addition already laminated piece of glass fiber was taken to make two skins for fiber glass core.

2.4.2. Making of the Panels:

The panels were made by dipping both sides of the honeycomb core into epoxy foam, then placing it in between to laminated skins and pressing that construction by placing weight on the top of one of the skins. This procedure was repeated with all the prepared cores and skins. Finally after twenty four hours the resin completely solidified and four composite honeycomb sandwich panels were received.

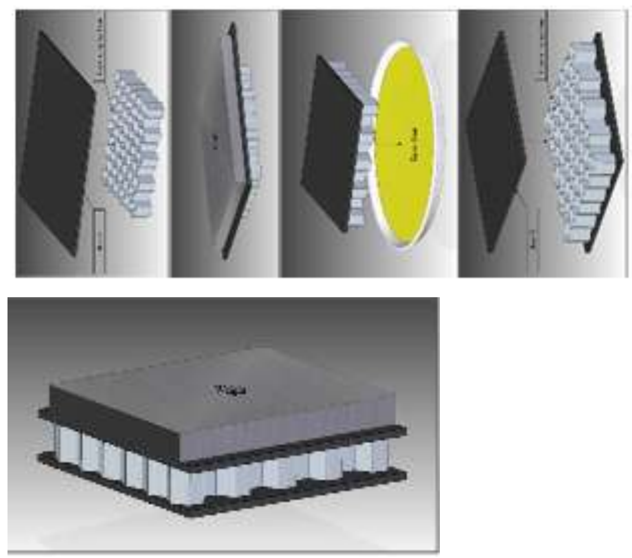


Fig 2.4.2 stages of building of honeycomb structures

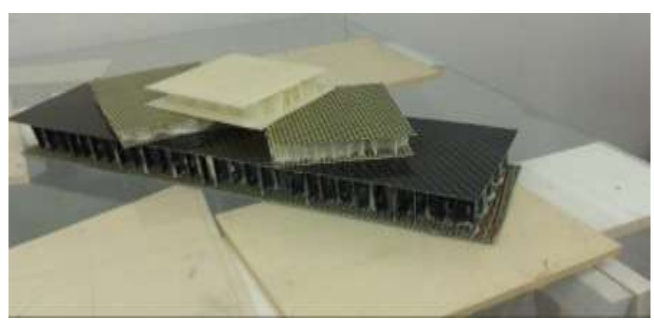


Fig 2.4.3 Composite honeycomb panel obtained

2.5. Model Analysis

2.5.1. Ansys

Ansys is general purpose software used to simulate interaction of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electrodynamics. Computing the life and foreseeing probable problems are possible by 3d simulation through ansys. It develops and markets FEM problems. Here we analyzed the created honeycomb composite for different boundary condition. We applied the load deformation can be observed for every corresponding load.

2.5.2. Solid work

Solid works is a solid modelling of CAD and CAE computer pr4ogramming that runs on Microsoft windows. By using the solid works we can design any solid models. Parameters refer to the constraints whose values determine the shape or geometry of the model. Building of model starts with 2D modelling; dimensions are added to the sketch to define the geometry. Dimensions can be controlled independently. Final drawings are created by parts or assemblies. Views are automatically generated from the solid model. Any parameters can be added even after the final drawing.

2.5.3. Model description

Here we designed the honeycomb composite by using the software solid works. We used aluminium honeycomb core with dimension of 100*100*20 (mm), and these are laminated with carbon fibers in both the vertical directions. Carbon fiber dimension is 100*100*0.15 (mm). These both materials are made to single honeycomb composite structure. This structure is analyzed in ANSYS software by giving certain boundary condition, load, specific values of the materials, and all required parameter. Relevant result is obtained.

2.6. Experimental Analysis:

The pre-pregs and adhesive film were from Advanced Composites Group, epoxy resin system VTM 264 34 wt.% and epoxy resin system VTA 260, respectively. The impact of producing one-skin samples was studied with prepregs reinforced with Toray carbon fiber T700, 200 g/m^2, unidirectional (UD), stacking sequence of $[0/90]_S$.

The pressure inside the volume isolated by the plies and enclosing the honeycomb was recorded during cure, as well as the air temperature insidethe furnace using a LAB View interface. The pressure inside the vacuum-bag was also recorded. The pressure sensors were from Ley bold, calibrated in mbar, measurement range from 1 mbar to 2000 mbar (0.1–200 kPa) and from 5×10^{-5} mbar to 1000 mbar (5×10^{-6}–100 kPa), connected to the honeycomb side and to the vacuum-bag side, respectively.

2.7 Testing Methods:

There are different testing machines or instruments for testing the mechanical properties of the fabricated materials. Here we used ILSS and UTM for the calculation of strength and failure point at different loads. In honeycomb structure we calculate bond to bond strength, layer to core strength, total laminate strength.

2.7.1ILSS Machine: Purpose of the Inter Laminar Shear Stress:

The inter-laminar shear strength (ILSS) characteristics describe the shear strength between laminates. Shear stress always is in the flexures. And the generation of normal stress by bending moment will be very large due to the less span comparing to thickness of materials. The shear stress occurred in the brittle material which tends to the measure of the shear strength.

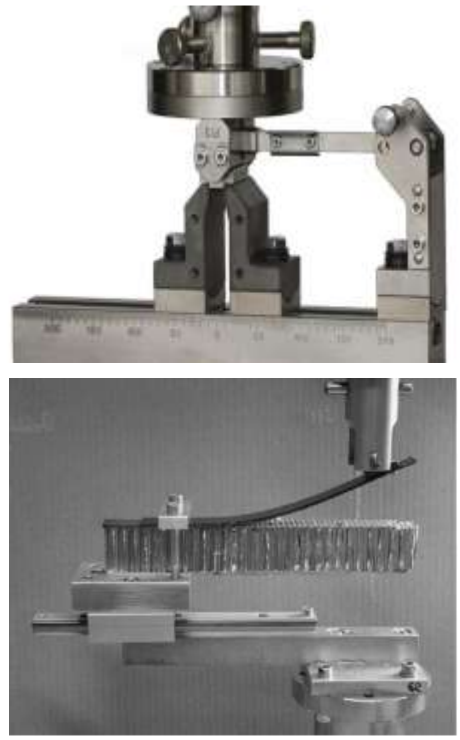


Fig 2.7.1 interlaminate shear strength testing machine

2.8. Universal Testing Machine

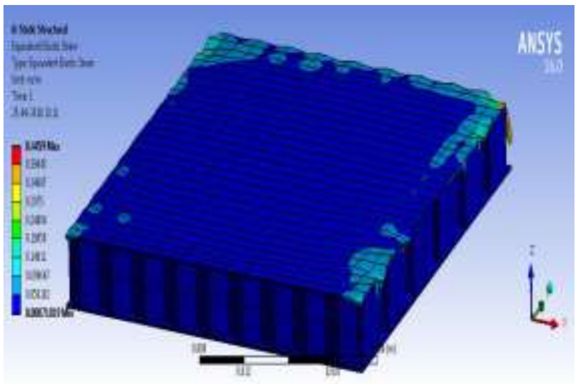
Laminates which are made by plates have different thickness. And UTM is used to test the tensile strength and compressive and fatigue life of the material. It gives the measure of tensile compression and it is versatile.

Fig 2.8 Universal testing machine

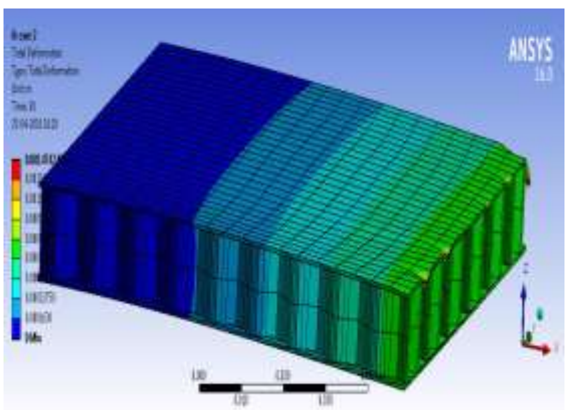
Break type gives the property of shear strength of the material and fiber matrix bonding of the composites. It's very simple to employ the test and there are two requirement are needed those are good alignment and precise cantering die.

III. RESULTS

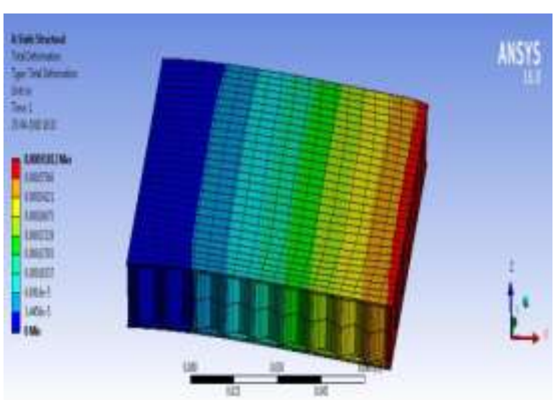
3.1. Analysis results: analysis of the considered panel for various applications of loads is carried out and shown the results below as follows.



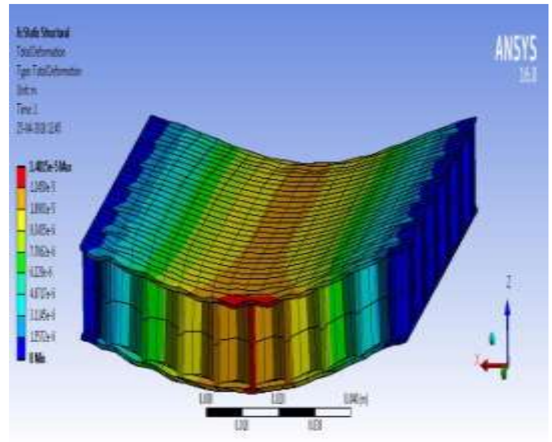
a) Pressure applied at one end



b) load on cantilever



c) Uniformly distributed load



d) bending load

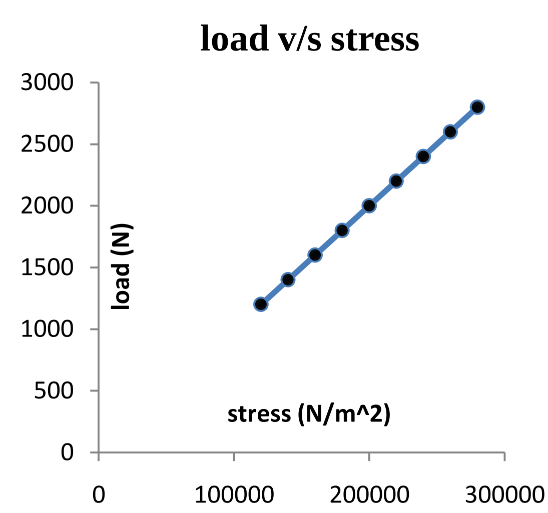
Comments a: pressure is applied on the fixed end panel and deformation is occurred at the edge. So the strength at the edges of honeycomb sandwich is lower that at the center.

Comments b: when pressure is applied the stress is observed maximum at the sides of the panel.

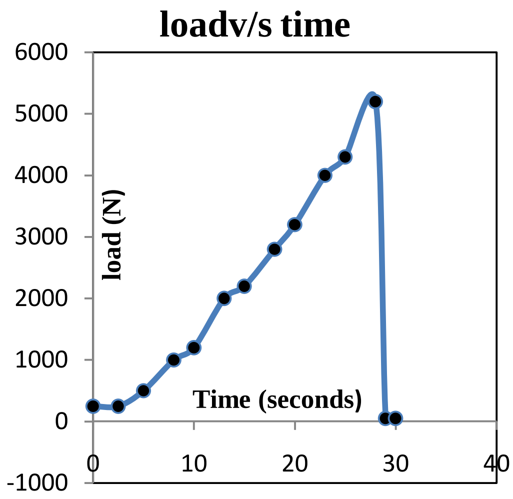
Comments c: when the point load is applied on the cantilever beam, deformation is maximum at the free end and the edges damages

Comments d: when the point load is applied on the cantilever beam, stress is maximum at the fixed

3.1.1. The variation of stress and strain for various loads is shown in below diagrams.



a) Load v/s stress



c) Load v/s time

The variation of stress and strain for various loads and the curve is shown as in the linear manner. For different time in seconds and various loads the curve is in increasing and drastic decrement which shows the limitation of maximum load for maximum time.

3.2.1 Mechanical test results:

Type of test: ILSS

Test environment: Room temperature

Test completion date : 06-01-2018,

Back Ground: Test specimen made from the component /test panel cured along components

3.2.2 Dimensional report of test specimen: (all dimensions are in mm):

20.0×10.1×2.1,20.1×10.1×2.2,20.1×10.0×2.1,

20.1×10.1×2.1,20.0×10.0×2.1,19.9×10.1×2.1

3.2.3 Lay-up scheme:

Position: 40 % ,

Nomenclature: G801BNO

Fiber orientation: 0^0/ 90^0.

Requirement: 56N/mm^2 (mm), 62N/mm^2 (avg)

Table 3.2.3.Time and speed calculation:

Date	Time	Sample ref	Speed	Max. load	test piece failure
06-jan-2018	09:37:03	EXP-JAN-18-1	3.0000	536.0kgf	Face sheet failure
06-jan-2018	09:38:11	EXP-JAN-18-2	3.0000	455.0kgf	Face sheet failure
06-jan-2018	10:12:14	EXP-JAN-18-NOMEX-1	3.0000	312.0kgf	cohesive failure
06-jan-2018	10:18:19	EXP-JAN-18-NOMEX 2	3.0000	252.0kgf	cohesive failure

3.2.4: Inter laminate data report:

Date: 19-12-2017, Test Speed: 2mm/min, Test Climate : room temperature

Table 3.2.4. Inter laminate test

Sl. no	Material	Name	Max load (N)	Inter laminate pressure (MPa)	Speed	Width (mm)
1	CARBOII-801	TOP-SHELL SUB	1877.648	69.9385	2.0	19.19
2	CARBOII-801	TOP-SHELL SUB	1821.820	61.49257	2.0	19.19
3	CARBOII-801	TOP-SHELL SUB	1851.220	66.115	2.0	19.19
4	CARBOII-801	TOP-SHELL SUB	1816.924	64.747	2.0	19.19
5	CARBOII-801	TOP-SHELL SUB	1862.300	57.225	2.0	19.19
6	CARBOII-801	TOP-SHELL SUB	1859.120	66.586	2.0	19.19
avg	CARBOII-801	TOP-SHELL SUB	1826.72	64.18355	2.0	19.19

Table 3.2.5. Test result of flat wise tensile test specimen:

Sl. no	Type of failure required	Type of failure observed	Max. load (Kgf)
1.	Core failure	Core failure	338
2.	Core failure	Core failure	496
3.	Core failure	Core failure	404

Table 3.2.6. Test result of drum peel

Sl no	Min required load in Newton/75 mm width	Average peak load in Newton/75mm width	Type of failure	Remark
1	493	1210	cohesive	Satisfactory
2	493	1010	cohesive	Satisfactory
3	493	1070	cohesive	Satisfactory

Table 3.2.7. Test result of bell peel:

Sl. no	Min required load in Newton/25 mm width	Average peak load in N/mm width	Average of 6 specimens in Newton/25mm width	Type of failure	Remark
1	285	452	482	Cohesive	Satisfactory
2	285	491	482	Cohesive	Satisfactory
3	285	485	482	Cohesive	Satisfactory
4	285	517	482	Cohesive	Satisfactory
5	285	477	482	Cohesive	Satisfactory
6	285	470	482	Cohesive	Satisfactory

IV. CONCLUSION

- 3D analysis of square panel (CMDS) is carried out and maximum stress concentration with composite material established. For various applied loads the distribution of stress is determined with respective time. This distribution of stress for composite material leads to fatigue life, aluminium 2024 and carbon fibre, carbon fibre has a percentage life cycles of failure of 82.31% is determined.
- By this approach we fabricated same dimension of aluminium beam and sandwich panel and tested in UTM, ILSS, and fatigue testing machine and found out that the experimental fatigue life of carbon fibre is 10 cycles greater than that of aluminium in most of the applied stress.
- By replacing the aluminium with composite can reduce the weight by 80%. So that acceleration is increased, so highly used in military aircraft.

V. FUTURE ENHANCEMENT

- At present the CMDS outer cover is made up aluminium 2024 alloy, but aluminium increases the weight. Instead of this carbon laminated honeycomb core composite will be placed and it contributes the weight reduction to a fighter aircraft.
- Carbon fiber has 82.09% of fatigue life than aluminium 2024 and 10 cycles greater fatigue lie than life this leads to more fatigue life to the CMDS outer panel. This is tested in UTM.
- For the known maximum stress distribution we can find the fatigue life and the crack initiation problems to know the life of the structure in aircraft.
- With the help of fracture mechanics we can find the stress intensity factor, strain energy release rate to know the delamination of the panel.

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