Carbon fibres as one of the key innovations of the 21st

Technology, Innovation

Carbon fibres are one of the key innovations made in the 21st century, found most commonly on aircrafts. The use of carbon fibre in aircraft is increasing significantly, from 1% of the total weight of a 747, to 50% of the total weight of a 787. These composites are one of the main reasons why the aviation industry is one of the key driving force in modern day globalisation due to its lightweight, yet strong and rigid properties, allowing aircrafts to have increased range of flight and increased efficiency as lesser amount of fuel is needed to fly the lighter weight aircraft.

The skin of today's aircraft fuselage and take a look at the carbon fibre sandwich laminates that makes up the skin, the first thing that we would observe is the core shape. The core is manufactured from carbon fibre reinforced plastic into hexagonal honeycomb structures. The honeycomb structure forms a stiff structure that evenly distributes the force acting on the structure in multiple direction.

Hence, this Aerospace Material project will help us understand how different sandwich structure can produce different stiffness yet keeping the product lightweight due to its low density. This report will explain how we experimented and came to a conclusion that hexagonal honeycomb is an ideal shape.

Scope

Sandwich laminates in practical use, are made from many different materials such as carbon fibre, glass fibre and metal. However, we will be using vanguard sheet for this study to make both the sandwich panel and core. There are many different sandwich designs but we will only be focusing on 4:

diagonal lines, triangles, diamonds and hexagonal. Due to equipment constraints, only 1 testing method was used throughout the experiment; 3 point bending test.

Main Text

We have taken some of these procedures to complete this project. Firstly, we have received the materials for the project which included 6 Vanguard Sheets and a locker with a key to keep our materials in. Next, we asked Mr Lai Tuck Wah to show us the operation of Hounsfield H5K-W tensile & compression testing machine which we used for the tensile test. A dog bone is then given to us to craft out our test pieces.

Properties of Vanguard Sheet

After gathering the materials we needed, we started off measuring angles(0, 30, 60, 90) on the vanguard sheets and traced out the dog bone that was provided with respect to the angles (Note: The 0 degree orientation is parallel with respect to the longer side of the sheet). We made 3 identical test pieces for each orientation in the case of any failures. We used the Hounsfield H5K-W tensile & compression testing machine to obtain the force values at which each orientation experienced tensile failure. In the end, we have only obtained 2 sets of results from each orientation as our first set did not break properly at the neck due to improper fastening to the machine. The 2 sets of data produced similar results and hence we deemed the results conclusive.

Application of Results

From the graphs, we can conclude that the 0 degrees orientation is the strongest being able to withstand a force of 110N in tension before failing. With this fact, we can now craft the sandwich core where the corrugated strips will be made from strips of vanguard sheets in the 0 degree orientation.

Construction

Four different core structures (16cm x 8cm x 2. 5cm) that is sandwiched between 2 vanguard sheets:

2cm width 45 degrees diagonal lines

2cm Equilateral Triangle shape Honeycomb

2cm Diamond shape Honeycomb (Diagonal of the square is 2cm)

2cm Hexagonal shape Honeycomb

To increase accuracy of results, we have decided to only have one variable, our core shape. Thus using corrugation method where we cut out strips of vanguard sheets, folding and forming corrugated strips, bonding them to form a corrugated block, sandwiching it with two vanguard sheet panels with the same type of adhesive(superglue) creating a sandwich structure(16cmx8cmx2. 5cm). For the diagonal lines core, we measured 45 degrees angle diagonal to the base piece with a 2cm width difference and marked it out with a pencil. Next, we drew a line from one end to another and measured the length of rectangular strip required before cutting each strip. We superglued the strips perpendicular to the base by using the corner of a ruler, followed by attaching another vanguard panel to the top so as to create a sandwich structure.

For the triangle honeycomb core, we cut out 4 strips of rectangular pieces (parallel to 0 degrees) and folded it into 2cm equilateral triangles and superglued them into one horizontal line until it has reached the base pieces length and breadth. Then, we superglued 4 rows of 8 triangles together before sandwiching the core with two vanguard sheet panels. For the diamond honeycomb core, we cut out 8 strips of paper with a width of 2. 5cm. We started folding and forming the strips of paper into a zigzag shape, with every crevice 2cm apart from each other. Then pasting each strip of zigzag shape on top of one another before sandwiching the core with two vanguard sheet panels.

For the hexagonal honeycomb, since it was too difficult to make an exact hexagon with only a ruler and pencil, we settled on an underexpanded hexagon which is of a 1cm sided square with two 1cm tall triangles on each side. Strips with width of 2. 5cm was cut and folded according to the shape of the hexagon. the folded strips were glued together to form the underexpanded hexagon. Finally, the core is sandwich with two vanguard sheet panels.

With the test pieces made into their 16cm x 8cm x 2. 5cm rectangular shapes, we can now test for their stiffness based on deflection. As aforementioned under apparatus, we were provided with seven 500g weights, five 200g weights, one 1000g weight and one weight hanger (460g). These weights were added in the following sequence for all test pieces; We first put on all the 500g weights(increments of 500g), followed by four of the 200g weight (increments of 400g), then replace the four 200g weight with the one 1000g weight, followed by putting on all the five 200g weight(increments of 400g, then 200g), the resultant total weight is hence 5960g.

We then drew diagonal lines on the surface of the test piece, from corner to corner, to find the center of the test piece. A raffia string was then tied along the centre. This ensures the load is applied at the center of the test piece. We also drew two lines, each 3cm from the vertical sides of the test pieces to be supported on each side beyond the drawn line. This ensures even distribution of loads.

As shown above, we supported each side of the test pieces with two identical dustbins. The dial gauge, supported by the table is then placed above the test piece, where the spirit level function on an iphone is used to ensure the gauge is perpendicular to the test piece. The weight hanger without weights is then hung up on the raffia string. The dial gauge is zeroed and we start to add weights. We take the readings only when the pointer stops for 5 seconds. We conclude that the sandwich structure has failed when the structure has deflected so much that it exceeds the dial gauge measurable range.