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Analysis Of Composite Material (Sandwich Panel) For Weight Saving

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ABSTRACT:

Material is the basic element of industry, foundry, and automobile application. Automobile industry used composite material now a day for to get many mechanical properties of material like stress, strain, stiffness, shearing, bending behaviour, thermal conductivity, and weight saving purpose. In automobile side weight saving is most important and necessary now a day for to get more efficiency of fuel and increase load capacity of vehicle. So, by using composite material we achieve weight reduction of material so we get above benefit and also increase service life of material by getting more mechanical properties of material compare to basic material. In this paper basic review is presented based on weight saving purpose in automobile application. By using various types of materials for composite material to get mechanical properties and weight reduction is present and consider various literatures of research for composite material. By using above approach develop a new material for automobile application.

Keywords: Honeycomb Sandwich panel, Hexagonal core, Mechanical testing, Impact behaviour.

1. INTRODUCTION:

In the most general of terms, a composite is a material that consists of two or more constituent materials or phases. Traditional engineering materials (steel, aluminium, etc.) contain impurities that can represent different phases of the same material and fit the broad definition of a composite, but are not considered composites because the elastic modulus or strength of the impurity phase is nearly identical to that of the pure material. The definition of a composite material is flexible and can be augmented to fit specific requirements. In this text a composite material is considered to be one that contains two or more distinct constituents with significantly different macroscopic behaviour and a distinct interface between each constituent (on the microscopic level). This includes the continuous fiber laminated composites of primary concern herein, as well as a variety of composites not specifically addressed.

1.1 Composite material:

Fibers or particles embedded in matrix of another material are the best example of modern day composite materials, which are mostly structural.
Laminates are composite material where different layers of materials give them the specific character of a composite material having a specific function to perform. Fabrics have no matrix to fall back on, but in them, fibers of different compositions combine to give them a specific character. Reinforcing materials generally withstand maximum load and serve the desirable properties.
Further, though composite types are often distinguishable from one another, no clear determination can be really made. To facilitate definition, the accent is often shifted to the levels at which differentiation take place viz., microscopic or macroscopic.
In matrix-based structural composites, the matrix serves two paramount purposes viz., binding the reinforcement phases in place and deforming to distribute the stresses among the constituent reinforcement materials under an applied force.
The demands on matrices are many. They may need to temperature variations, be conductors or resistors of electricity, have moisture sensitivity etc. This may offer weight advantages, ease of handling and other merits which may also become applicable depending on the purpose for which matrices are chosen.
Solids that accommodate stress to incorporate other constituents provide strong bonds for the reinforcing phase are potential matrix materials. A few inorganic materials, polymers and metals have found applications as matrix materials in the designing of structural composites, with commendable success. These materials remain elastic till failure occurs and show decreased failure strain, when loaded in tension and compression.
Composites cannot be made from constituents with divergent linear expansion characteristics. The interface is the area of contact between the reinforcement and the matrix materials. In some cases, the region is a distinct added phase. Whenever there is inter-phase, there has to be two inter-phases between each side of the inter-phase and it's adjoin constituent. Some composites provide inter-phases when surfaces dissimilar constituents interact with each other. Choice of fabrication method depends on matrix properties and the effect of matrix on properties of reinforcements. One of the prime considerations in the selection and fabrication of composites is that the constituents should be chemically inert non-reactive.

1.2 Classification of composite material:

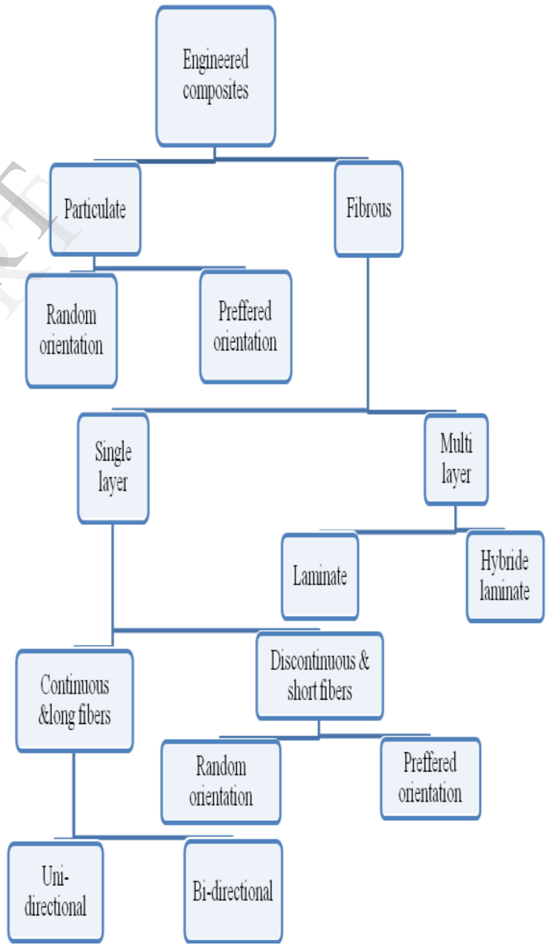

Fig.1.1 Major types of composite material [4]

1.3 Sandwich panel:

Sandwich structures (beams, panels etc.) consist of a combination of different materials that are placed together so that the material properties of each one can be utilized for the structural advantage of the whole assembly. Sandwich panels generally consist of three significant components, two thin, stiff face sheets and a thick, light and weaker core. The variety of types of sandwich constructions basically depends upon the configuration of the core, not to mention the material constituents. The most common types of core are: foam, honeycomb and web core truss. The faces that must be stiff, strong and thin; are separated and bonded to a light, weaker and thick core.

The adhesion of both materials is very important for the load transferring and therefore the functioning of the sandwich as a whole. Structural sandwich panels with cellular core are used in aircraft and automotive construction, in load bearing structures and in sports equipment, wherever weight-saving is required. The principal advantage of sandwich panels is that the rigidities can take any values in function of geometrical parameters. Thus, the designer has the choice for optimizing the material solution. Structural sandwich panel is a structure, which is realised by two skins separated by a lightweight core. Structural sandwich represents a good compromise between stiffness and lightness.

Aluminium sandwich construction has been recognized as a promising concept for structural design of light weight systems such as wings of aircraft. A sandwich construction, which consists of two thin facing layers separated by a thick core, offers various advantages for design of weight critical structure. Depending on the specific mission requirements of the structures, aluminium alloys, high tensile steels, titanium or composites are used as the material of facings skins. Several core shapes and material may be utilized in the construction of sandwich among them; it has been known that the aluminium honeycomb core has excellent properties with regard to weight savings and fabrication costs.

Sandwich structured composites are a special class of composite materials which have become very popular due to high specific strength and bending stiffness. Low density of these materials makes them especially suitable for use in aeronautical, space and marine applications. Geometry of sandwich plate shown in figure: 1.2.

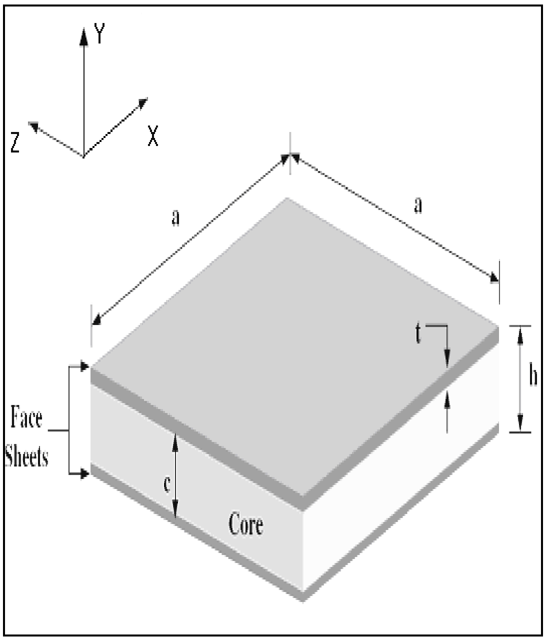

Fig. 1.2 Geometry of composite material [5]

Sandwich panels are used for design and construction of lightweight transportation systems such as satellites, aircraft, missiles, high speed trains. Structural weight saving is the major consideration and the sandwich construction is frequently used instead of increasing material thickness.

The conventional single skin structure, which is of single plates reinforced with main frames and stiffeners normally necessitates a fair amount of welding, and has a considerable length of weld seams. Further, the lighter but thinner plates employed tend to increase weld distortions that may in some cases require more fabrication work to rectify. More weld seams also mean a greater number of fatigue initiation locations as well. Honeycomb sandwich construction, with a honeycomb core is sandwiched by two outer facing skins is better able to cope with such difficulties.

Sandwich panels also provide added structural weight savings in the structure. It is for these reasons that the sandwich construction has been widely adopted for large weight critical structures. Honeycomb-cored sandwich panels have been used as strength members of satellites or aircraft, thus efficiently reducing their structural weight.

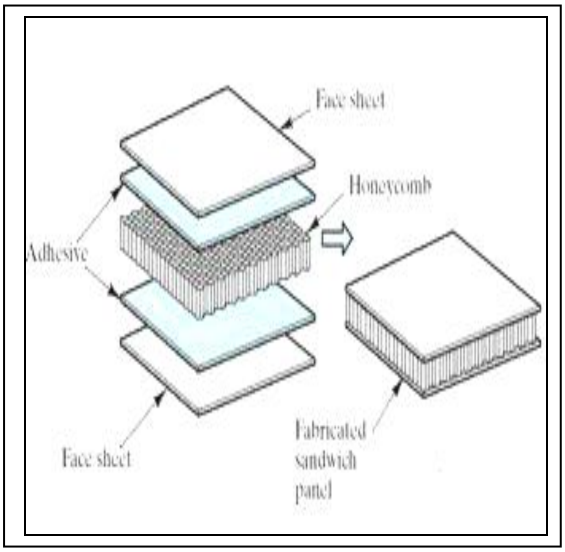

Fig. 1.3 Structure of sandwich panel [6]

Sandwich composites primarily have two components namely, skin and core as shown in Figure 1.3. If an adhesive is used to bind skins with the core, the adhesive layer can also be considered as an additional component in the structure. The thickness of the adhesive layer is generally neglected because it is much smaller than the thickness of skins or the core. The properties of sandwich composites depend upon properties of the core and skins, their relative thickness and the bonding characteristics between them.

2-LITERATURE SURVEY:

Sanjib Goswami & Wilfried Becker [1] in 2000 worked upon lightweight sandwich construction is very useful and common due to their superior specific bending stiffness and bending strength. In many cases the sandwich consists of an upper and lower laminate face sheet and an intermediate hexagonal cellular aluminium core. The sandwich plate considered for this study is made up of two composite face sheets (top and bottom) and hexagonal aluminium honeycomb core is in between them.

De-lamination and de-bonding is a very fundamental problem for both composite and sandwich materials. Due to some manufacturing defects such as improper gluing of face sheet and core material, there may exist a weak zone at the interface of face sheet and core. Under a specific loading, this weak zone may grow and ultimately result in inter laminar or face sheet core de-bonding and its possible growth, which is characterised by the local discontinuity of materials between the upper and lower sub-laminate. The embedded de-lamination is dangerous as it cannot be seen from outside and may cause a serious reduction in load carrying capacity of the structure. The structure having imbedded de-lamination may fail under much lower load than usually expected.

The simplest way to implement Irwin's crack closure integral is to set up a detailed finite element model with an initial crack and then to extend the crack virtually by the edge length Δa of the finite elements along the crack tip ligament and simply to release the crack tip double node as indicated in Fig. 2.1. Thus the crack closure integral can be approximated in a form suitable for finite element calculations as follow:

$$G_I = \frac{1}{2\Delta a} F_y u_y,$$

$$G_{II} = \frac{1}{2\Delta a} F_x u_x.$$

Where, Fy and Fx are the forces in y and x directions required to hold the crack faces closed and u_y and u_x are the crack opening displacements.

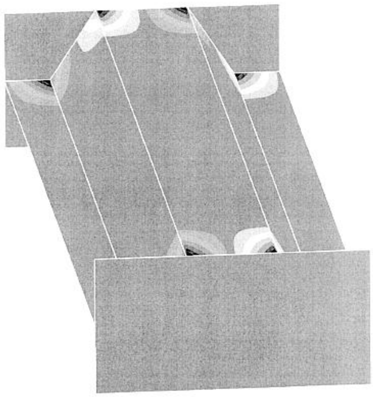

Fig. 2.1 Contour plot showing the shear stress variation and concentration at the interface of core and face sheet.

In this study, hexagonal core thickness has been considered as the study parameter and the energy release behaviour when the hexagonal cell thickness is very thin has been investigated. Fig. 2.2 shows the variation of energy release rate GII with the crack length when the thickness of the core is 4.0 mm. The figure reveals that the curve starts at a much lower value than that of the original curve of larger cell thickness. The peak value of GII for the present study is slightly less but comparable to the original figure of thick sandwich plate. Concluding, it can be stated that in the case of very thin core thickness, small de-laminations are clearly more harmless than in the case of a relatively thick core.

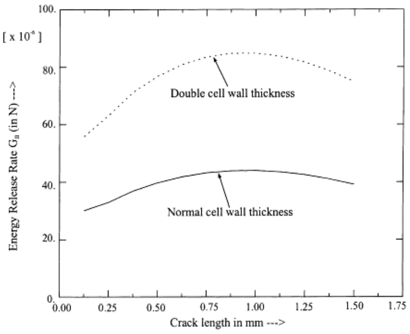

Fig. 2.2 Variation of energy release rate GII for normal cell wall thickness (solid line) and double the normal cell wall thickness (dotted line).

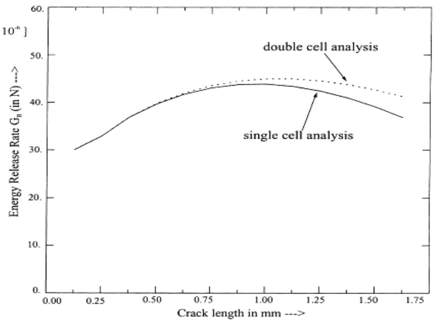

Fig. 2.3 The variation of GII with the crack length for single cell analysis (solid line) and double cell analysis (dotted line).

Within the investigations made so far it has been assumed that the unit cell appears periodically and thus also the considered de-bonding. For larger de-bonding this implies some interaction between neighbouring de-bonding. In order to get some idea of this interaction a (periodic) two-cell situation has been analysed, where in one cell there is a de-bonding and in the other cell there is no de-bonding. Fig. 2.3 shows a comparative study of the energy release rate GII for a single cell (solid line) and two unit cells joined together (dotted line). The variation of energy release rate GII for these two cases shows that in the beginning with smaller crack length, the energy release rate values are very close, but as the crack length increases, the difference also increases with higher GII values for the two cell case. This observation can be explained in the way that with smaller crack length, the interaction between two adjacent cells is less whereas with larger crack length, the interaction gets significant.

V. Crupi, G. Epasto, E. Guglielmino [2] in 2012 worked upon lightweight components having good mechanical properties and energy absorbing capacity, especially in the transport industry. The static bending tests produced various collapse modes for panels with the same nominal size, depending on the support span distance and on the honeycomb cell size. Simplified collapse models were applied to explain the experimental observations and a good agreement between predicted and experimental limit loads was achieved.

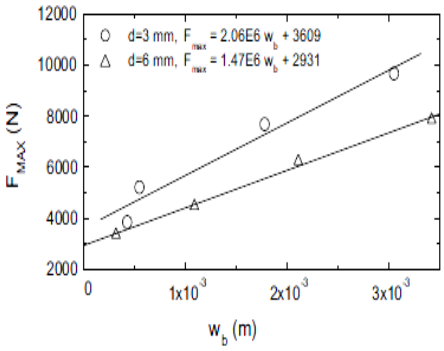

Fig. 2.4 Peak load v/s sandwich deflection

According to the spring - mass model, it can be assumed a linear relationship between the impact load and the corresponding global displacement K_b of the sandwich panel and the K_{bs} stiffness is the slope of this linear function. Moreover, the K_{bs} stiffness doesn't change with the impact velocity. The values of the peak loads Fmax were plotted vs. the corresponding values of the deflection W_b of the mid-plane of the panel and a linear regression was performed in order to obtain the values of the stiffness K_{bs} for each sandwich typology (d = 3 and 6 mm), as shown in Fig. 2.4 For the case of low values of impact force, the displacement of the structure is negligible and the post-impacted specimens did not show out-of-plane displacement of the lower skin but only local displacement, so the peak load has to be higher than a certain value (the constant term of the linear function) to produce the global displacement W_b. This behaviour is confirmed by the low-velocity impact tests carried out on the two typologies of honeycomb panels (d = 3 and 6 mm) at a velocity of 1 m/s. The global displacements wb are null for both the sandwich typologies and the peak load is equal to 2100 N for the honeycomb panel with d = 6 mm and to 2600 N for the honeycomb panel with d = 3 mm.

N. Baral, D.D.R. Cartié, I.K. Partridge, C. Baley, P. Davies [3] in 2010 worked upon Sandwich panels of the same areal weight and with the same carbon/epoxy facings but using a novel foam core reinforced in the thickness direction with pultruded carbon fibre pins, do not show signs of damage until above 1200 J impact energy. This suggests that these will offer significantly improved resistance to wave impact. Quasi-static test results cannot be used to predict impact resistance here as the crush strength of the pinned foam is more sensitive to loading rate than that of the honeycomb core.

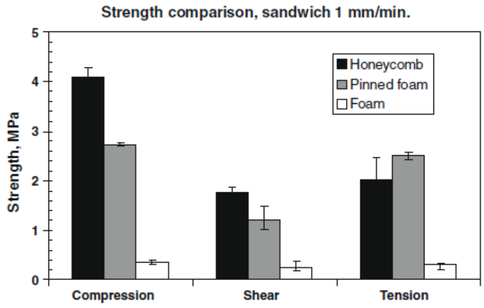

Fig. 2.5 Mean strength values, quasi-static tests (error bars indicate standard deviations).

A comparison of the measured strengths of the three materials under compression, shear and tensile loading in standard tests is presented in Fig. 2.5. The quasi-static strength of the reference 64 kg/m3 honeycomb core is higher than that of the pinned foam under both out-of-plane compression and shear loading. However, the through thickness tensile strength of the pinned foam is higher.

3-FUTURE WORK:

From the above related literature sandwich panel is prepared by mathematical model and software simulation. Based on maximum weight reduction in composite material is achieved and increase in material's mechanical properties. New composite material itself develops a new mechanical property. By changing skin material and core material weight is more reduce to increase load carrying capacity in automobile and aerospace industry and also increase mechanical property of composite material.

4-CONCLUSION:

From the above literature survey it may be concluded that by using proper material and design reduce weight of material. Using proper face sheet material increase material's mechanical properties like, strength, stress, shear stress, stiffness and bending behaviour. Face sheet material is hard and stiff and core material is light in weight and in core material some shape is given like, triangle, square and hexagon for weight reduction purpose and stress distribution in material. By saving weight in automobile and aero-space industry fuel efficiency is increase and load carrying capacity of vehicle is also increase.

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