Develeopment and Ultra Sonic Testing of Blast Resistant Sandwich Panel

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Abstract: ***Composites are being used in many areas of ship construction to improve the performance and prepare the ships for the challenges of the future. Marine structures are to be stiffer, stronger and tolerant to corrosion and dynamic loads. Sandwich composites further enhances these advantages by using thin layers of GFRP or CFRP layers sandwiched with a low density foam or balsa wood core , effectively increasing strength and reducing the weight. The present study is to develop such sandwich structures with high specific strength and stiffness to with stand shock. These structures can be used for stealth application. Different types of sandwich panels are developed with cores made of foam and balsa wood with different skins and different thicknesses to get panels for multiple advantages. This paper presents development and ultrasonic test of one such sandwich panel. The results of dry scan method are presented which were used to find fitness after blast.***

Keywords: composite sandwich Panels, air blasts, dry scan method

1. Introduction

Composite sandwich panels with GFRP and CFRP faces and low –density cores material are in demand due to high performance applications, especially to reduce the weight, thereby increasing the speed of the vehicle with more efficient power plants. Coming to defense applications speed and high pay load capacity is desirable.

In this paper, development of blast resistance sandwich panel and its ultrasonic testing is described. In this study, the Ultrasonic signals are being sent through Dry scan method with Transmitter and Receiver probes. By using Ultrasonic flaw detector under dry scan method, the composite sandwich panel with balsawood as Sandwich was developed, and inspection methodology has been established. number of Sandwich panels have been fabricated and tested using the same technique. Finally the method of inspection by using Ultrasonic flow detector in dry scan method for the above Sandwich panels has been established. The above tests were conducted by using this technique not only in the laboratory but also in the field conditions.

2. Literature Review

J.E.Slater, 1994 presented some guidelines for selection of a blast resistant GFRP composite panel design for naval ship structures, to design a ship superstructure in GFRP.

Brian Hayman, Andreas Echtermeyer and Dag McGeorge, Det Norske Veritas, 2001 presented the structural performance of different composite structures with different loadings, also evaluation of non –destructive inspection methods for single skin and sandwich composites was presented

Thomas Muthiasen Wulf, 2003 automated method was identified for the inherent defects using Ultrasonic flow detector, under Pulse Echo technique for different thickness.

3. Development of Composites Sandwich Panel

A sandwich panel is one which have high strength layer sandwiched with low dense and low strength material in the middle as a core as shown in Fig.1. These structures have to withstand for mechanical loads such as shock wave, ballistic impact loads caused by high explosions.

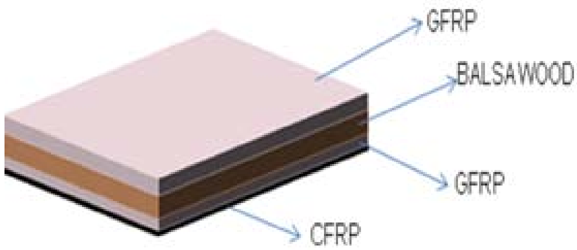

Figure 1: Schematic of Composite sandwich panel

A combination of Glass fibers as reinforcement combined with carbon fibre reinforced; make a good hybrid composite for stealth applications especially for radar absorption. In our case a combination of CFRP and GFRP layers with balsawood as the core material is developed with different thicknesses. In this paper, study made with 60mm thick is presented. Balsa wood has less density and gives an effect like honeycomb when used as core material. In comparison to the conventional steel or Aluminum structures, replacement with fiber reinforced plastic structure for a ship has the following advantages

- Due to its low modulus characteristic, it reduces the rigidity at the hull-superstructure interaction thus eliminating the fatigue cracking.
- It has a substantially lower specific weight than that of steel or aluminum construction.
- It gives a light structure with excellent shock resistance
- Thermal insulation
- Low maintenance cost as they are less corrosive and occurs spectroscopic failure in addition to these the

hybrid composites have immense applications in defence due to the following:

- Fiber reinforced plastic has better fire resistance than aluminum structure
- It has better ballistic resistance when combined with ceramic layers.
- Nonmagnetic material

The material itself will not serve the purpose, proper fabrication process and curing is a must for achieving the desired properties of the hybrid composites. Vacuum Assisted Resin Transfer Moulding (VARTM) is used for fabrication as shown in Fig.2.

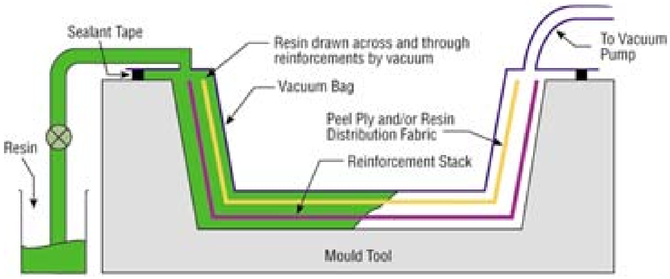

Figure 2: Schematic of VARTM setup

The Glass Fabric, Carbon Fabric and balsawood is laid as per the above schematic. The whole dry stack is then vacuum bagged, low Viscosity resin is allowed to flow into the layers of Hybrid Fibers at room Temperature. The resin distribution over the whole Fabrics are carried out by Using VARTM. For this process resins must be low in viscosity, thus comprising mechanical properties so generally epoxy, polyester and vinylester resins are used. Stitched materials work well in this process since the gaps allow rapid resin transport.

4.Qualification Tests

The following tests have been carried to qualify the product for readiness:

- Non Destructive Tests like Ultrasonic test, Barcol Hardness Test, Density tests of Balsa Wood and Compression Test
- Destructive Tests comprises of dry scan calorimeter (DSC) for curing status, Glass Transition (Tg) test ,Tensile tests on Laminates, Flexural tests on Laminates, ILSS test on Laminates, Compression test for Balsa Wood .

However the above are not sufficient, further tests are needed for critical application. The most important one being air blast test.In our study the panel is fixed at a distance of 1.5m from the explosive which gives shock wave and the intensity is increased from 400kpa to 2000kpa for different thickness panels. The panel withstood the air blast test successfully. The Non destructive Test (NDT) was carried out for the Composite Panel by using Ultra Sonic Flaw Detector in Dry scan Method with Through Transmission Mode as shown in Fig.3

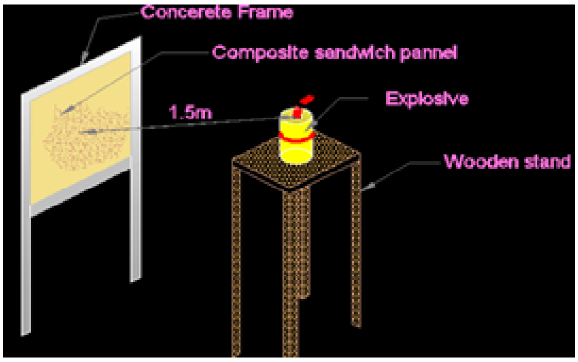

Figure 3: Schematic of blast test

NDT Test procedure: When sound waves travels through a media its intensity diminishes with distance due to scattering or absorption of sound energy. Scattering occurs due to inhomogenity in the material under test. In this scenario a test procedure has been carried out by using a Probe of 0.5 MHz frequency. Using this procedure located the lowest scattering and lowest dB loss point. This lowest dB value is used as best reference parameter of Sandwich panel by keeping all the parameters of instrument constant except the Gain value.

Both sides of the Sandwich Panels were marked in to a uniform grid. The distance between each nodal point of grid is 200 mm. The diameter of the Probe is 10 mm for both Transmitter and Receiver (T R) . The Ultra sonic signal was sent through probe and received the signal to scan the entire product as per the grid nodal points. By keeping both the transmitter and receiver exactly opposite to each other as per the Grid marked on sandwich panels, noted the gain value in terms of dB. These tests were carried out before and after blast tests of sandwich panels as a part of critical application for checking the integrity of Panel. Similar method was followed for graphite plates in our previous paper [4].

5. Results and Discussions

Maximum transmission of input signal is possible before blast test as there is no flaw. Table.1 shows the dB values of the panel tested for integrity before the blast test. F7 grid shows the minimum 45.8 dB value point and G6 shows the maximum value of 69.9 dB value. Fig.4 shows a cumulative signal without defect.

Table 1: Before blast Ultrasonic wave propagation in dB

	1	2	3	4	5	6	7	8	9	10
B	62.9	52.3	61.0	49.1	59.5	65.3	60.6	61.7	63.3	68.1
C	68.1	65.5	62.2	52.6	60.5	69.6	66.6	63.8	60.3	62.6
D	68.8	58.8	54.4	55.6	54.9	67.9	66.6	57.9	63.1	57.4
E	67.1	47.1	50.4	47.3	66.1	62.1	56.9	50.7	50.7	49.4
F	66.1	51.7	52.9	53.6	61.9	63.0	45.8	46.9	54.5	49.9
G	56.1	62.3	50.1	54.9	62.0	69.9	63.6	62.7	60.0	63.6

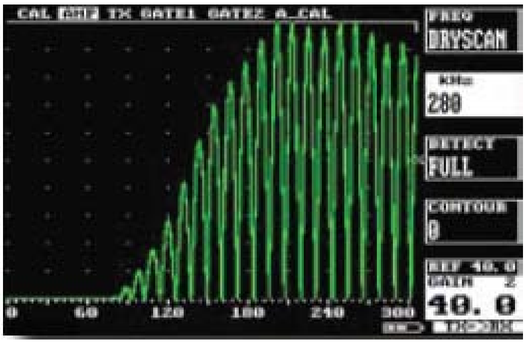

Figure 4: Cumulative signal without defect

After the blast test the sandwich panels are tested and Table.2 shows one such panel test report. The last Air Blast Test was conducted at 2000 kPa, and reasonable internal changes could be seen through ultra Sonic test as shown in the Table 2. Grid no F7 has the least value of 49.6 dB and grid G5 gives maximum value of 85.6 dB . Now the range has increased, visual damage was also observed.

Table 2: After blast Ultrasonic wave propagation in dB

	1	2	3	4	5	6	7	8	9	10
B	64.9	57.7	65.0	67.1	78.9	78.9	69.6	65.0	66.6	78.3
C	75.5	70.2	71.5	65.9	68.8	71.1	82.2	66.2	76.0	76.2
D	71.1	69.8	63.7	62.0	59.4	69.9	87.2	64.3	81.4	74.7
E	71.2	63.2	62.1	69.9	72.2	73.3	60.5	52.4	70.5	64.5
F	70.5	65.1	58.4	60.9	62.0	69.0	49.6	72.2	84.9	72.1
G	77.5	73.6	67.0	70.7	85.6	77.6	70.1	71.5	60.0	69.4

Typical spectrum obtained is show in Fig.5 the amplitudes diminish due to flaws.

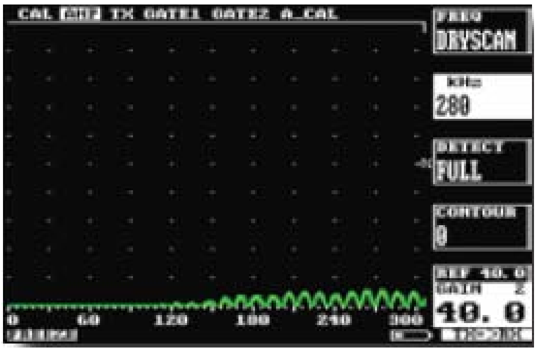

Figure 5: Cumulative signal with severe flaw

The status of severity of the defect before and after tests can be observed from Table.3

Table 3: Ultrasonic Report showing difference in dB

	1	2	3	4	5	6	7	8	9	10
B	2	5.4	4	18	[illegible]	13.6	9	3.3	3.3	[illegible]
C	7.4	4.7	9.3	[illegible]	8.3	1.5	15.6	2.4	15.7	13.6
D	2.9	11	9.3	6.4	4.5	2	20.6	6.4	18.3	17.3
E	4.1	16.1	11.7	22.6	6.1	[illegible]	3.6	1.7	19.8	15.1
F	4.4	[illegible]	5.5	7.3	0.1	6	3.8	25.3	30.4	22.2
G	21.4	[illegible]	[illegible]	[illegible]	23.6	7.7	6.5	8.8	0	5.8

In this test 6 dB difference may be considered as no defect and beyond 6 dB up to 10 dB may be considered as minor defect and between 10 dB and below 20 dB will represents the medium defect. The highest attenuation of ultrasonic signal shall represents the severe defect when it crosses 20 dB and above. However the cluster of defects as per the above dB ranges represents the internal damage as shown in Table.3.

6. Conclusions

1) Dry scan method was used to identify the inherent flaws of the FRP sandwich panel before and after air blast test. This method can be used in both laboratory and field conditions.
2) Using ultrasonic testing the load and location of the panel at which flaws occur were identified.
3) Development and ultrasonic testing method of hybrid sandwich panel was established for the first time to best of our knowledge.

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