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DESIGN, MANUFACTURING AND TESTING OF COMPOSITE PACKAGING CASES FOR AIRBORNE EQUIPMENT

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ABSTRACT

A composite material is a combination of two or more different materials which are insoluble with each other and it gives superior quality than its constituents. Composites can be used not only for structural applications, but also in various other applications such as automobiles, aerospace, marine, etc. Fibre reinforced plastic (FRP) materials are widely used in various engineering industries because of their superior performance and tailor made properties. Though FRPs are widely used in various fields, they are flammable. Extensive research has been carried out on composite packaging cases which are made of FRP composites. The motive to develop this project is to improve the impact strength, reduce the weight and to reduce moisture absorption in order to give environmental safety to the products being stored. This was done by using different thickness of filler material in GFRP. The model was developed using solid works software from the existing literature and then case study was done on the packaging box. The manufacturing of the packaging box was done using the glass fibre reinforcement with polyester resin by vacuum infusion bagging process and various tests were carried out. From this study, we found out opportunity to improve the environmental design of the packaging cases and hence improve the quality and safety standards of the packaging cases.

Keywords: Glass-Polyester, Uni-Directional, Bi-Directional.

I. INTRODUCTION

The composite material is one, which is combination of two or more material working together to produce new material having properties different from those materials on their own. The selection for type of composite used is based on the type of application. Polymer matrix composite are used in automotive, aerospace, marine and construction and also in the present study for packaging cases we are using polymer matrix composites for airborne packaging cases [1]. The packaging cases are used by the department of Defence for specialized shipping containers. The packaging cases are mainly used to support and protect its prescribed contents and materials while being stored, handled, shipped to and to protect personnel equipment from hazardous contents. The packaging containers of this type are energy absorbing system, l features to make handling easier or safer and temperature control systems [2]**.** During the quality testing of the case their goodness with drop and toppling test. But the main focus is on the evaluating the ruggedness of equipment even when the packaging box may get

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damaged to some extent during the quality testing, but attention is not given. Since the main function is been served the main purpose of protecting the equipment Problems faced during the hand layup process involve Non uniform thickness of packaging, case is obtained, Surface finish is low, Quantity of resin used is more & Impact Strength obtained is low[3].

II. MANUFACTURING PROCESS

In the geometrical modelling we have created computer aided design (CAD) of model of physical geometry of packaging cases. For engineering application model should have higher in accuracy of shape and geometric size. Small packaging case having dimensions, 430mm in length, 430mm in width and height is 352mm including top. In this packaging cases all sides are planes and edges having arc radius 45mm.

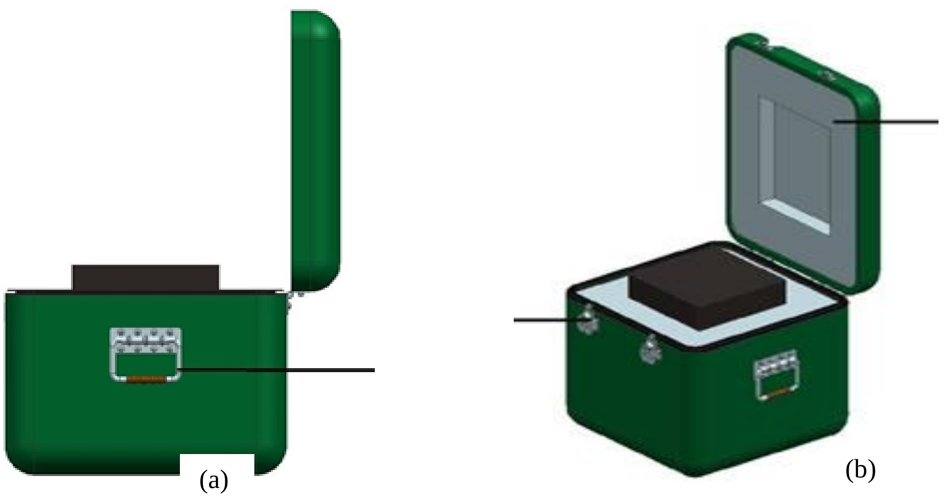

Fig.1 3D drawings of small packaging case (a) front view (b) side view

2.1 Materials selected

Fiber glass of Multi directions (Chopped mat)-300GSM, Fibre glass of Multi directions (chopped mat)-450GSM, Fiber glass of Bi-Directional-300GSM, Polyester resin, PVC Foam as core material.

2.2 Process Flow

Mould is prepared so that the shape of product is obtained by the mould. The product is made inside of a female mould to obtain the smooth outer surface of the product. Fibre glass mat will be cut according to the required shape and size of the box. The gel coat is the thin layer of resin somewhat about mm in thickness and applied on the outer surface of the product [4]. Fibre glass mat will be laid in the mould arranging the overlaps at critical parts of the boxes to withstand any impact or penetration. Firstly for packaging case I we have used multi-directional glass fibre of 450 GSM and cut according to its dimensions and inserted in the mould using hand, after then glass fibre of 300 GSM is placed above the bidirectional glass fibre. Then third layer of core mat of 2mm thickness is placed above it, then fourth layer of glass fibre of 450 GSM is placed on it. Then fifth layer of glass fibre 300 GSM is placed on it. After the mat lay up of various sequences the nets are placed so as to provide a better resin flow. On the all four sides of flange the spiral tube are placed. Spiral tube helps to flow resin. After the layering of flow net the peel ply is placed by hand. Peel ply gives good inner surface finish.

After laying of peel ply in the mould a plastic bag is taken and checked for any defects and the vacuum bag is cut depending upon the size of the packaging case and then the vacuum bag is placed upon the peel ply in the mould. The side edges of the vacuum bags which are

On the flange are sealed using the sealant [5].

Table 1 Total thickness of packaging cases

Packaging cases	Sequence of layering	Thickness of each layer in mm	Total thickness of packaging case
I	1. Glass fiber of multi directional (450GSM)	0.6	4.2
	2. glass fiber of bi-directional (300GSM)	0.6	
	3. core mat	2	
	4. Glass fiber of multi directional (450GSM)	0.6	
	5. glass fiber of bi-directional (300GSM)	0.4	
II	1. glass fiber of bi-directional (300GSM)	0.6	4.2
	2. Glass fiber of multi directional (450GSM)	0.6	
	3. glass fiber of bi-directional (300GSM)	0.6	
	4. core mat	1.5	
	5. Glass fiber of multi directional (450GSM)	0.6	
	6. glass fiber of bi-directional (300GSM)	0.4	
III	1. glass fiber of multi-directional (300GSM)	0.4	4.2
	2. glass fiber of bi-directional (300GSM)	0.6	
	3. Glass fiber of multi directional (450GSM)	0.6	
	4. Glass fiber of multi directional (450GSM)	0.6	
	5. core material	1	
	6. Glass fiber of multi directional (450GSM)	0.6	
	7. glass fiber of bi-directional (300GSM)	0.4	

The resin inlet connector is fitted in the middle of the vacuum bag so as to provide proper resin flow in the mould. The vacuum connector is attached to the spiral tube to create the vacuum inside the vacuum bag. Once it is ok the clamp attached to the resin inlet connecter is opened and resin is injected through RIC. The curing is done for an hour at ambient temperature [6]. Once 100% curing is obtained the component is removed from the mould. The entire pin holes on the surface will be filled and smoothen the trimmed edges by filing. Required coloured Pu paint is sprayed. Pu lacquer applied to give high gloss or mat finish on the surface. This lacquer will resist surface with any scratches [7].

III. EXPERIMENTATION & RESULTS

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3.1 Impact Test

A steel hemispherical striker having a radius of 50mm and a mass of 1.3kg was used and this was attached to the holder of mass 4.2 kg to the drop rig assembly of Rosandrig. The Rosand rig is fitted with a number of sensors to get the data for the required test. Piezo electronic sensor was attached to striker to measure the force when striker hits the box. For all the test the boxes are mounted on a standard head within the rig frame. To carry out the impact test total 4 impact test were conducted [8].

Table 2 Impact test result for packaging cases

Sl.no	File title	Packaging case (i)	Packaging case (ii)	Packaging cases (ii)
1	Conditioning	Ambient	Ambient	Ambient
2	Drop height	165.5	165.5	165.5
3	Point of impact	S T B	S T B	S T B
5	Speed (m/s)	5.45	5.45	5.43
7	Impact energy	10.25	13.21	17.24
8	Friction %	2.4	2.8	2.9
9	Shock abs. mat	PVC Foam	PVC Foam	PVC Foam
10	Thickness (mm)	2	1.5	1
11	HeadF.size (cm)	570	570	570
12	HeadF.mass(Kg)	4.68	4.68	4.68
13	Packaging case material	GF	GF	GF
14	Friction %	5	5	5

3.1.1 Impact energy & friction for packaging case (I)

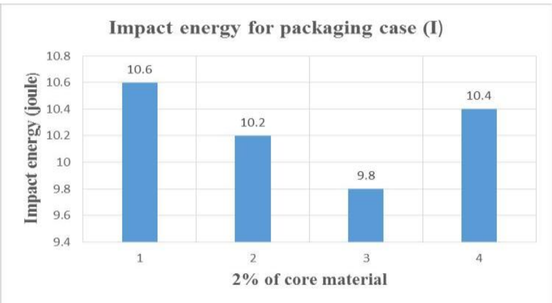


Fig. 2 Impact energy for 2% of core material

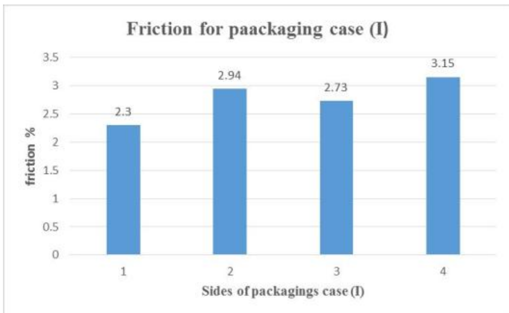


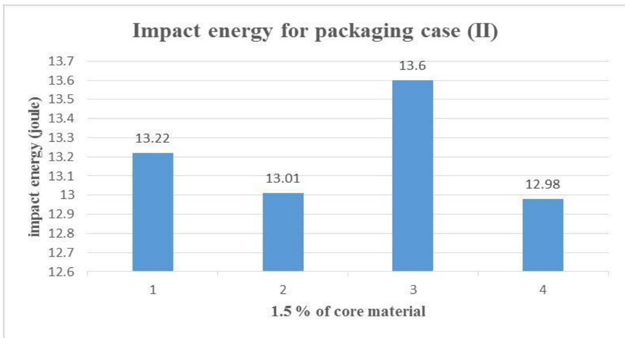
Fig. 3 Friction *vs.* side of packaging case

From the above data table we have plotted graph impact energy for 2 % of core material of packaging case (I).

Graph shows that 1, 2, 3 and 4 are right, top, base and left side of the packaging case respectively. So the average value of impact energy is 10.4 joule.

Fig.3 shows that graph for friction percentage *vs* 2 % of core material of packaging case (I). Graph shows that 1, 2, 3 and 4 are right, top, base and left side of the packaging case respectively. So the average value of friction is 3.15 %.

3.1.2 Impact energy & Friction for packaging case (ii)



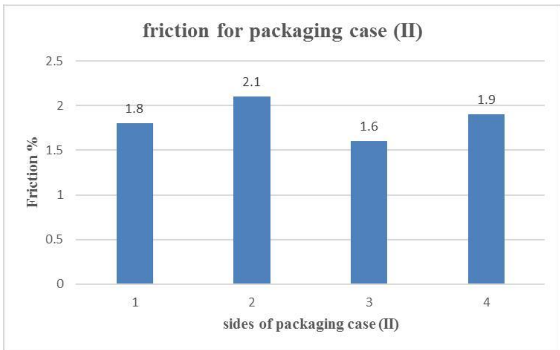
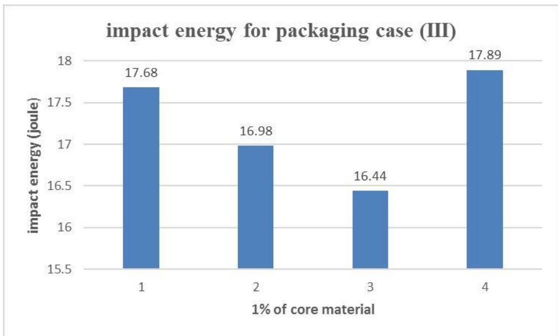


Fig.4 impact energy for 1.5% of core material **Fig.5 friction *vs.* side of packaging case (ii)**

From the above data table we have plotted graph impact energy for 1.5 % of core material of packaging case (II). Graph shows that 1, 2, 3 and 4 are right, top, base and left side of the packaging case respectively. So the average value of impact energy is 13.21 joule. Fig.5 shows that graph of friction percentage for 1.5 % of core material of packaging case (I). Graph shows that 1, 2, 3 and 4 are right, top, base and left side of the packaging case respectively. So the average value of friction is 1.85 %.

3.1.3 Impact energy & Friction for packaging case (iii)



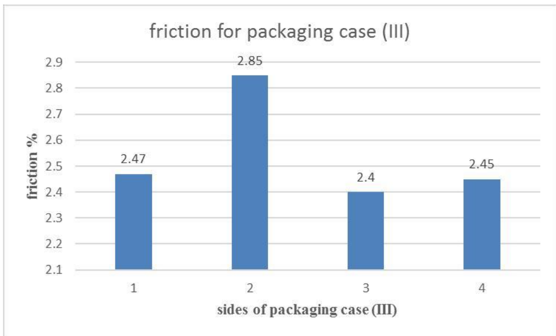


Fig.6 impact energy for 1% of core material **Fig.7 friction *vs.* side of packaging case (iii)**

From the above data table we have plotted graph impact energy for 1% of core material of packaging case (III). Graph shows that 1, 2, 3 and 4 are right side, top, base and left side of the packaging case respectively. So the average value of impact energy is 13.21 joule. Fig.7 shows that graph for friction percentage for 1.5 % of core material of packaging case (III). Graph shows that 1, 2, 3 and 4 are right side, top, base and left side of the packaging case respectively. So the average value of friction is 3.15

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3.1.4 Comparison of impact energy between packaging cases (i), (ii) and (iii)

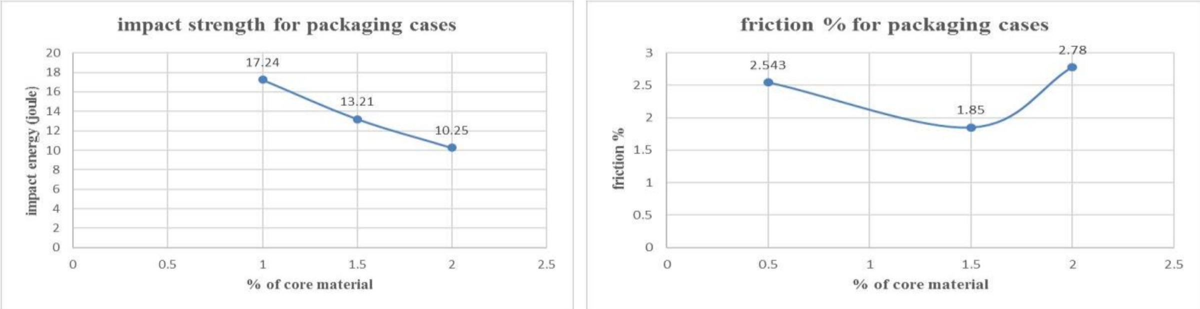

Fig.8 Comparison of impact energy & friction between packaging cases (i), (ii) and (iii)

The above graph shows that the comparison of impact energy between the packaging cases (1), packaging case (ii) and packaging case (iii). Average impact energy for packaging case(i) is 10.25 joule , for packaging case (ii) is 13.21 joule and for packaging case (iii) is 17.24. As a comparison result shows that as a percentage of core material increase impact energy of packaging cases decreases. The graph shows that the comparison of friction percentage between the packaging cases (1), packaging case (ii) and packaging case (iii). Average friction percentage for packaging case (i) is 2.78 % , for packaging case (ii) is 1.85 % and for packaging case (iii) is 2.543.

3.2 Penetration Test

A Steel cone with an angle 60^0 of a point and 0.5mm radius was used for the penetration test. The striker was connected to Rosand rig for the test. A measured energy value of 30 joules was used by the striker to impact the box. A combined mass with the rig of 4.912 kg was used to drop at a height of 0.66m to reach 30 joule energy to obtained required impact of 50KN and this test was conducted without the standard form fitted[9].

3.3 Drop Test

After production of the box, it will be physically and visually examined. After examination of the box it is dropped from a height of 120cm on each face, corner and edge. A total of 22 drops on a concrete floor are done. After the completion of the 26 drops the box is again visually and physically examined [10].

3.3.1 Drop test result for height 120 cm & 140 cm

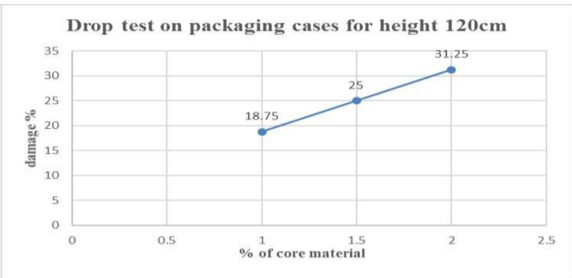

Fig.9 Drop test result for height 120 cm

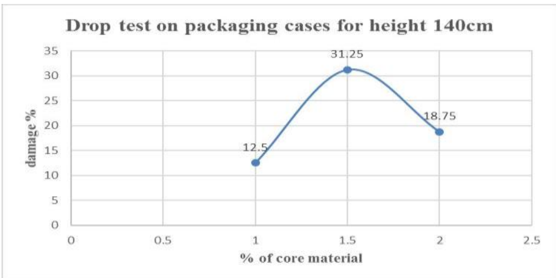

Fig.10 Drop test result for height 140cm

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From the result of drop test data table for 140cm & 120cm drop height we have plotted the graph damage % vs. % of core material. Graph conclude that damage is more for 1.5 % of core material and lower for other two. So we can say that damage may be occurs due to uneven laying of mat or improper resin flow.

3.4 Moisture Content Test

This property of packaging case depends upon the void content. Higher the void content in the packaging case, more the moisture absorb and the vice-versa, which in turn leads to low fatigue resistance, weathering or scatter in the strength property[11].

Table.3 Result of Moisture Content Test on Packaging Cases

Packaging cases	Oven dry weight of packaging case in kg	Weight of packaging cases after 24 hours in water bath in kg	Moisture content %
I	7.38	7.52	1.89
II	7.98	8.13	1.87
III	8.34	8.54	2.39

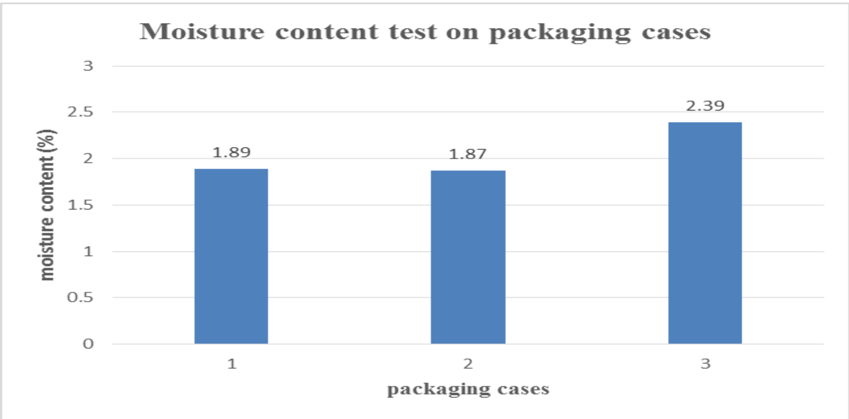

Fig.11 moisture content test on packaging cases

It clearly shows that moisture content for packaging case (i) is about 1.89 %, for packaging case (ii) is 1.87 % and for packaging case (iii) is 2.39 %. This moisture content test conclude that higher moisture content in packaging case (iii) and other two are lower and equal to each other.

IV. CONCLUSION

Vacuum infusion permits high surface finish and hence a good quality enhancement achieved. Increase in percentage of core material increased the shock absorbing capacity & hence impact energy release rate decreased. Due to high surface finish the percentage of friction obtained was well within the safe limit. Penetration test indicated presence of only small surface cracks implying a good distribution of resin with fibers. Minor damages obtained from drop tests. Very less void content hence permitting to minimum moisture content.

V. ACKNOWLEDGMENT

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