Comparative study on the 2D fabric materials by weighted property method in FRP composites

Mahan Miraskar M [1], Kiran Kumar P [2]

[1]*M.Tech student, Dept. of Mechanical Engineering, S J B Institute of Technology, VTU, Bangalore 560 060, India*
[2] *Professor, Dept. of Mechanical Engineering, S J B Institute of Technology, VTU, Bangalore 560 060, India*

---***---

Abstract- *Composites have benchmarked the industrial market by replacing other materials with respect to its performance in terms of selection of material Fibres and its orientation, Thermal, Mechanical, Tribological and water absorption. Here weight ratio is the main reason which made composite material era to grow up very vastly in the manufacturing sectors whose applications are applied as per requirement of the customer. Strength to weight percentage is mandatory in selection of the material in the Aerospace and Aircraft industry, Corrosion is given most prominence in the marine industry due to salinity, Impact energy absorption is the precaution taken by the Automobile industry been tested in CFD analysis in case of Fatal accidents safety stands first, In case of Dams, construction industry it's the basic step to test the tensile property, compression and flexural property. As Composites can be selected for various applications, Designer has to analyze the importance of selection of right Reinforcement*

Key Words**:** ***Benchmarking, water absorption, weight ratio, salinity, CFD analysis and Reinforcement.***

1. INTRODUCTION

Inspite of demonstrating the advantages of composites as one of the adaptable Engineering material with respect to its through-thickness and the Impact performance The Glass Fiber reinforced composite been evolved from the materials that have diverse ranging of applications. Composites nowadays been used in Space craft, Ships, Automobiles, Chemical Processing equipment's. This is only because of their light-weight, better fatigue resistance, corrosion resistance, outstanding specific stiffness, very high specific strength as they are compared to alloys of metal like aluminum and steel. The directional mechanical properties of fabricating the composites are advantageous because of its outstanding combination of Thermal, Mechanical and physical properties which are based on weight saving criteria and the reason today the have been used in the place of metals in various applications. GFRP composites are multi constituent materials that have reinforcing glass fibers that are embedded in polymer matrix which is rigid. Many of the engineering applications today are made of glass fibers, aramid and carbon.

Engineering applications will require high strength, fatigue resistance and high stiffness. Composites may be reinforced with fibers that are continuous than the particles that are small or which are called as whiskers. The two dimensional (2D) laminated structures which are characterized by the continuous fibres have their structure which will be aligned on the plane of x and y directions, there is no fibers which are aligned in the z direction. This can be a disadvantage interms of ease of processing, high cost, impact damage resistance and its mechanical performance. The main disadvantage of composite material is that the current manufacturing processes are very expensive, still the fabrication of composites are done by conventional processing techniques like Auto clave, Hand lay-up and resin transfer molding .

These needs high skilled labor to stack, cut and consolidating the laminate plies to preformed application. In aircraft production the structures are 60 plies of carbon fabric prepreg tape that are individually stacked and been hand aligned, Naval ships hulls are made of 100 plies which are woven from glass fabric that are consolidated by hand and they need to be stacked. The z direction lacking binder means the plies are stacked individually that will add considerably to time of fabrication. The lacking of thickness glass fibers means plies may slip during lay-up and this will lead to misaligning of the fibre orientations in the components, the fore coming problem with fabrication of composites is that production rates have been often low because of slow curing of resin at elevated temperature.

Complex shape composites fabricating cost more because prepreg tapes and some of the fabrics have poor draping. The materials cannot be easily moulded into Complex shapes, as a result theses composite components will be assembled from a large quantity of separate parts that can be joined by adhesive bonding, cocuring and mechanical fastening. This will be a major problem in the aerospace industries where the structures of composite like wing section will be made of huge number small laminated parts like stiffners, skin panels and stringers. The composite components fabrication problems have got impeded to its usage of composite in structures of aerospace and aircraft because of its significance as it is very expensive than the aluminium alloys.

As high cost is concerned another disadvantage in 2D laminate is its low through-thickness properties which are only due to the lacking of z-direction fibres. so the 2D arrangement of glass fibers provide less strength and little stiffness because of these properties will be determined by mechanical properties and resin to fiber interface .A comparison of through thickness and in plane strengths in 2D laminates is been shown in the figure B .so it is seen that properties of through-thickness are less than 10% of in-plane properties. Due to this 2D laminates cannot be used as structures that support interlaminar shear loads and through thickness.

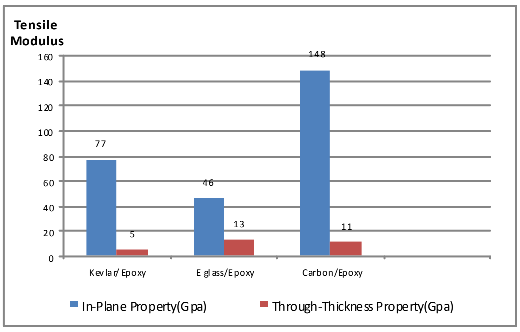


Figure 1: Tensile Modulus Representation

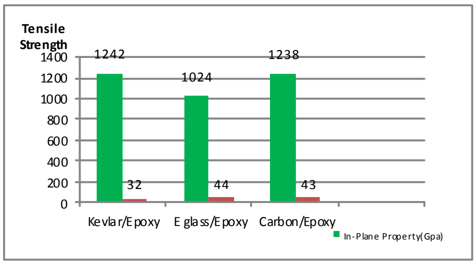


Figure 2: Tensile Strength Representation

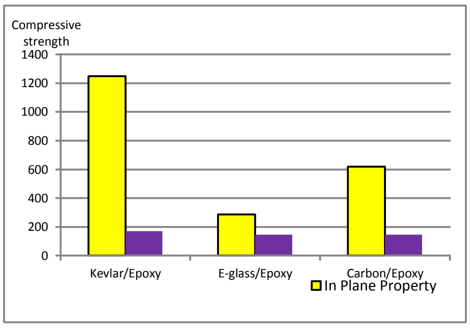


Figure 3: Compressive Strength Representation.

2. LITERATURE SURVEY.

Dieter, et al, [1] They have given us a clear idea on weighted property method on selection of the material by ranking them and the first step in the manufacturing industry is to select the right optimized material, even though there are many methods for selection they have turned Logic fuzzy method based on machining, Profit and cost analyzing, Multi-Design criteria method Limit Properties methods and weighted property method. Each property are concerned based on the attributes and material requirements.

MYER KUTZ, et al,[2] They have studied the various material characteristics and based on the mechanical properties the material selection is been documented in the form of the DATA hand book ,which will be useful for the material selection criteria in the future.

L. Tong, et al, [3] they have made documentation on the 3D reinforcement of fibre in polymer composites, about the manufacturing process that are been carried in 3D fibre preforms, it may be weaving, stitching, braiding and knitting, The consolidation of the preform in cases like the Injection Equipment, the important criteria of the selecting the Resin, the type of tools used ,they also gave a brief explanation on the properties of the 3D weaved composites interms of microstructures.

X. Wang, et al, [4] they did study on the aramid/basalt hybrid composites based on the less velocity impact loading properties in 3 Dimensional FRP composites, the fibre arrangement was noted with interplay hybrid composites had showed ductile indices higher, absorption of higher specific energy and less peak load in case of both weft and warp .They studied rule of mixture, in the brittle mode of intraply composite they confirmed the low energy absorption.

K. Palani Kumar et al , [5] he has conducted the machinability experiment on the glass fiber reinforced polymer composite materials in which his work showed the he has conducted the machinability experiment on the glass fiber reinforced polymer composite materials in which his work showed the various fiber angled orientation in case of the machinability of theses GFRP tubes were varying from 31^0 to 89^0.The surface roughness was greatly influenced by the cutting speed feed and orientation angle of the fiber. Here the machining process of the GFRP composites with the less feed rate, normal cutting speed and low fibre orientation angle and normal depth of the cut are preferred.

J Naveen et al, [6] he has made studies on Glass fiber reinforced polymer composite material, in his research works the water absorption properties, thermal, Tribological and mechanical properties of GFRP composites, with the increase of the fiber glass with respect to its weight there was a increase in ultimate tensile strength and flexural strength and also with the term(Vf) which is nothing but volume fraction of the glass fiber if it was increased it lead to increase in the young's modulus of the composite material. The natural frequency for all of the conditions was measured lower wear was found with respect to the damping properties of GRP with the increase in Glass fibers content ,it was also observed that impact and compressive strengths would gradually decrease.

Dr.Mohammed Jasim Khadim, et al, [7] they did study on the conceptual design which was on the material selection by weighted property method, the documented the process and selection criteria stages based on the properties required Manjunath Shettar et al, [8] he has completed his experiment on investigation and fabrication of epoxy based Hybrid glass fiber composite material, this research work are showing clearly about 6% of tensile strength of fiber coir is the best characteristic the specimen will have in tensile testing. With the addition of the coir fibers the young's modulus and tensile strength are seen to decrease, In case of the coir fiber specimen the impact test was found highest of 4%, it is observed keenly that the impact energy decreases with the increase in the alkali percentage treatment of fibers, and flexural testing results were also obtained where the treated yield fibers showed 6% which was the best result.

Athid D et al [9], he did experimentation on the Tribological and mechanical characteristics on GFRP composites, here he showed the Sisal/Glass, Jute/Glass combination had a increase in the tensile, Impact and Flexural strength. While flexibility is considered in comparison of Glass fiber and Natural rubber, they had increase in the fracture toughness and Tensile strength, better wear resistance was more in bi-directional GFRP composite than the unidirectional material composite.

3. DISCUSSION AND CALCULATION:

There are a number of important properties and requirements to evaluate and compare, this can be solved from DFM concept called Weighted Property Method. The terms used in are (β) Scaled value and (α) Index or Weighing factor.

Here Multiplied scaled properties Sum and index will represent the (γ) Performance index. The combination of the manufacturing process and the material selection will decide the priority in the highest ranking performance index for the desired optimum solution.

The properties of Material like Density, Corrosion, Yield strength, Specific modulus; machinability & Young's modulus are considered while making weighted residual method.

Table-1: Weighted Factor

SL. No	Property	Weight Index(α)
1	Density	6
2	Cost	11
3	Tensile Strength	4
4	Compressive Strength	5
5	Flexural Strength	2
6	Impact Strength	1
7	Major Poisson Ratio	9
8	In-plane Shear Modulus	7
9	Young's Modulus	3
10	Thermal Exp.Co-ef	10
11	Resin Impregnation	8

Table 2: Material Properties

Material	Scaled Factor Index(β)										
Mechanical Properties	Density	Cost (Rupees)	Tensile Strength	Compressive Strength	Major Poisson Ratio	In-plane Shear Modulus	Young's Modulus	Thermal Exp.Co-ef	Flexural Strength	Impact Strength (Joules)	Resin Impregnation	Availability
Carbon Fiber	1.612	4000	602	571	0.11	6	70	2.15	304.81	2	3	3
Kevlar Fiber	1.4	3500	480	190	0.2	2	31	7.4	167	2.8	3	3
E-Glass	1.9	210	480	425	0.22	4	24	11.6	480	3.1	5	5
Boron Fiber	2.48	3800	1410	282	0.23	5	205	18	440	1.8	3	3

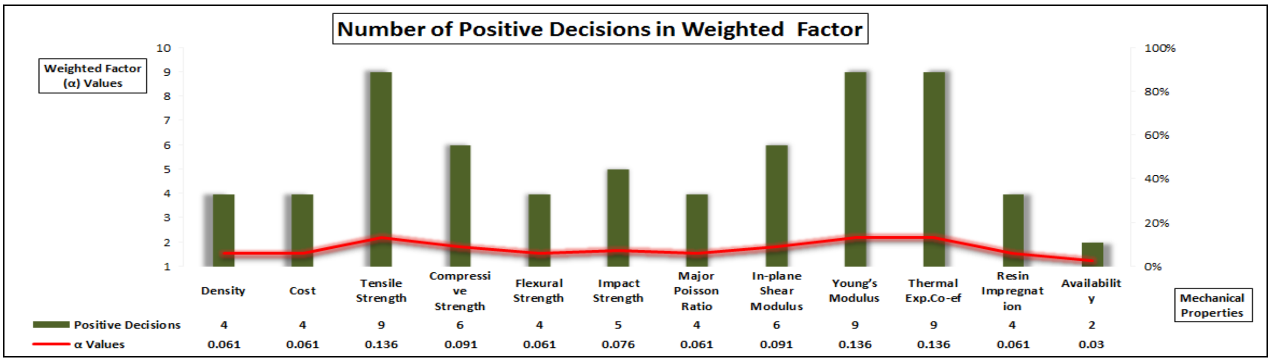
Table 3: Scaled Factors consideration

Material	Scaled Factor Index(β)										
Mechanical Properties	Density	Cost(Rupees)	Tensile Strength	Compressive Strength	Major Poisson Ratio	In-plane Shear Modulus	Young's Modulus	Thermal Exp.Co-ef	Flexural Strength	Impact Strength(Joules)	Resin Impregnation	Availability
Carbon Fiber	86.85	5.25	42.70	202.48	47.83	100.00	34.14634146	100.00	69.28	64.52	60	60
Kevlar Fiber	100.00	6.00	34.04	67.38	86.96	33.33	15.12195122	29.05	37.95	90.32	60	60
E-Glass	73.68	100.00	34.04	150.71	95.65	66.67	11.70731707	18.53	109.09	100.00	100	100
Boron Fiber	56.45	5.53	100.00	100.00	100.00	83.33	100	11.94	100.00	58.06	60	60

Table 4: Ranking and Performance value

Material Properties	Performance Index [γ = ∑ (β*α)]												
Fibers	Density	Cost(Rupees)	Tensile Strength	Compressive Strength	Major Poisson Ratio	In-plane Shear Modulus	Young's Modulus	Thermal Exp.Co-ef	Flexural Strength	Impact Strength(Joules)	Resin Impregnation	Availability	Performance Index	Ranking
α	0.061	0.061	0.136	0.091	0.061	0.076	0.06	0.091	0.136	0.136	0.061	0.03	1	
Carbon Fiber	5.30	0.32	5.81	18.43	2.92	7.60	2.05	9.10	9.42	8.77	3.66	1.80	75.17219344	3
Kevlar Fiber	6.10	0.37	4.63	6.13	5.30	2.53	0.91	2.64	5.16	12.28	3.66	1.80	51.52159921	4
E-Glass	4.49	6.10	4.63	13.71	5.83	5.07	0.70	1.69	14.84	13.60	6.10	3.00	79.76595295	1
Boron Fiber	3.44	0.34	13.60	9.10	6.10	6.33	6.00	1.09	13.60	7.90	3.66	1.80	72.95770562	2

Figure 5: Ranking and performance indexing of the material



Depending on the importance of the material requirement the method selection plays an important role while assigning a certain weight. In the weighted property method the value which is obtained by multiplying scaled values by using the properties of weighing factors (α).for each material the weighted property values are summed to performance index (γ).As per the mechanical properties of the various fibers the optimum highest performance index material is chosen.

$$\text{Scaled Property } (\beta) = \frac{(\text{Numerical Value of Property})}{(\text{Maximum value in List.})} \times 100$$

In case of Corrosion, loss, cost and etc. the least value is preferred and the less value is considered rating as 100.

$$\text{Scaled Property } (\beta) = \frac{(\text{Minimum Value in the list})}{(\text{Numerical Value of the Property})} \times 100$$

Material Performance Index (γ),

$$\gamma = \sum (\beta^* \alpha).$$

This is always depending on the positive decisions where least values of the cost, density, corrosion and thermal expansion and tensile, compression, flexural, impact strength properties are taken largest values.

The product of weighted index and scaled property results to the performance index

4. CONCLUSION:

Considering the density, cost, tensile , flexural, impact, compression, young's modulus, resin impregnation, performance index and availability the comparison with Carbon ,Kevlar, E-glass and boron fiber was made and was found that E-glass had ranked better than the other 3 fibers with respect to their orientation and mechanical properties. E-Glass can be used in further projects as a value added value engineering material in future.

5. REFERENCES:

[1] Engineering design by Dieter, fourth edition, Mc Graw Hill Education.

[2] Hand book of Material selection, edited by MYER KUTZ.

[3] 3D fiber reinforced polymer composites by L. Tong.

[4] Dr.Mohammed Jasim Khadim, Dr.Mithal Al-basem , Material selection in conceptual design by using weighting property method, Engg Tech Journal,Vol:29,No.1.2011.

[5] Syed Altat Hussain , V. Pandurangadu , K. Palani Kumar , Machinability of the glass fiber reinforced plastic (GFRP) composite materials, International Journal of Engineering, Science and Technology, Vol. 3, No.4, 2011.

[6] TP Sathish Kumar, S Satheesh kumar and J Naveen, Glass fiber-reinforced polymer composites- a review, Journal of Reinforced Plastics and Composites 2014, Vol. 33(13) 1258-1275 the Author(s) 2014.

[7] Dr.Mohammed Jasim Khadim, Dr.Mithal A-basem , Material selection in conceptual design by using weighting property method, Engg Tech Journal,Vol:29,No.1.2011.

[8] N.S.Mohan, Manjunath Shettar, Ritesh Bhat, Fabrication and Investigation of Epoxy resin based Glass Fiber-Coconut Fiber Hybrid Composite Material, 10th International Conference on Mechanical & Automobile.

[9] Kiran kumar.P, Suresh Talur ,Selection of material by weighted property method for Savonius Vertical Axis Wind Turbine Rotor blade, IRJET April 2015

[10] Manjunath Shettar, Vithal Rao Chauhan & Pavan Hiremath, An Experimental Study of Mechanical Properties of GFRP Hybrid Composite with Different Fillers, e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 3, March 2015.