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Experimental Investigation Of Glass Fiber Reinforced Composites Using Impact Test

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Abstract: Composite is a combination of two or more chemically distinct and insoluble phases. The composites consist of one or more discontinuous phases (reinforcement) embedded in a continuous phase (matrix). Composite Material is mainly used to improve the properties of material. The present paper reviews various types of composite material used in different industrial and commercial applications. study of various manufacturing technique for preparation of composite material are described. Various mechanical testing techniques are presented to check the characterisations.

Composites are extensively used because of their high strength to weight ratio. Moreover, the use of versatile synthetic fiber in preparation of the composites with concern toward the environment issues to develop composites using glass fiber reinforced. In the present paper, glass fiber reinforced epoxy composites are synthesized considering three factors viz. epoxy to hardener ratio, curing temperature and fiber percentage to study the tensile behavior of the composites. The experiments were conducted based on Taguchi L9 orthogonal array considering three design parameters. The experimental data were analyzed using Taguchi optimization technique and optimum combinations of process parameters values for tensile strength was determined. Analysis of variance (ANOVA) was carried out to obtain the significance of factors affecting the tensile strength. It was observed from the analysis that the percentage of fiber has more significant effect on tensile strength at 95% confidence level.

Index Terms - Composite material, compression molding, taguchi methods, tensile strength, shear strength, bending strength, impact strength, hardness strength of test, analysis of variance.

I. INTRODUCTION

The automobile and aeronautical industries are continuously looking for light weight and more resistant materials in order to improve the effectiveness and reliability of their systems. Composite materials have proved to be an excellent solution to this demand. Composite material is a macroscopic combination of two or more distinct materials, having a noticeable interface between them. Composite laminate is a combination of fiber and resin mixed in proper form. One of the unique properties of composite laminate is high specific strength. Composites are being utilized as feasible substitutes to metallic materials in structures where weight is a major concern, e.g., aerospace structures, high speed boats and trains.[1]

Glass fibers reinforced polymer composites have been prepared by various manufacturing technology and are widely used for various applications. Initially, ancient Egyptians made containers by glass fibers drawn from heat softened glass. Continues glass fibers were first manufactured in the 1930s for high-temperature electrical application. Nowadays, it has been used in electronics, aviation and automobile application etc. Glass fibers are having excellent properties like high strength, flexibility, stiffness and resistance to chemical harm. It may be in the yarns, fabrics and mats. Each type of glass fibers have unique properties and are used for various applications in the form of polymer composites. The mechanical, tribological, thermal, and vibrational properties of various glass fiber reinforced polymer composites were

described[2].Composite materials produce a combination properties of two or more materials that cannot be achieved by either fiber or matrix when they are acting alone. Fiber-reinforced composites were successfully used for many decades for all engineering applications[3]

The mechanical behavior of a fiber-reinforced composite basically depends on the fiber strength and modulus, the chemical stability, matrix strength and the interface bonding between the fiber/matrix to enable stress transfer [4]. Suitable compositions and orientation of fibers made desired properties and functional characteristics of GFRP composites was equal to steel, had higher stiffness than aluminum and the specific gravity was one-quarter of the steel [5]. The properties of composites depend on the fibers laid or laminated in the matrix during the composites preparation. High cost of polymers was a limiting factor in their use for commercial applications. Composite materials have wide range of industrial applications and laminated GF reinforced composite materials are used in marine industry and piping industries because of good environmental resistance, better damage tolerance for impact loading, high specific strength and stiffness [6]. Polymeric composites were mainly utilized in aircraft industries such as rudder, elevator, fuselage, landing gear doors, that is due to light weight, reduction of higher fatigue resistance in the fasteners and number of components [7]. Polyester matrix-based composites have been widely used in marine applications; in marine field the water absorption was an important parameter in degradation of polymer composites [8]. The different mechanisms were used to identify the degradation of material such as initiation, propagation, branching and termination [9]. Epoxy resins have been widely used for above applications that have high chemical/corrosion resistance properties, low shrinkage on curing. The capability to be processed under various conditions and the high level of cross linking epoxy resin networks led to brittle material [10]

Energy dissipation of composite was important when they were subjected to vibration environment. Several factors influenced the energy dissipation of FRP composites such as fiber volume, fiber orientation, matrix material, temperature, moisture and others like thickness of lamina and thickness of the composites [11]. All polymeric composites have been temperature-dependent mechanical properties. The dynamic stability of polymer matrix composites like the storage modulus and damping factors were essential to investigating under cold and higher temperature [12].

II. MATERIAL SELECTION

1. Based on the type of matrix material

Each type of glass fibers have unique properties and are used for various applications in the form of polymer composites. Functional characteristics of GFRP composites was equal to steel, had higher stiffness than aluminum and the specific gravity was one-quarter of the steel . Properties that have made glass fiber so popular in glass fiber reinforced composites include low cost, high production rate, high strength, high stiffness, relatively low density, non flammable, resistant to heat, good chemical resistance, relatively intensive to moisture able to maintain strength properties over a wide range of conditions, good electrical insulation. Glass fibers reinforced polymer composites have been prepared by various manufacturing technology and are widely used for various applications. Glass fibers are having excellent properties like high strength, flexibility, stiffness and resistance to chemical harm. Lapox L-12 is an unmodified epoxy laminating resin designed for high performance applications with low viscosity (Fig. 1). It can be used with various hardeners for making GFRP. The choice of hardener depends on processing method.

Hardener K6 is a low viscosity room temperature curing liquid hardener. It is commonly employed for hand layup applications.

Being rather reactive, it gives rapid cure at normal ambient temperatures. Laminates can be subjected to operating temperatures from 40 _C to 120 _C. Lapox L-12 and Hardener K-6 can be mixed easily at room temperature. Since three process parameters are considered, an L9 orthogonal array was selected by using Taguchi method [8]. The process parameter considered in the study and their levels are shown in Table 1. As per L9 orthogonal array, using Taguchi method a total of 9 experiments are conducted to study the tensile strength of the GFRP.

Fig.1:-Glass with Epoxy resin and K-6 hardener.

2. Manufacturing process of Composite Material

Compression Molding-

The Compression molding is very high-pressure method. it is suitable for molding the glass fiber reinforcements with high-strength. In this process the bottom half of the mold weighed charge is placed The charge may be BMC (bulk molding compound) or SMC (sheat moulding compoung) these are mixture of chopped glass strands and resin. Both the parts of mold are bonded and heated to 2500 to 4000 F, where the pressure around 60 to-100 bar is applied to the charge. Maintain the heat and pressure up to the molding material come in contact with all mold areas and it is cured. Compression molding process is also used for producing composite from unconventional fibers Unconventional fibers like flax, hemp, sisal etc are comingled with the fiber of the thermoplastic polymer. Then it is hot pressed in the mold to melt the thermoplastic fiber thereby forming the composites.

Advantages

Compression molding is a fast molding process.

The process is automated.

Good surface finishes are obtainable, contributing to lower finishing cost.

Labour costs are low.

Applications:

automobile components, electrical components etc are produced by using BMC and SMC.

Fig.2:- Composite molding machine

III. DESIGN OF EXPERIMENT USING TAGUCHI METHOD

- The experiments are to be carried out based on Taguchi design technique, which is to be used to acquire data in a controlled way. An orthogonal array and analysis of variance have been applied to investigate the influence of process parameters mechanical properties of glass fiber composite.

TABLE NO – 1 Parameters and their levels

E/H ratio	Parameter and levels		
	Glass fiber %	Temperature	Pressure
2	20	40	1
4	20	80	2
6	20	120	3
4	40	120	1
6	40	80	2
2	40	40	3
6	60	40	1
2	60	80	2
4	60	120	3

3. Impact Testing:-

The damage tolerance is a major concern with composite laminates. The compression after impact (CAI) testing provides a measure of damage tolerance. The compression after impact (CAI) test is applied on a rectangular laminate panel. These test consists of two parts: The first part of the test, the panel is clamped around the periphery and then subjected to a controlled impact in the centre of the panel (A drop tower is required to provide the impact), In second part, the panel is then placed in a jig and subjected to an edgewise compressive load until it fails. The failure load gives an indication of the residual strength of the panel after the impact damage. CAI standards in use include: ASTM D7136/D7137

Figure 3. The specimens of composite material after impact test

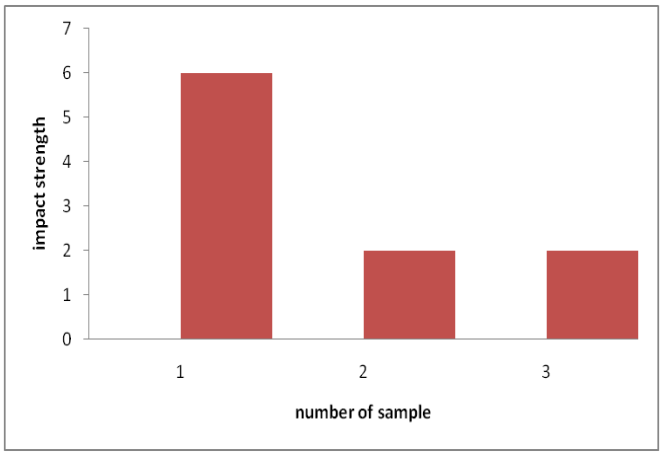

Figure 4. The specimens of composite material after impact test Sample no 1, 2,3 shows impact strength is 6,2,2

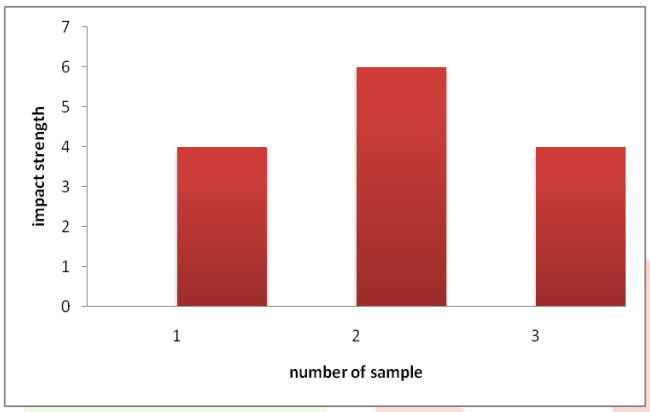

Figure 5. The specimens of composite material after impact test Sample no 1 ,2,3 shows impact strength is 4,6,2

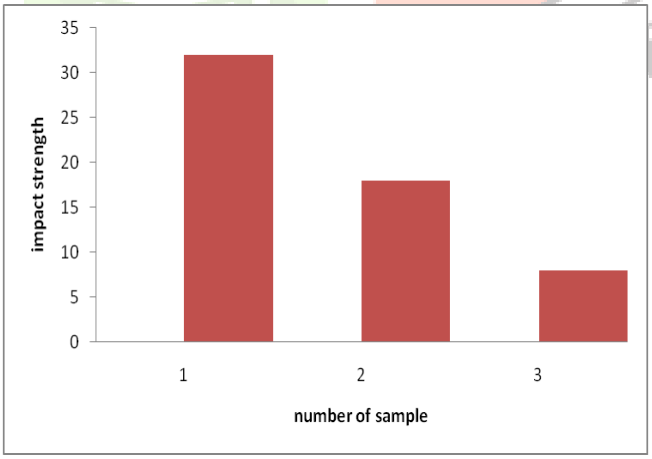

Figure 6. The specimens of composite material after impact test Sample no 1, 2, 3 shows impact strength is 32,18,8

TABLE NO – 2 L9 Orthogonal array used in the current study

E/H ratio	Parameters and levels			
	Glass fiber %	Temperature	Pressure	Impact strength
2	20	40	1	6
4	20	80	2	2
6	20	120	3	2
4	40	120	1	4
6	40	80	2	6
2	40	40	3	4
6	60	40	1	32
2	60	80	2	18
4	60	120	3	8

ANOM

The average effect of the measure on the response gives analysis of variance i.e ANOM. Fig. 7 shows the ANOM of impact strength. It can be depicted that a combination of epoxy to hardener ratio of 6, glass fiber percentage of 60 and curing temperature of 40^0C gives maximum impact strength.

ANOVA

Analysis of variance (ANOVA) is a statistical test used to evaluate the difference between the means of more than two groups. This statistical analysis tool separates the total variability within a data set into two components: random and systematic factors.

A one-way ANOVA uses one independent variable. A two-way ANOVA uses two independent variables. Analysts use the ANOVA test to determine independent variables' influence on the dependent variable in a regression study.

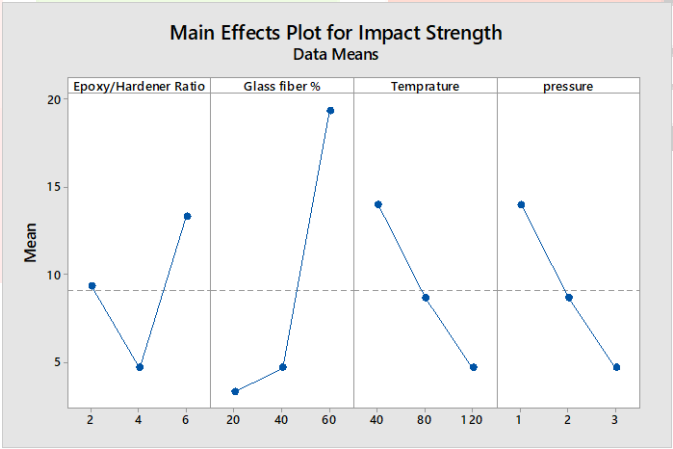

Figure 7. ANOM of impact strength

It is observed that deflection of specimen is minimum for epoxy to hardener ratio 4, fiber percentage 20, curing temperature of 120^0 C and pressure 3. In main effects plot the significance of each parameter can be judged by the inclination of plot. The parameter with highest line inclination has greater significance than the rest. From the main effects plot, it is seen that the parameter glass fiber is the most significant parameter while other parameters epoxy to hardener ratio, temperature and pressure fiber are also significant parameters.

TABLE NO – 3 ANOVA table of Impact Strength

Source	DF	Adj SS	Adj S	F-Value	P-Value
Epoxy/ Hardener Ration	2	86.76	43.38	1.01	0.497
Glass fiber %	2	472.89	236.44	5.52	0.153
Temperature	2	105.42	52.71	1.23	0.448
Error	2	85.69	42.84		
Total	8	776.89			

Conclusions

Composite material has wide applications in various automobile industry, application due to its advantages in the form of strength durability and lightweight properties. A study has carried out on its Manufacturing techniques and testing methods which shows its complexity of manufacturing and wide range testing applicability as excess of its standards. Increase in glass fiber contain should improve the mechanical properties of composite material. There should be increase in impact strength of composite due to effect of percentage addition of hardener with epoxy resin. Significant change in mechanical properties of glass fiber reinforced composite (GFRP) material should be observe with change in curing temperature. Increasing fiber volume fraction increased the impact strength. The effect of exposure temperature and fibre volume fraction on impact strength of GFRP composite depends on the parameter controlling the mode of failure. i.e. matrix or fiber. Taguchi method should show optimum tensile strength, shearing strength, bending strength, hardness strength.

References

1. Banea M, da Silva LF. Adhesively bonded joints in composite materials: an overview. Proc Inst Mech Eng Part L: J Mater Des Appl 2009; 223(1):1–18.
2. Mr.Chavan V.B., Prof.Gaikwad M.U, Review on Development of Glass Fiber/Epoxy Composite Material and its Characterizations International Journal of Science, Engineering and Technology Research (IJSETR) Volume 5, Issue 6, June 2016.
3. Erden S, Sever K, Seki Y, et al. Enhancement of the mechanical properties of glass/polyester composites via matrix modification glass/polyester composite siloxane matrix modification. Fibers Polym 2010; 11: 732–737.
4. Alam S, Habib F, Irfan M, et al. Effect of orientation of glass fiber on mechanical properties of GRP composites. J ChemSoc Pak 2010; 32: 265–269.
5. Faizal MA, Beng YK and Dalimin MN. Tensile property of hand lay-up plain-weave woven e glass/polyester composite: curing pressure and ply arrangement effect. Borneo Sci 2006; 19: 27–34.
6. Leonard LWH, Wong KJ, Low KO, et al. Fracture behavior of glass fiber reinforced polyester composite. J Mater Design App Part L 2009; 223: 83–89.
7. Visco AM, Calabrese L and Cianciafara P. Modification of polyester resin based composites induced by seawater absorption. Compos Part A 2008; 39: 805–814.
8. Hameed N, Sreekumar PA, Francis B, et al. Morphology, dynamic mechanical and thermal studies on poly (styrene-co-acrylonitrile) modified epoxyresin/glass fibre composites. Compos Part A 2007; 38: 2422–2432.
9. Sridhar I and Venkatesha CS. Variation of damping property of polymer composite under saline water treatment. IJIET 2013; 2: 420–423.
10. Colakoglu M. Damping and vibration analysis of polyethylene fiber composite under varied temperature. Turkish J EngEnvSci 2006; 30: 351–357.
11. Naghipour M, Taheri F and Zou GP. Evaluation of vibration damping of glass reinforced polymer reinforced glulam composite beams. J StructEng 2005; 131: 1044–1050.
12. Mahender, T. (2019). Mechanical properties and optimization of processing parameters for epoxy/glass fiber reinforced composites. Materials Today: Proceedings.

13. Callaghan, D. J., Vaziri, A., &Nayeb-Hashemi, H. (2006). Effect of fiber volume fraction and length on the wear characteristics of glass fiber-reinforced dental composites. Dental Materials, 22(1), 84-93.
14. Parbin, S., Waghmare, N. K., Singh, S. K., & Khan, S. (2019). Mechanical properties of natural fiber reinforced epoxy composites: A review. Procedia Computer Science, 152, 375-379.
15. Cavalcanti, D. K. K., Banea, M. D., Neto, J. S. S., Lima, R. A. A., da Silva, L. F. M., &Carbas, R. J. C. (2019). Mechanical characterization of intralaminar natural fibre-reinforced hybrid composites. Composites Part B: Engineering, 175, 107149.
16. Pickering, K. L., Efendy, M. A., & Le, T. M. (2016). A review of recent developments in natural fibre composites and their mechanical performance. Composites Part A: Applied Science and Manufacturing, 83, 98-112.
17. Balasundar, I., Raghu, T., &Kashyap, B. P. (2016). Taguchi Based Optimisation of Artificial Neural Network to Establish a Direct Microstructure: Mechanical Property Correlation in a near-α Titanium Alloy. Transactions of the Indian Institute of Metals, 69(10), 1929-1941.
18. Jagannatha, T. D., & Harish, G. (2015). Mechanical properties of carbon/glass fiber reinforced epoxy hybrid polymer composites. International Journal of Mechanical Engineering and Robotics Research, 4(2), 131-137.
19. González, C., Vilatela, J. J., Molina-Aldareguía, J. M., Lopes, C. S., &LLorca, J. (2017). Structural composites for multifunctional applications: current challenges and future trends. Progress in Materials Science, 89, 194-251
20. Sanjay, M. R., Arpitha, G. R., & Yogesha, B. (2015). Study on mechanical properties of natural-glass fibre reinforced polymer hybrid composites: A review. Materials today: proceedings, 2(4-5), 2959-2967.
21. Sathishkumar, T. P., Satheeshkumar, S., & Naveen, J. (2014). Glass fiber-reinforced polymer composites–a review. Journal of Reinforced Plastics and Composites, 33(13), 1258-1275.
22. Adrian, P. P., & Gheorghe, B. M. (2010). Manufacturing process and applications of composite materials. Annals of the Oradea Univ., Fascicle of Management and Technological Engineering, 9.
23. Steigmann, R., Savin, A., Goanta, V., Barsanescu, P. D., Leitoiu, B., Iftimie, N., ... & Curtu, I. (2016, August). Determination of mechanical properties of some glass fiber reinforced plastics suitable to Wind Turbine Blade construction. In IOP Conference Series: Materials Science and Engineering (Vol. 147, No. 1, p. 012140). IOP Publishing.