ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 18, Issue 4, 2024

Experimental study on composite material made of GFRP added with silica using high compression moulding hand layup method

[1]Drs Narsingh Rao, [2] N Praveen

[1]Associate Professor, Vidya Jyothi Institute of Technology, narsinghraodrs@vjit.ac.in

[2]Assistant Professor, Vidya Jyothi Institute of Technology, npraveen@vjit.ac.in

Abstract:

Glass Fiber Reinforced Polymeric (GFRP) Composites are most commonly used as bumpers for vehicles, electrical equipment panels, and medical devices enclosures. These materials are also widely used for structural applications in aerospace, automotive, and in providing alternatives to traditional metallic materials. In this study, the E-glass Epoxy laminates was manufactured and fabricated as per ASTM standard 300x300x4mm. The tensile and flexural strength of an E-glass epoxy laminated composite plate is to be analyzing by using UTM (Universal testing machine). Experiments like tensile test, three point bending and compression test were conducted to find the significant influence of filler material on mechanical characteristics of GFRP composites. The tests result has shown that higher the filler material volume percentage increases the strength of glass epoxy composites. An experimental study has been carried out to investigate the mechanical properties of glass-fiber reinforced epoxy composite filled with different proportions of SiC particles. It was found that bending, hardness and compressive strength was increased with the increase in percentage of glass fibres and SiC. But the fracture Strength of GFRP was decreased. SiC filler material makes FRP composite material harder and brittle which is the reason for reduction in tensile strength..It is possible to enhance the tensile strength of the composite by proper distribution of the glass fiber in the composite.

Keywords: Glass fiber, laminated polymer composites, SiC

1. Introduction

GFRP composites are one of the most commonly used engineering materials in application areas such as aerospace, defense, construction, automotive, marine, nuclear, robot, healthcare, and chemical industries due to their easy availability, low cost, high hardness, high fracture strength [1]. They meet the special features of the developing technology better than traditional materials. However, their fabrication methods and fiber types influence the mechanical and tribological properties [2] fabricated GFRP composites from glass fiber mat and glass fiber woven fabrics by filament winding. The mechanical properties of GFRP composites produced with woven fabrics were found to be higher than those produced with glass fiber mat fabricated short GF-reinforced nylon six composites having different weight ratios by the melting–mixing method [3]. It was observed that wear resistance of composites increased with GF content. As the mechanical and tribological behaviors of GFRP composites are improved, their usage areas are increasing day by day and they are subjected to different processing methods Although GFRP composites are shaped by different production methods, their dimensions and geometric shapes must be taken into account. In some cases, machining methods such as turning, milling, drilling are often needed to give the final shape of these composites [4]. As GFRP composites have the anisotropic structure, problems such as rapid tool wear, bad surface quality, excessive cutting force and power consumption are encountered during machining These problems can be controlled with cutting parameters such as cutting tool material, feed rate, cutting speed, and depth of cut investigated the effects of feed rate, cutting speed, depth of cut, and fiber orientation angle on cutting forces. Cutting forces was determined to increase with increasing the feed rate, cutting speed, depth of cut, and fiber orientation angle.

Scope of work:

This experimental study aims to investigate the mechanical properties and performance of composite materials fabricated using Glass Fiber Reinforced Plastic (GFRP) reinforced with silica particles. Two manufacturing methods, High Compression Molding (HCM) and Hand Layup, will be employed to produce composite specimens with varying silica content

2. Literature Review

This literature review provides an overview of existing research on GFRP composites reinforced with silica. It focuses on experimental studies that have investigated the effects of silica addition on the mechanical properties, and water absorption characteristics of these composites. Balaji et al [5] conducted experiment on Experimental Study of Mechanical Properties and Drilling Properties of Glass Fiber Composite. This paper presents an investigation on aspects of various mechanical properties and drilling of Glass fiber Mat Composite. Drilling experiments was conducted to study the delamination factor and hole quality on GFRP composites. Also the study carried out for Tensile Strength, Hardness and Flexural Strength of Glass Fiber Composite. Madhusudhan et al **[6]** did experiment on mechanical characteristics and tribological behavior study on natural - glass fiber reinforced polymer hybrid composites: a review, the author shows that the combination of Glass/Jute, Glass/Sisal increases the tensile strength, Flexural and Impact strengths. Incorporation of Natural Rubber to the Glass Fiber composites increases Tensile and Fracture toughness as well as flexibility. Pavan Hiremath et al **[7]** studied Investigation on Mechanical and Physical Properties of GFRP-Egg Shell Powder Hybrid Composites. The work was focused on to analyses the influence of egg shell powder as filler materials on the mechanical behavior of glass fiber, reinforced resin matrix. All composite with filler material exhibited better tensile strength than unfilled composites. Adding filler material might have resulted in restriction of propagation of crack and delamination. The shape and size of egg shell powder was the fine-tuning factor. By using egg shell filler material the composite doors can be made stiffer and less economical for domestic applications S. Mohan et al **[8]** has done experiment on Fabrication and Investigation of Epoxy resin based Glass Fiber-Coconut Fiber Hybrid Composite Material, this research work shows the result of Tensile testing of 6% treated coir fiber specimens show the best tensile characteristics. The tensile strength and Young's Modulus were found to be decreased with incorporation of coir fibers. Madhusudhan et al **[9]** made experiment on Investigation on wear resistance behavior of sic filled hybrid composites, the author shows that the study wear test was conducted on polymer matrix composites with ceramic filler with a view of investigating variation of the wear resistance. Unfilled polymer composites shows higher wear loss when compared to composites filled with SIC filler. TP Sathishkumar et al **[10]** made experiments on Glass fiber-reinforced polymer composites - a review. This research work shows that the mechanical, dynamics, tribological, thermal and water absorption properties of GFRP composites have been discussed. Ultimate tensile strength and flexural strength of the fiber glass polyester composite increased with increase in the fiber glass Vf of fiber weight fractions. Syed Altaf Hussain et al **[11]** conducted experiment on Machinability of glass fiber reinforced plastic (GFRP) composite materials. the author studied machinability of GFRP composite tubes of different fiber orientation angle vary from 30 to90 degrees. In machining of GFRP composites the surface roughness is highly influenced by feed followed by cutting speed and fiber orientation angle. Depth of cut has very little effect in machining GFRP composites. Madhusudhan et al **[12]** conducted experiment on the experimental study on wear behavior of sic filled hybrid composites using taguchi method. The author concludes that the material was predominantly influencing the

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

wear character, followed by load on the material, later abrading distance and then by speed of rotation of disc. Taguchi material analysis is best suited to minimize the number experiments.

3. Materials & Methods

This study aims to investigate the effects of adding silica to GFRP on its mechanical properties, specifically compressive strength and flexural strength. High compression molding (HCM) and hand layup methods were used to fabricate the composite samples.

Glass Fiber: E-glass fibers with small diameters are produced by extruding thin strands of silica glass. The reason why e-glass fibers were used in this study is that they are extremely strong, lightweight, and robust, making them ideal for composites when compared to metals. Moreover, the bulk strength and weight properties of this material are very favorable, and it is easily molded. A fiber-reinforced polymer composite is strong and lightweight since fibers are used as reinforcement agents

Table 1: Properties of GF reinforcement

Properties	Values	Units
Tensile strength	3400	MPa
Elasticity modulus	77	GPa
Application temperature limits	− 60…+650	°C
Melting temperature	1120	°C
Specifc weight	2.60	g/cm3
Diameter of fber	13–15	µm

Silicon Carbide: In an Acheson graphite electric resistance furnace, silicon carbide (SiC) is produced by combining silica sand and carbon at high temperatures. Under an inert atmosphere at low temperatures, it can also be prepared by the thermal decomposition of a polymer. In addition, it has a low density, high strength, high hardness, high thermal conductivity, and excellent thermal shock resistance. In composites, silicon carbide is one of the best filler materials.

Table 2: Mechanical properties of SiC

Properties	**Silicon Carbide**
Density (g/cm3)	3.3
Tensile Strength (MPa)	588
Coefficient of Thermal Expansion (10^{-6}/°C)	4.6
Young's modulus (GPa)	137
Shear Modulus (GPa)	51

Preparation of Composite Specimens by Hand Lay-Up Technique

In the present study, a hand lay-up technique was used to fabricate two laminates using epoxy and polyester resins. The materials used to fabricate the laminates were shown in Fig 1. Initially, the releasing agent was applied over the mold to facilitate the removal of the laminates. The 300 mm long and 300 mm wide E-glass fibers were laid in a normal direction after a thin layer of resin mixed with SiC was applied to the mold. A weight of 5 kg was placed over the fiber to remove any air bubbles, and the weight was left undisturbed for about 3 hours. On the surface of the first layer, the resin mixed with SiC was applied and rolled with rollers to achieve a homogeneous structure. After the third layer was laid on top, the resin was again spread over and rolled. This process was repeated until eight layers were formed. To remove the air bubbles, a weight of 10 kg was applied to the entire setup. It was then left for 24 hours to cure. The same procedure.

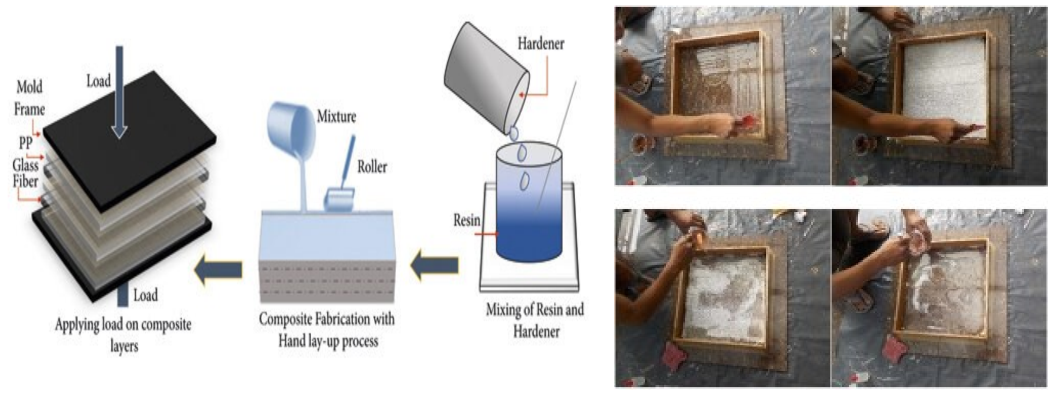

Fig 1: Preparation of Composite Specimens by Hand Lay-Up Method

Materials and manufacturing process:

Materials used-E class glass fibre is a material that contains extremely fine fibres of glass. It is light in weight, extremely strong, and robust. It is formed when thin strands of silica glass are extruded into many fibres with small diameters. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes. It is used as a reinforcing agent for composites to form a very strong and light fibre reinforced polymer (FRP) composite material. Two samples were prepared as per composition as given in table

Table 3: Composition of composite samples

S.No.	SiC	Glass fiber	Epoxy
Sample 1	2%	52 %	46 %
Sample 2	4%	50 %	46 %

Epoxy resin Epoxy resin is used to give great binding properties between the fibre layers. The Epoxy resin used at room temperature is LY 556. Hardener (HY 951) is employed to improve the interfacial adhesion and impart strength to the composite. A resin and hardener mixture of 10:1 is used to obtain optimum matrix composition. Silicon carbide (SiC) is produced by combining silica sand and carbon in an Acheson graphite electric resistance furnace at a high temperature. It can also be prepared by the thermal decomposition of a polymer under an inert atmosphere at low temperatures. It has low density, high strength, high hardness, high thermal conductivity and also excellent thermal shock resistance. Silicon carbide is the one of the best filler material that is being used in composite. The synthetic resin for such processes is a monomer for making a plastic thermo-setting polymer. During the setting process, the liquid monomer polymerizes into the polymer, thereby hardening into a solid.

Preparation of composite specimen

The composite materials used for the present investigation is fabricated by hand layup process as shown in figure. Chopped glass fibers were used to prepare the specimen. The layers of fibers are fabricated by adding the required amount of epoxy resin. The silicon carbide powder was mixed with the epoxy resin. The prepared laminate were shown in figure

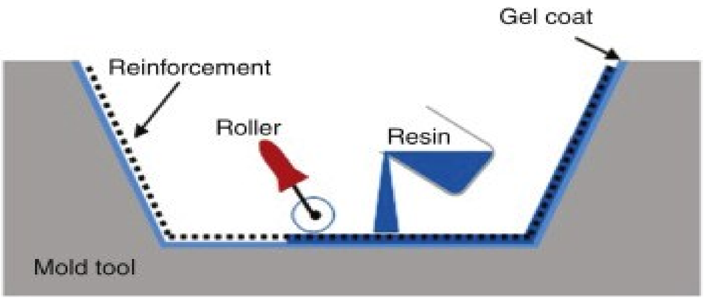

Fig 2: Hand layup method

Fig 3: Prepared laminate Sample

Mechanical testing of samples:

Tensile test- The hybrid composite material fabricated is cut into required dimension using a saw cutter and the edges finished by using emery paper as shown in figure 4 for mechanical testing. The tensile test specimen is prepared according to the ASTM D638 standard. The dimensions, gauge length and cross-head speeds are chosen according to the ASTM D638 standard. A tensile test involves mounting the specimen in a machine and subjecting it to the tension. The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The tensile force is recorded as a function of the increase in gauge length. During the application of tension, the elongation of the gauge section is recorded against the applied force. Length = 260mm, width = 24mm, thick = 5mm.

Fig 4: GFRP samples

Hardness test:

Hardness testing of polymeric materials, including plastics and rubbers, is performed by the Shore Durometer Test according to ASTM D2240. Like the hardness tests for metal, this

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

method determines a material's hardness value or resistance to indentation by penetration of an indenter into the test sample. Because the flexibility of polymers varies, LTI is equipped with various indenters for use in testing different types of materials from elastomers to rigid plastic.

4. Results And Discussion

The use of composite materials in the different fields is increasing day by day due to their improved properties. Engineers and Scientists are working together for number of years for finding the alternative solution for the high solution materials. In the present study natural fibers are added to the glass fiber reinforced composite materials and their effect on mechanical properties is evaluated and tabulated in tables.

Table 4: Tensile strength of GFRP composite

Samples	Percentage of SiC (%)	Tensile strength(N/mm2)
Sample – 1	2	107.95
Sample – 2	4	88.77

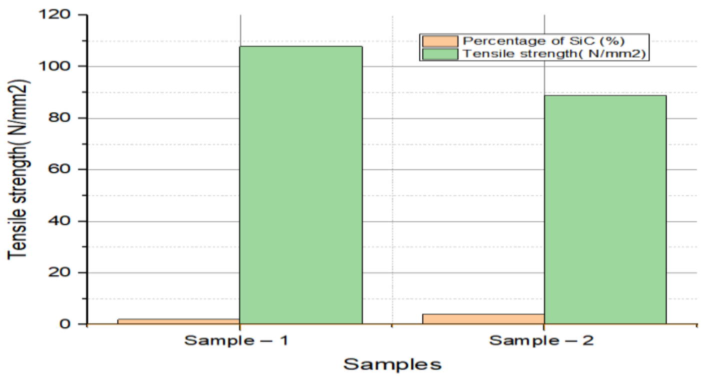

Fig 5: Validation of Tensile strength(N/mm2)

The graph shows the tensile strength of two samples (Sample-1 and Sample-2) containing different percentages of SiC. The x-axis represents the samples, and the y-axis represents the tensile strength in N/mm².

- Sample-1 has a higher percentage of SiC compared to Sample-2.
- ·Sample-1 also exhibits a higher tensile strength compared to Sample-2.

Table 5: Compressive strength of GFRP composite

Samples	Percentage of SiC (%)	Compressive Strength (N/mm2)
SAMPLE – 1	2	172
SAMPLE – 2	4	180

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

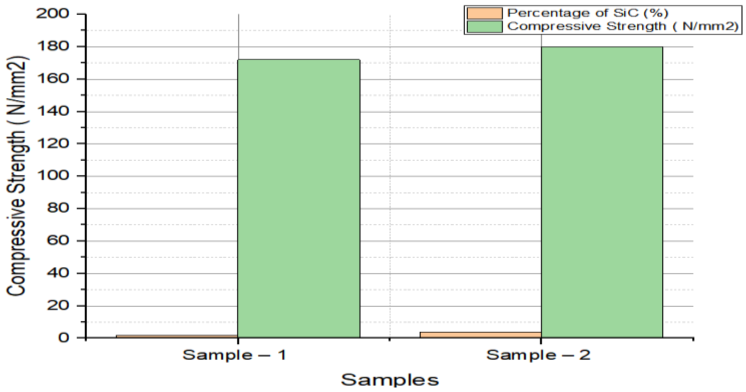

Fig 6: Validation of Compressive Strength (N/mm2)

The graph shows the compressive strength of two samples (Sample-1 and Sample-2) containing different percentages of SiC. The x-axis represents the samples, and the y-axis represents the compressive strength in N/mm².

- Sample-1 has a higher percentage of SiC compared to Sample-2.
- Sample-1 also exhibits a higher compressive strength compared to Sample-2.

Table 6: Fracture strength of GFRP composite

Samples	Percentage of SiC (%)	Fracture strength (N/mm2)
SAMPLE – 1	2	101.55
SAMPLE – 2	4	83.26

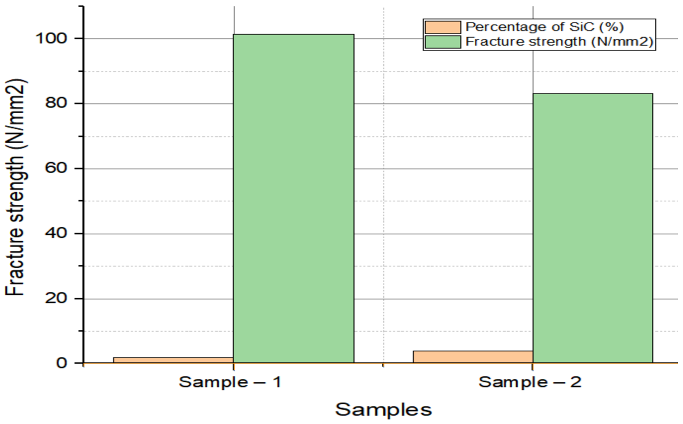

Fig 7: Validation of Fracture strength (N/mm^2)

The graph shows the fracture strength of two samples (Sample-1 and Sample-2) containing different percentages of SiC. The x-axis represents the samples, and the y-axis represents the fracture strength in N/mm².

- Sample-1 has a higher percentage of SiC compared to Sample-2.
- Sample-1 also exhibits a higher fracture strength compared to Sample-2.

Table 7: Hardness of GFRP composite

Samples	Percentage of SiC (%)	Hardness kgf/mm^2
SAMPLE – 1	2	85
SAMPLE – 2	4	87

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

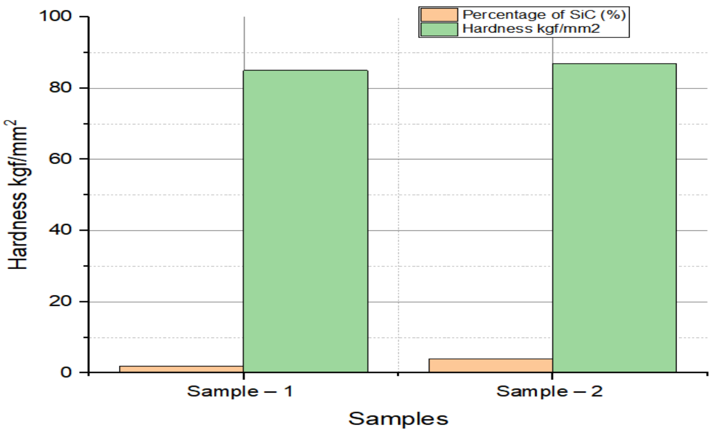

Fig 8: Validation of Hardness kgf/mm^2

The graph shows the hardness of two samples (Sample-1 and Sample-2) containing different percentages of SiC. The x-axis represents the samples, and the y-axis represents the hardness in kgf/mm^2.

- Sample-1 has a higher percentage of SiC compared to Sample-2.
- Sample-1 also exhibits a higher hardness compared to Sample-2.

Conclusions

The addition of silica to GFRP using high compression molding and hand layup methods can significantly enhance its compressive and flexural strength. The optimal silica content for maximum strength improvement was found to be around 10%. This work shows that successful fabrication of glass fiber with random oriented reinforced polyester composites with different fiber contents is possible and very cost effective by simple hand lay-up technique. Bending and compressive strength increases with when SiC is taken as a filler material. SiC filler material makes material harder and brittle which is the reason for reduction in tensile strength value. It is possible to enhance the tensile strength of the composite by proper distribution of the glass fiber in the composite.

Future Work:

- Investigate the effects of silica content on other mechanical properties such as impact strength and fatigue resistance.
- Explore different types of silica particles and their influence on composite properties.
- Evaluate the long-term durability and environmental performance of silica-reinforced GFRP composites.

References:

1. Ramesh B, Eswari S, Sundararajan T (2020) Flexural behaviour of glass fibre reinforced polymer (GFRP) laminated hybrid-fibre reinforced concrete beams. SN Appl Sci 2:204. https://doi.org/10.1007/s42452-020-1966-2
2. Çelik YH, Kilickap E, Koçyiğit N (2019) Evaluation of drilling performances of nanocomposites reinforced with graphene and graphene oxide. Int J Adv Manuf Technol 100(9–12):2371–2385. https://doi.org/10.1007/s00170-018-2875-z
3. Kumar P, Vengal K, Kundavarapu R, Ravishankar V, Venkata D, Kaki R (2020) Modeling of glass fiber reinforced composites for optimal mechanical properties using teaching learning-based optimization and artificial neural networks. SN Appl Sci 2(1):131. https://doi.org/10.1007/s42452-019-1837-x

4. Vijay BR, Srikantappa AS (2019) Physico-mechanical and tribological properties of glass fiber based epoxy composites. Int J Mech Eng Rob Res 8(6):929–934. https://doi.org/10.18178/ijmerr.8.6.929-934
5. R.Balaji, C.Sivakandhan, P.Munusamy, D.Muthukumar, Experimental Study of Mechanical Properties and Drilling Properties of Glass Fiber Composite, ISSN : 2248-9622, Vol. 7, Issue 1, (Part -3) January 2017, pp.24-30.
6. T. Madhusudhan, Dr M Senthilkumar, Athith D, Mechanical Characteristics and Tribological Behaviour Study On Natural - Glass Fiber Reinforced Polymer Hybrid Composites: A Review, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 pISSN: 2395-0072 Volume: 03 Issue: 04 Apr-2016.
7. Pavan Hiremath, Manjunath Shettar and M. C. Gowrishankar, Investigation on Mechanical and Physical Properties of GFRP-Egg Shell Powder Hybrid Composites, Indian Journal of Science and Technology, Vol 9(32), DOI: 10.17485/ijst/2016/v9i32/97024, August 2016.
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 Engineering {ICMMAE'2016} Dec. 14-15, 2016 Pattaya {Thailand}.
9. T. Madhusudhan, Dr. M. Senthil Kumar, Investigation On Wear Resistance Behavior Of Sic Filled Hybrid Composites, International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 2, February 2017, pp. 82–92 Article ID: IJMET_08_02_010 ISSN Print: 0976-6340 and ISSN Online: 0976-6359.
10. TP Sathishkumar, S Satheeshkumar and J Naveen, Glass fiber-reinforced polymer composites - a review, Journal of Reinforced Plastics and Composites 2014, Vol. 33(13) 12581275 The Author(s) 2014 Reprints and DOI: 10.1177/0731684414530790.
11. Syed Altaf Hussain , V. Pandurangadu , K. Palani Kumar , Machinability of glass fiber reinforced plastic (GFRP) composite materials, International Journal of Engineering, Science and Technology, Vol. 3, No. 4, 2011.
12. T. Madhusudhan and M. SenthiL Kumar, Experimental Study On Wear Behaviour Of Sic Filled Hybrid Composites Using Taguchi method, International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 2, February 2017, pp. 271–277 Article ID: IJMET_08_02_033 ISSN Print: 0976-6340 and ISSN Online: 0976-6359.