

Investigation on Mechanical Properties of Epoxy Reinforced with Industrial Waste

Dr. V.L.Raja¹, R. Manivannan², D. Nandhakumar³, M. Nandhakumar⁴, P. Pradeep⁵,

Associate Professor, Department of Mechanical Engineering, Muthayammal Engineering College, Rasipuram,
Namakkal, Tamilnadu, India¹

Students. Department of Mechanical Engineering, Muthayammal Engineering College, Rasipuram, Namakkal,
Tamilnadu, India^{2,3,4,5}

ABSTRACT: Green Productivity is a developing strategy that combines the techniques of productivity improvement and environmental protection to produce environmentally compatible goods and services. Green Productivity approach has become inevitable in order to enhance productivity and environmental performance for overall socio-economic development. It is the application of appropriate techniques, technologies, and management systems to produce environmentally compatible goods. The performance demanded from the materials today is very high and diversified such that it could not be satisfied by any one single material. This has paved way for new materials called composites. Composite materials are made up of two or more physically or/and chemically distinct phases suitably arranged or distributed with an interface separating them. Different materials are combined in such a way that their good properties are better used and their deficiencies are minimized to the possible extent.

This project combines both these phenomenon by reinforcing silica fume, an industrial waste which is available at a very low cost, in epoxy resin. The mechanical properties of the epoxy composites are investigated experimentally and also validated using ANSYS software. The mechanical properties were found to get enhanced at higher concentration of silica fume. The effective usage of the industrial waste ensures pollution reduction and manufacture of quality product at low cost.

KEYWORDS: Epoxy, Mechanical properties, Polymer Matrix,

I. INTRODUCTION

Composites tend to have characteristics such as high modulus, low density and excellent resistance to fatigue, creep, creep rupture, corrosion and wear. Composites could be natural or synthetic. The composites are classified as ceramic material composite, metal matrix composite & polymer matrix composite. A fiber reinforced composite (FRC) is a composite building material that consists of three components: the fibers as the discontinuous or dispersed phase, the matrix as the continuous phase and the fine interphase region which is also known as interface. Composite is a fast growing field where researches are being carried out in order to introduce a new generation material for replacing old systems and drawbacks in existing systems. The natural fiber composites have a potential to replace glass in many applications when compared to manmade fibers. Here we researched a new composite material with filler materials and epoxy resin. A composite is a material that is formed by combining two or more materials to get some superior properties. Almost all the materials which we see around us are composites. Some of them like woods, bones, stones, etc. are natural composites, as they are either grown in nature or developed by natural process. Natural fibers such as sisal, jute, coir, and banana are to this category. Because of the superior mechanical properties of fiber, the use of fibers as reinforcements started gaining momentum during the 20th century. The aerospace industries took the lead in using fiber reinforced laminated plastics to replace several metallic parts. The fibers like glass, carbon, boron, Kevlar and plastics such as phenolic, epoxies and polyesters caught the imagination of composite designers. One major advantage of using fiber reinforced plastics instead of metals that they invariably lead to a weight efficient design in view of their

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higher specific modulus and strength properties. Composites due to their heterogeneous composition, provide unlimited possibilities of deriving any characteristic material behavior. This unique flexibility in design tailoring plus other attributes like ease of manufacturing, especially molding to any 2 shape with polymer composites, reparability, corrosion resistance, durability, adaptability, cost effectiveness, etc. have attracted the attention of many users in several engineering and other disciplines. Every industry is now notice the application of composites in many disciplines starting from sports goods to space vehicles.

II. METHODOLOGY

The literatures regarding the work were collected and the problem was clearly identified. Silica fume, resin and hardener were procured. The composite material was then manufactured by reinforcing Silica fume with relative weight fraction in epoxy resin. Static mechanical properties were measured by conducting appropriate tests and the results were documented. The following shows the methodology of the problem selection of raw material is mostly good in all properties and easily available after selection of raw material, fabrication is done by compression moulding method. Hand lay-up methods testing is carried out using ASTM standard.

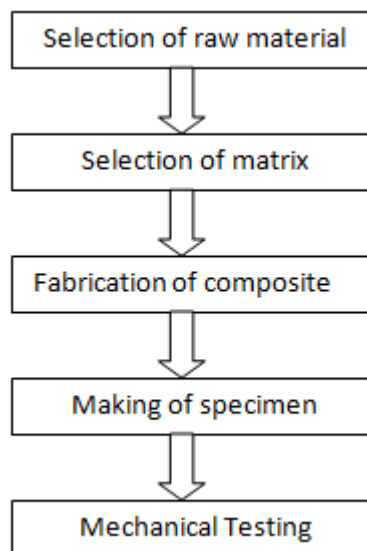


Fig 1: Flow chart of methodology

2.1 Mould Preparation

The fabrication of the composite materials is carried out through the compressed moulding. The mould used for preparing composites as per the ASTM standard having dimensions of 290mmx290mmx3mm. For beadings were used to maintain a 3mm thickness all around the mould plates. The function of these plates are to cover, compress the material after the matrix is applied, and also to avoid the dust particles from entering into the composite parts during the curing time.

2.2 Preparation of Epoxy and Hardener

The polymer matrix used to fabricate the specimen was epoxy LY556 of density. 1.15 to 1.20 g/cm, mixed with hardner HY951 of density 0.97 to 0.99 g/cm. The weight ratio of mixing epoxy and hardner was 10:1.

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Vol. 6, Issue 3, March 2017

2.3 Preparation of composites

Polymer composite reinforced with various ratios of were prepared by compounding neat Epoxy with the three alkali treated.

2.4 Fabrication process

The compression molding is used for fabricate the Silica fume composites. For fabricate the Silica fume composites 65% of rein hardner mixture 10:1 ratio and remaining 35% Silica fume are used. The mixed Epoxy resin and hardner is filled in the pattern. Silica fume are randomly poured in the resin hardner mixture without any gap. The roller is rolled in the mould. Again the mould is filled in pattern by next layer and Silica fume poured randomly done till the height of the mould 10mm. The lid is fixed on the top of the frame for distribute the load of evenly on the mould. The setup is kept inside compression molding with hot temperature 373k. After 2 hours the mould is take away from the pattern, finally the hybrid natural Silica fume composite is fabricated.

2.5 Properties of Material

To determine the material properties (Density, Flexural modulus, Flexural rigidity, Hardness number, % gain of water) of natural Silica fume reinforced composite material by conducting the following respective tests.

- Tensile test
- Flexural test
- Impact test
- Density test
- Hardness test

III. RESULT AND DISCUSSION

3.1 Tensile Test

The tensile test is carried out by cutting the specimens at the following dimensions. The table below shows the variation of the tensile strength for the different filler materials.

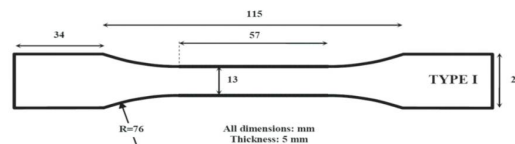
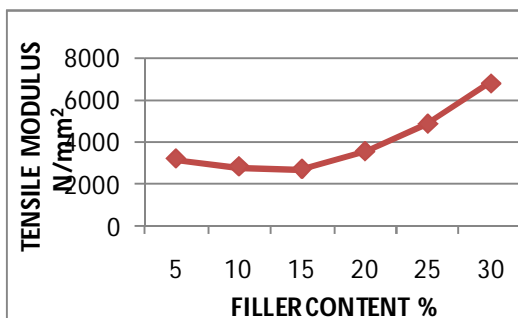


Figure 2. Dimension for the test specimen

Table 1. Tensile Test results



Graph .1 : Tensile modulus strength of Silica fume composite sample

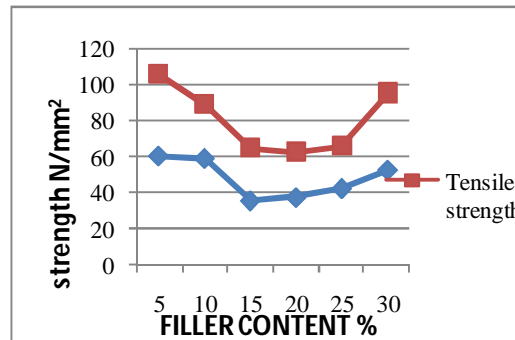
S.no	Sample percentage	Tensile strength (N/mm ²)	Tensile modulus (GPa)
1	0 %	44.46	3.17
2	5 %	29.062	27.90
3	10 %	28.735	3.41
4	15 %	21.606	2.77
5	20 %	23.19	3.50
6	25 %	25.732	3.74

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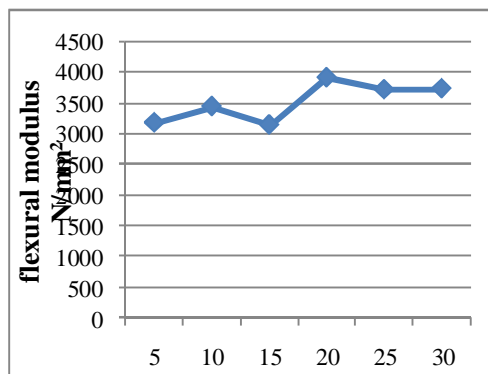
Vol. 6, Issue 3, March 2017



Graph 2. : Tensile strength and flexural strength comparisons of Silica fume composite sample

3.2 Flexural Test

From the below table we can see the increasing range of the Flexural values adding the different percentage of sample here the flexural modulus calculated by the grafts.



Filler content %

Graph 3. : Flexural modulus strength of Silica fume composite sample

Table 2. Flexural test results

S.no	Sample percentage	Flexural strength (N/mm ²)	Flexural modulus (GPa)
1	0 %	59.973	3165.48
2	5%	59.739	3430.48
3	10%	33.587	3130.93
4	15%	32.387	3897.99
5	20%	35.362	3703.242
6	25%	48.214	3717.4

3.3 Impact test

For analyzing the sudden load carrying capacity of the Silica fume reinforced composite samples an impact test is carried out. The impact test was performed according to ASTM D 256. The specimen is clamped in to the pendulum impact fixture with the notched

Side facing the striking edge of the pendulum. The pendulum is released and allowed to strike through the specimen. The tested results are given below .

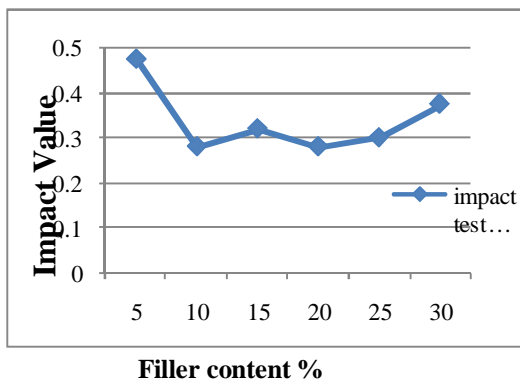
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Vol. 6, Issue 3, March 2017

Table 3. Impact strength of various specimens test results



S.no	Sample of percentage	Impact test value(J)
1	0 %	0.475
2	5%	0.4
3	10%	0.25
4	15%	0.15
5	20%	0.225
6	25%	0.375

Graph 4. : The sample percentage of Silica fume impact strength composite material

3.4 Hardness Test

The below table shows that hardness values are varied sample of percentage. Shore – D hardness test was conducted on the specimen using a standard Shore -D hardness test.

A load of 250 kg was applied on the specimen for 30 sec using 5 mm diameter hard metal ball indenter and the indentation diameter was measured using a microscope test.

S.no	Sample of percentage	Shore - D Hardness Number
1	0 %	67
2	5%	66
3	10%	57
4	15%	63
5	20%	65
6	25%	67

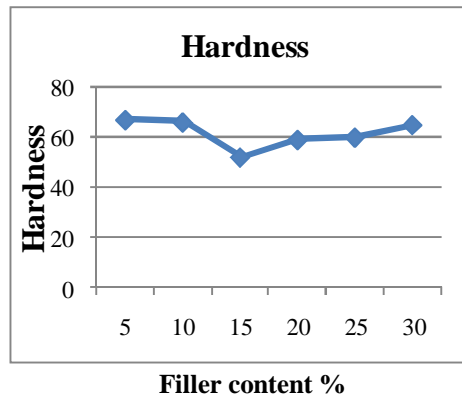
Table 4. : Hardness test result

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Vol. 6, Issue 3, March 2017



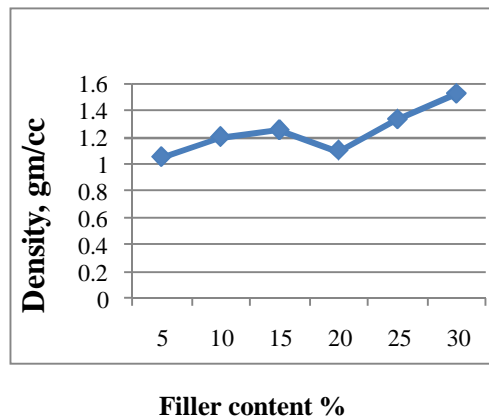
Graph 5. : The variation of hardness values

3.5 Density Test

From the below table we can see the increasing range of the density values by adding the sample of Silica fume. Here the density is calculated by taking the specimen at a dimension of 20*20*5mm(L*B*W).

S.no	Sample of percentage	Density (gm/cm ³)
1	0 %	1.05
2	5%	1.10
3	10%	1.20
4	15%	1.21
5	20%	1.33
6	25%	1.52

Table 5. Density calculation



Graph 6. : The variation in density values

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 3, March 2017

IV. CONCLUSION

An attempt was made to use the concept of 'recycle' in green productivity and the idea of sustainable development, in the manufacturing of polymer composites for mechanical components. Nylon 66 was compounded with silica fume in different weight fractions from 5% to 25% increasing in steps of 5%. The density, hardness, tensile, flexural and impact properties were investigated. All the properties found to decrease in the over concentration of the filler materials but after 20% weight fraction of filler material, these properties get increased. This suggests that with more reinforcement the properties could be further enhanced.

The objective of green productivity, that is ensuring environmental protection while making business profitable is found to be achieved in this attempt because usage of silica fume in nylon composites reduces environmental pollution which simultaneously have performance enhancement and profitable application

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