NOVEL RECYCLING OF GFRP WASTE: A COST EFFECTIVE AND ECO-FRIENDLY APPROACH

S.SASIDHARAN[1], Prof. R.SURENDRAN[2], A.R.AJITHKANNA[3]

[1]PG Scholar, Department of Manufacturing Engineering, Government College of Technology, Coimbatore
[2]Assistant Professor, Department of Mechanical Engineering, Government College of Technology, Coimbatore
[3]UG Scholar, Department of Civil Engineering, PSG College of Technology, Coimbatore

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Abstract - *The main purpose of the project is to utilize the waste Glass fiber reinforced plastic (GFRP) for different applications under mechanical recycling process. Fiber reinforced polymer (FRP) materials are being increasingly used in several applications, but especially in the construction and transportation industries. The waste management of FRP materials made with thermosetting resins is a critical issue for the composites industry because these materials cannot be reprocessed. Therefore, most thermosetting FRP waste is presently sent to landfill, in spite of the significant environmental impact caused by disposing of it in this way. Because more and more waste is being produced throughout the life cycle of FRPs, innovative solutions are needed to manage it. In this work a new composite material was studied and tested based on fiberglass waste mixed with polyester resin in different ratios of GFRP fiber waste and polyester resin at 65%, 70%, 75%. The newly fabricated composites were characterized for their mechanical properties such as compressive strength, Flexural strength, Hardness, Impact strength and Water absorption as per ASTM standards. The results demonstrate the possibility of using an unexplored waste stream (glass fiber waste) as a reinforcement agent in resin, which may reduce the amount of wastes in landfill, while simultaneously contributing towards the circular economy.*

***Key Words*: *Glass fiber reinforced plastic (GFRP)*, Mechanical properties, waste management, Thermosetting resins, Circular economy.**

1. INTRODUCTION

Composite materials can be formed by combining two or more materials with different properties together at macroscopic level to get enhanced properties as a combined effect. Composite materials are consists of two phases: the matrix phase & reinforcing phase. Epoxy resins, which are thermoset material are widely used as matrix in many fiber reinforced composites; particular interest to structural engineers owing to the fact that they provide a unique balance of chemical and mechanical properties combined with wide processing versatility.

1.1 TYPES OF COMPOSITE

There are three principal ways in which the reinforcing material can be incorporated: as grainy material (or particulates), as fiber (in the form of individual fiber embedded in the matrix) and as layers (fibers woven into mats which are laid on top of one another to create a laminate) The reinforcing materials provide increased strength and stiffness to the composite. The matrix materials, on the 4 other hand, are responsible not only for covering the reinforcements (thereby protecting them from environmental and chemical damage).

In this work, glass fiber reinforcement in polyester resin matrix was produced by hand lay-up technique with varying fiber percentages (15%, 30%, 45%, and 60% by weight percent). The compression, flexure, impact and hardness tests were carried out and their performances were evaluated.

1.2 POLYMERS AND FIBERS

Commercial plastics are known as resins and are made of polymers. These polymers have been compounded with modifying or stabilizing additives. Typically based on the element carbon, polymer molecules are made from simple, oil-based raw materials. The starting materials for polymers are called monomers and they are small molecules. These small molecules go through a process called polymerization which combines them and forms very large molecules or polymers.

Fibers are the load-carrying elements and provide strength and rigidity, while the polymer matrices maintain the fibers alignment (position and orientation) and protect them against the environment and possible damage.

2. MATERIALS AND METHOD

2.1 RESIN

The unsaturated polyester resin (Medium Reactive General Purpose Lamination Grade Resin) of the grade VBR-2303. The ortho lamination resin properties are listed in table 1.

Cobalt naphathanate as accelerator and methyl ethyl ketone peroxide (MEKP) as catalyst were used.

Table -1: properties of Ortho lamination resin

S.no	Properties	Units	Values
1	Appearance	Nil	Pale yellowish clear liquid
2	Viscosity @ 25 deg C**	Cp	470
3	Density @ 25 deg C	gm/cm^3	1.132
4	Volatile content	%	35.9
5	Acid value	mg-KOH/gm	25.86
6	Gel time @ 25 deg C #	Min	14

2.2 WASTE EXTRACTION AND SAMPLE PREPARATION

Fig. 1 shows the processes involved in extracting GFRP waste in this study. The raw GFRP waste produced from the fiber products like automobile accessories, doors, windows, wind mill blades and marine applications was collected from the industry. In general, mechanical recycling is a technique used to reduce the size of scrap composites into smaller pieces known as recyclates. The waste pulverised using shredding machine. Now the mixed GFRP containing fiber waste and powder waste was obtained. The above waste are separated by sieving method. The fiber waste shown was settled in a sieve and it was separated physically by hand.

Fig.2 shows the stages of sample preparation of GFRP waste product. From the extracted waste, 40% of the total waste is utilized which contains only fiber waste. The fiber waste and resin is taken in a various proportion like F35:R65, F30:R70 and F25:R75.

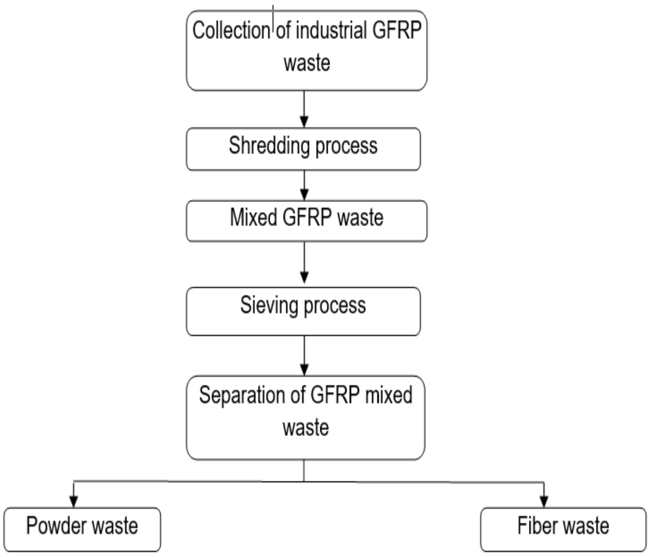

Fig -1: Waste extraction

Fig -2: Stages of Sample preparation

The waste fiber and resin was completely mixed and laid on the mould. The mixture was evenly spreaded by hand layup process and it was allowed to cure for particular period of time. After curing the specimen is taken from the mould. The specimen was machined and cut into a required dimension shown in Fig 3.

Fig -3: Sample preparation

3. RESULT AND DISCUSSION

3.1 HARDNESS TEST

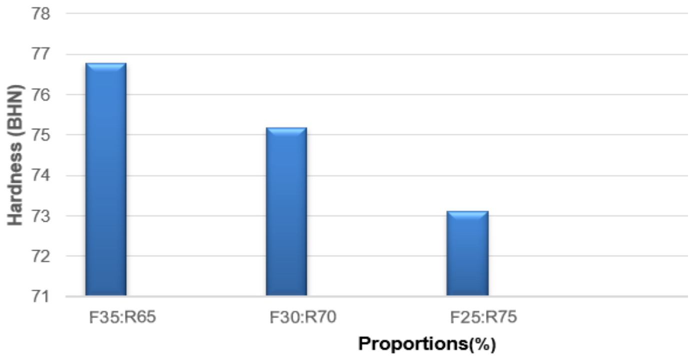

Chart – 1: The variation of hardness value with glass fiber content

The hardness was decreased with respect to decrease in fiber waste content shown in Chart 1, polymer has low hardness, but this hardness value is greatly increase when the resin reinforced by glass fiber due to distribution the test load on glass which decrease the penetration of test ball to the surface of fabricated composite material.

The hardness for the prepared samples with different ratios were tested and the results are shown in Table 2

Table -2: Hardness Test

SI. NO	Sample	Diameter of impression (mm)	Diameter of ball indenter (mm)	Brinell Hardness Number (BHN)
1	F35:R65	3.30	5	76.78
2	F30:R70	3.33	5	75.18
3	F25:R75	3.37	5	73.10

3.2 IMPACT TEST

The impact strength for the prepared samples with different ratios were tested and the results are shown in Table 3

Table -3: Impact Test

SI.NO	Sample	Energy absorbed (J)	Area of Cross Section (mm^2)	Impact Strength (KJ/m^2)
1	F35:R65	62	81	765.43
2	F30:R70	61.33	81	757.20
3	F25:R75	60.33	81	744.81

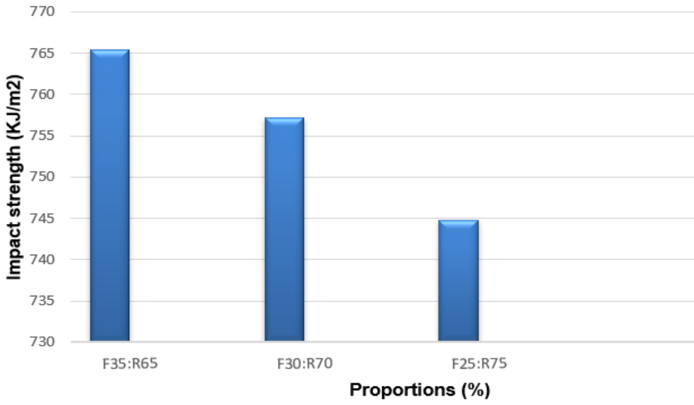

Chart -2: The variation in impact strength with glass fiber content

The impact strength was decreased with respect to decrease in fiber content. The impact resistance considered low to the resins due to brittle property. But after reinforced it by glass fiber. The impact resistance will be increased because the fiber will carry the maximum part of impact energy shown in Chart 2.

3.3 FLEXURAL TEST

The flexural strength for the prepared samples with different ratios were tested and the results are shown in Table 4.

Table -4: Flexural Test

SI.NO	Sample	Applied Load (kg)	Applied Load (N)	Flexural Strength (N/mm^2)
1	F35:R65	4.12	40.4	8.75
2	F30:R70	3.94	38.65	8.37
3	F25:R75	3.50	34.33	7.45

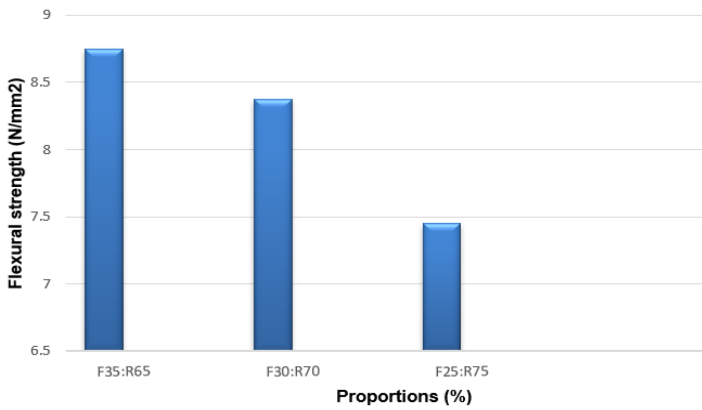

Chart -3: The variation in Flexural strength with glass fiber content

The flexural strength was decreased with respect to decreased in fiber content shown in Chart 3. The fiber act as a reinforcement for the material, so that the higher fiber content gives maximum bending strength.

3.4 COMPRESSION TEST

The compressive strength for the prepared samples with different ratios were tested and the results are shown in Table 5

The compressive strength was increased with respect to increase in resin content. The resin act as a matrix material and generally matrix material takes compression. From the above results it was inferred that maximum resin content will give maximum compressive strength.

Table -5: Compression Test

SI.NO	Sample	Applied Load (kN)	Area of Cross Section (mm^2)	Compressive Strength (N/mm^2)
1	F35:R65	149	2025	73.58
2	F30:R70	191.66	2025	94.64
3	F25:R75	234	2025	115.56

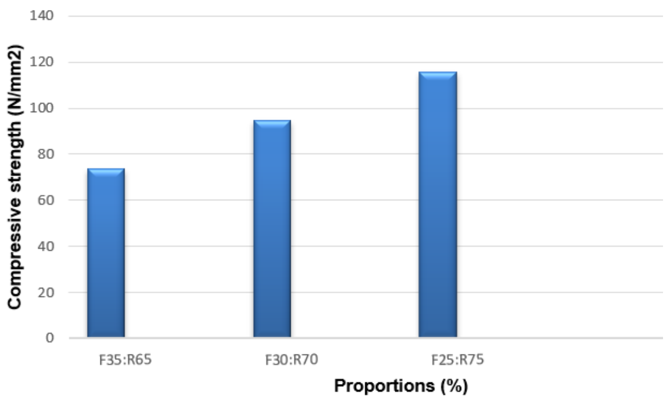

Chart -4: The variation in compressive strength with glass fiber content

3.5 WATER ABSORPTION TEST

The water absorption for the prepared samples with different ratios were tested and the results are shown in Table 6

Table -6: Water Absorption Test

SI.NO	Sample	weight of dry specimen W_1 (gm)	weight of water absorbed specimen W_2 (gm)	% Water Absorption
1	F35:R65	110.10	110.10	0
2	F30:R70	105.95	105.95	0
3	F25:R75	112	112	0

4. CONCLUSIONS

This work mainly concerned with the utilization of GFRP waste produced in industry. Thermosetting FRP products are being increasingly used in several industrial applications. GFRP waste will not get degraded or decomposed because of its inert nature while dumping in landfills. Using GFRP waste and resin a new product is manufactured and several tests like Hardness, Impact strength, Flexural strength, Compressive strength and water absorption are conducted. Hardness, Impact strength and flexural strength was increased when the fiber content was increased. Compressive strength was increased when the resin content was increased. Considering the test results and cost effectiveness it is decided to manufacture Wash basin among another applications. The product was manufactured with different ratios of waste fiber and resin. Among the three proportions F35:R65 was effective in both mechanical properties and economic consideration. In this work 40% of total waste which contains only fiber content is utilized.

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