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Mechanical Properties of Recycle Polymers Reinforcement with Glass Fiber Composite Material

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Abstract: Glass fiber are commonly use in this industry application for some manufacturing product. As we know waste polymer is a big issue for our country. Recycled polymer will affect our environmental problem. In this review paper, research about the recycled polymer is mixing with glass fiber to form a new specimen with higher strength than before. Method that had been used to mix this product is Brabender Plastograph and the polymer will be inject by injection molding to for a new specimen followed the standard. As the review that have been research the polymer for (PET Polyethylene Terephthalate) and PP (Polypropylene) this product is analyze their characteristic to perform a new material. Next, several types of fiber are research to know their specific characteristic that suitable for mixing the polymer. The main objective for this review is to review the mechanical strength of reinforce carbon polymer by using tensile, impact & flexural test and to study the suitable percentage ratio of reinforcement between glass fiber and polymer. The percentage of fiber and polymer had been research very specifically to form a new specimen. The method of mixing is using the Brabender Plastograph for mixing with using percentage of weight. After mixing injection molding is used to form a specimen to follow standard material and tested by using flexural and tensile test to find out their strength. The percentage below 10% is most suitable and the value for glass fiber compared to polymer. The result for tensile test is had increase their strength around 43% and flexural increase around 47% when mixing with glass fiber which is better than before. Therefore, the waste polymer will be recycled to form a new specimen with higher strength and useful for future.

Keywords: Glass Fiber, Polymer, Mixing, Recycled, Tensile Strength, Flexural Strength.

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1. Introduction

The high performance and durability of composite fiber development in recent years has remarkably strong [1]. The rapid rise in the applications of carbon fiber reinforced polymer matrix composites (CFRP) and thermoset polymers as the matrix makes the recovery of the fibers is creating a waste recycling challenge [3]. Recycling is known as the most environmentally sustainable and eco-friendly mechanism for the disposal of plastic waste [4]. The polymer industry produces products with outstanding physical and mechanical properties, but also with very low degradability and a significant amount of waste [5]. The effect of recycled polymer fiber on mechanical and durability performance of concrete has been increasingly studied in recent years, primarily because of the economic and construction industry [7].

This is an overview of the characteristics of glass fibers and their composites in terms of thermal and flammability, along with theoretical and computational modelling of composite [8]. The study was conducted to understand the effect of reprocessing on glass fiber and polymer mechanical and mechanical properties [4]. High processing temperatures (compared to thermosets), long cooling times, high viscosity (limiting processing techniques) and, for high crystallinity thermoplastics, high shrinkage after processing are some of the difficulties when processing thermoplastics [9].

The aim of this project is to provide a thorough assessment of carbon fibers and glass fiber recycling and current potential applications for carbon fibers recovered. The concepts of the circular economy pertinent to the recycling of CFRP are highlighted in terms of manufacturing wastes of product and re-manufactured CFRP [3]. However, due to their non-degradability and low recyclability, the adverse environmental effect of synthetic fiber reinforced composites has been a concern [8].

2. Materials and Methods

Methodology for this experiment is dependent on the machine that have been used to form a specimen product. First step is granulating the polymer into a small piece by using plastic granulator machine. After granulating into a piece, the polymer and fiber will mix it into Brabender Plastograph by follow their suitable melting point of temperature. After that the mixing product will undergo injection molding by following the standard mold for mechanical testing. The tensile and flexural test is used to measure or calculate the mechanical strength. The data will be recorded and compared with the different mixing of percentage fiber.

2.1 Materials

PP (polypropylene) is a recyclable thermoplastic polymer that is widely used in a variety of applications. PP is tough and resistant to a variety of chemical solvents, acids, and bases [16]. Heat distortion temperature, transparency, flame retardancy, and dimensional balance are only some of the advantages of PP. PP has a few useful homes, along with temperature of warmth distortion, clarity, flame retardant and dimensional balance [11]. Due to the most lower melting point among the other polymer which is 165C and 900 g/cm^3.

GF are the most frequently used synthetic fibres because to their superior strength and durability, thermal stability, impact, chemical, friction, and wear resistance [2]. Glass fibres are the most used to reinforce plastics due to their low cost and reasonably strong mechanical characteristics [16]. Based on its low cost and strong mechanical properties, glass fiber is one of the most used fibers for automotive applications [8]. The mechanical properties of a woven-mat GF-reinforced unsaturated polyester composite with exact fibre percentages of 5, 10, 15, 20, 25, and 30% were investigated. The tensile electricity, Young's modulus and elastic strain increased by adding of the GF [17].

2.2 Methods

For the procedures of this experiment flowchart shows the procedure or the method when doing this experiment step.

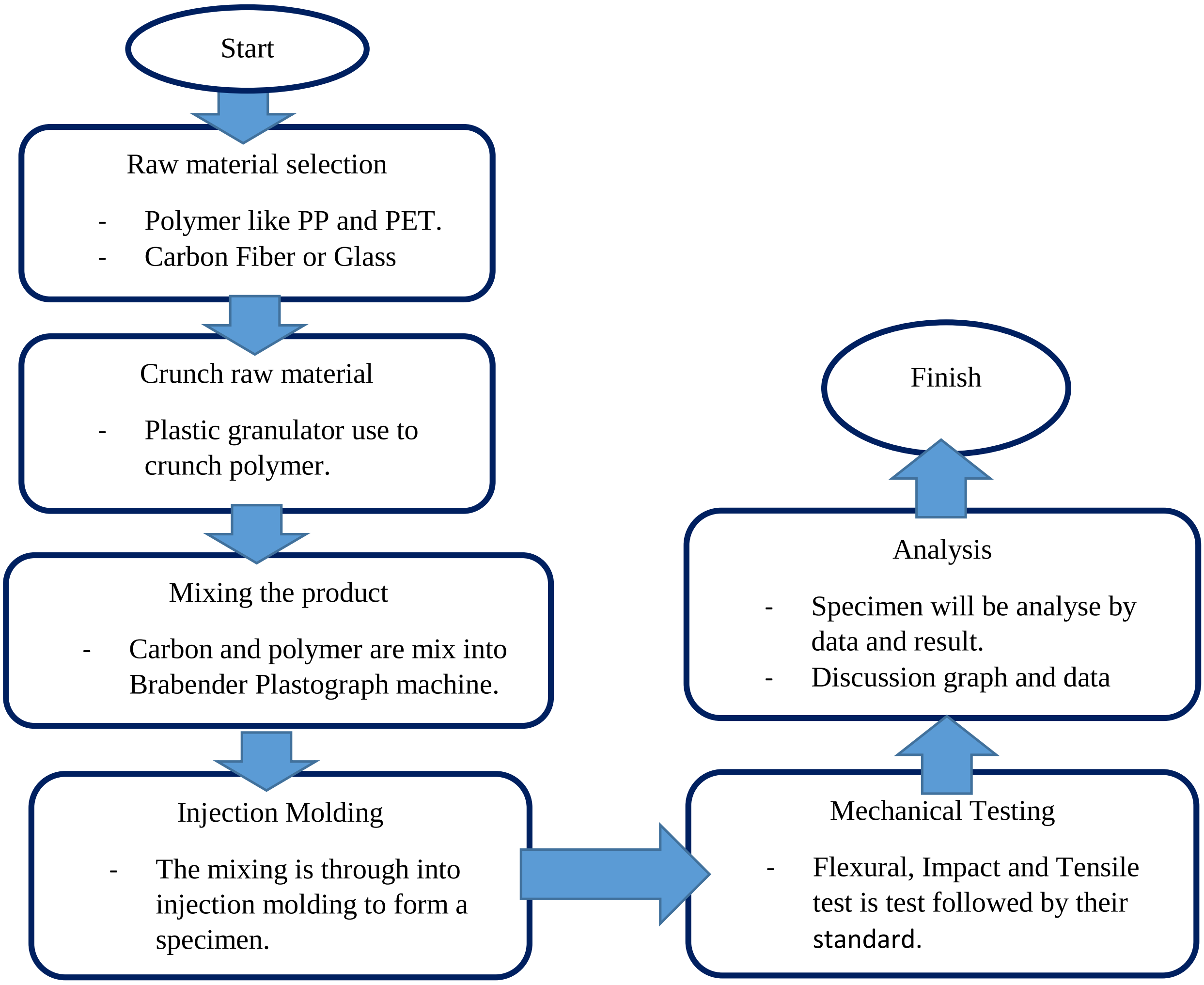

Figure 1: Methodology flowchart

Equations and formula for this experiment is focusing on Brabender Plastograph machine for mixing the product. This is shown due to the volume of the machine is small and have their amount that been provided. This machine is calculating in parameter of volume to use it. These are formula weight calculation ratio for this machine.

$M = V \times fc \times K$ Eq.1

M = sample weight

V = mixer chamber volume (55 g/cm^3)

Fc = composite density (g/cm^3)

K = constant (example = 0.7, 0.8…)

3. Results and Discussion

In this chapter, it focused on the result analysis and discussion from the experimental review from the journal and article. It will discuss about the percentage of glass fibre that reinforced with polypropylene and the mechanical testing of this specimen. From the result that we had go through from flexural test and tensile test. This test has been chosen to test our specimen product to get the result and discussion about the effect of percentage glass fibre.

3.1 Tensile Strength

When the glass fibre percentage is 20%, the tensile sample has a tensile strength of 44.6 MPa. When the glass fibre content was 30%, the tensile strength of the tensile sample reached 56.9 MPa, and the tensile strength was increased by 43.4 percent. Tensile samples' elongation at break dropped from 256.7 percent (pure PP) to 45.5 percent MPa (30 percent GF/PP sample) [25].

Sample S2 has a higher yielding point of 15.47 MPa due to the addition of 3% fibre, and the yield strength improves by 12% when compared to the pure mixture. Figure 3.1 also reveals that sample S3 has a higher yield strength of 16.51 MPa than the pure blend, which is about 20% higher. When fibre content is increased to 9%, the yielding point of the composite increases to 17.89 MPa, which is roughly 30% higher than the yielding point of a pure mix. Finally, the inclusion of 12 percent glass fibre increases the yield strength of the blend composite to 19.66 MPa, which is nearly 43 percent greater than the yield strength of the pure blend.

Sample S1 has a low modulus of 1.24 GPa due to the lack of fibre content. When 3 percent glass fibre is added, the modulus of the S2 sample increases to 1.58 GPa, which is about 27% greater than the modulus of the pure mixture. It can also be seen that with the addition of 6% fibre, the composite has a greater modulus of 1.97 GPa, which is 59 percent higher than the pure blend. If the fibre percentage is increased to 9%, the composite's modulus increases to 2.1 GPa. Finally, sample S5, which contains 12 percent glass fibre, has a much higher modulus of 2.42 GPa, which is 95 percent greater than plain polymer blend. Figure 3 below shows the elastic modulus result [26].

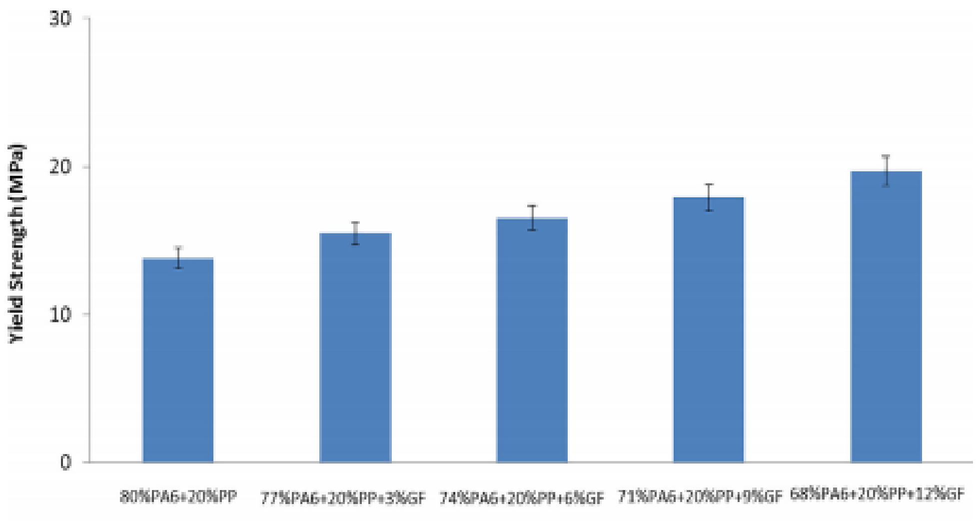

Figure 2: yield strength [26]

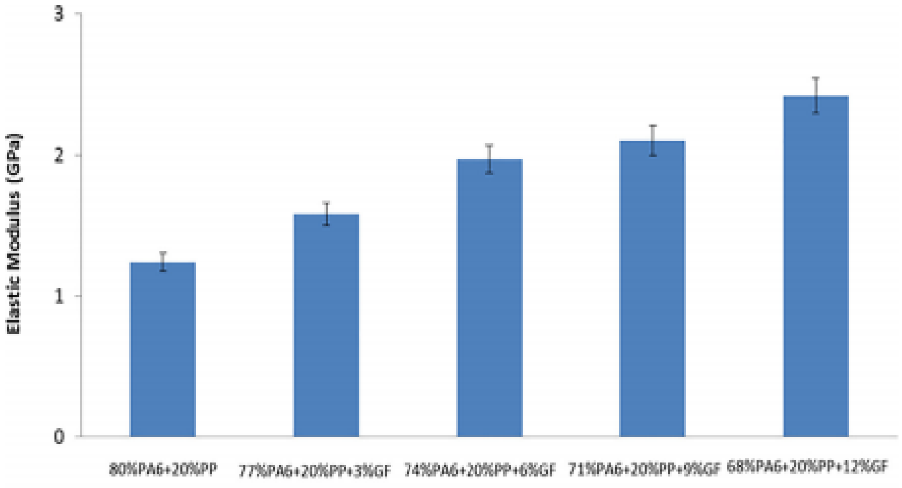

Figure 3: Elastic modulus [26].

3.2 Flexural strength

This revealed that banana fibre reinforced PP composites outperformed unreinforced PP composites in terms of deformation resistance while under load. The PP/Banana yarn composite had a 72 percent better flexural strength than the unreinforced PP composite. The greatest flexural strength of the PP/Banana yarn sample was 52.88 MPa, which was like the tensile strength. The PP/Banana mat composite demonstrated higher flexural strength than the PP/Raw banana fibre composite, in contrast to tensile strength. As shown in Figure 4 bar chart, the flexural strength of the three different banana fibre reinforced PP composites is higher than the unreinforced PP [11].

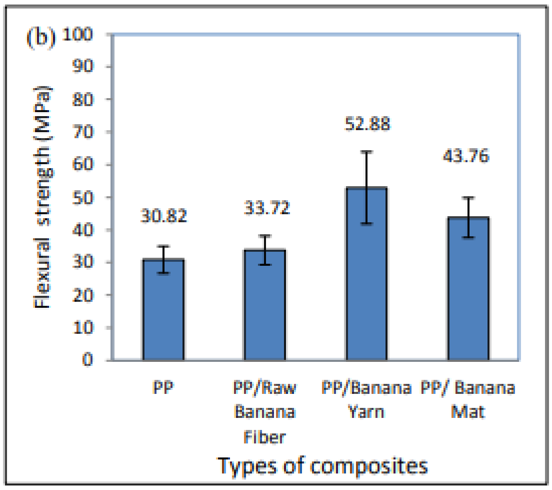

Figure 4: Bar chart flexural test for PP and PP/Banana fiber composite [10].

The PLA carbon fibre composite's maximum flexural strength and modulus were 74 MPa and 21 GPa, respectively. The PLA had a flexural strength of 66 MPa, which was raised to 67 MPa by adding 10 wt% carbon fibre reinforcement. The flexural strength increased to around 78 MPa when the weight fraction was increased to 15%. In terms of flexural strength (430 MPa) and flexural modulus, carbon fibre composites surpassed glass fibre composites (38.1 GPa). The highest documented flexural strength and flexural modulus for glass fibre composites were 149 MPa and 14.7 GPa, respectively, which is about 40% of the strength and modulus reported for carbon fibre composite.

The flexural strength and modulus of PP and short carbon fibre composites were enhanced by 150 percent and 400 percent, respectively, by changing the fibre orientation. When compared to flat orientation printed composites, with 34 vol percent fibre on-edge printed PA composites with carbon fibre showed a 43 percent increase in impact strength, 47 percent for Kevlar fibre, and just 4 percent for glass fibre reinforcement. The strength behaviour varies depending on the fibre content (2, 4, 6, 8, and 10 wt percent) [1].

3.3 Tables

Table 1: Summaries of some previous research that closely related to this research.

Year	**Percentage weightage (%)**	**Fiber**	**Finding**
2020	3, 5, 7.5, 10, 15, 30	carbon fiber	An ABS composite containing 10% continuous carbon fibre had a tensile strength of 147 MPa. Fibre reinforcing of 5 to 10% in FDM polymers improved tensile strength and modulus.
2017	-	Banana, yam fiber	As a result, banana yarn is the strongest. When compared the banana yarn configuration proved to be the most effective. This was due to the yarn fibres in the composite being continuous and commingled by their configuration.
2021	10, 20, 30	glass fiber	The experimental results high-strength glass fibres play a role in skeletal reinforcement, with tensile strength nearly linearly increasing as glass fibre content increases.
2019	10, 20, 30	Glass fiber, carbon fiber, aramid fiber	The maximum nominal stress tended to decrease as the fibre concentration rise. At the beginning of the load, the slope tended to rise. These patterns were evident and analysed in all the items.
2018	3, 6, 9, 12	Glass fiber	The findings show, the larger fibre content, plastic deformation occurs at a greater stress level, and the composite has a higher yield strength. These findings show as fibre increases, the composite's resistance to elastic deformation improves.
2020	30, 50	Glass fiber	The addition of 50 wt% glass fibre to composites increases their stiffness by six times. The reinforcements also help to improve the composites tensile strength. Blending 50 wt% TLCP into the composite increases the tensile strength by 114 percent. The addition of 50 percent long glass fibre to polypropylene increases the tensile strength of the composite by more than three times.

4. Conclusion

In conclusion, due to the study the effect of fiber is give different mechanical properties characteristic. It will get a different result when using recycled carbon fiber, glass fiber, carbon fiber and natural fiber. Due to the research the percentage of glass fiber is under 10% of glass fiber and others is polymer. The amount of low glass fiber is because of the density different weight polymer and glass fiber. For the range percentage for 3%, 5% and 7% of glass fiber is the most suitable for this experiment. Next the suitable polymer to use in this experiment is polypropylene compared to other polymer due to the temperature of melting point. For tensile test range between 3% to 12% give the increase of tensile strength to 43.4%. For the flexural test the range percentage from 2% to 10% give increasing in flexural strength to 43% to 47%. Moreover, this experiment review is still in research for many years recently to improve the mechanical industry in future. Next, the objective to investigate the mechanical strength of reinforce carbon polymer by using tensile, impact & flexural test had been achieved due to the result that have been review and to find the suitable percentage ratio of reinforcement between glass fiber and polymer when the result had been compared.

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