Study of Mechanical Properties of Carbon Fiber Reinforced Polypropylene

Arun Kumar D T
Asst. Professor, Dept. of Mechanical Engineering
SET, Jain University
Kanakapura (T), Ramanagara (D) – 562112, Karnataka, India

Kaushik V Prasad
M.Tech scholar, Dept. of Mechanical Engineering
RV College of Engineering
Bangalore – 560059, Karnataka, India

P S Raghavendra Rao
Asst. Professor, Dept. of Mechanical Engineering
SET, Jain University
Kanakapura (T), Ramanagara (D) – 562112, Karnataka, India

***Abstract*— Polypropylene is the most widely used plastic next to polythene. Polypropylene as it is cannot be used in many applications. The strength of plastic needs to be improved in many applications. Addition of reinforcement materials like carbon fibers with an organic compound like maleic anhydride improves the strength of polypropylene. The aim of the present work was to study the improvement in mechanical properties of pure polypropylene by introducing small percentages of carbon fibers. Compositions of 2, 4, 6 and 8 percent of carbon fiber and 1 percent of maleic anhydride were added to pure polypropylene. Standard specimens for tensile, flexural and impact test were prepared as per ASTM standards using injection moulding technique. It was observed that increasing the carbon fiber content increased the strength of pure polypropylene. Highest strength was observed in all three tests for polypropylene reinforced with 8 percent carbon fibers. The composite can find its applications in battery housings, automotive parts requiring high impact and bending strength etc. Further addition of nano – fillers, natural fibers etc. can throw a wider prospect in the advancements of this composite.**

Keywords*— Polypropylene; Carbon fiber; Maleic anhydride; Injection moulding.

I. INTRODUCTION

Plastic materials today have captured the eye of global market and are slowly replacing the conventional engineering materials. Polypropylene (PP) is one of the most widely used plastics in the world and is ranked third in usage after polythene. Polypropylene finds its application in many housewares, appliances, bottles, heater ducts where high heat deflection is required etc. [1]. Thermoplastics have gained significant attention all over the world as the curing process is omitted, it is less hazardous and recyclable [2]. However the strength of pure propylene can be increased with addition of reinforcing fiber material. Yunus et al. [3] reported that tensile strength of polypropylene reinforced with 10 percent of short carbon fiber was comparable with that of carbon steel. Further, in their studies it was concluded that increase in fiber length can enhance thermal stability of the composite. Addition of maleic anhydride (MAH) to fiber reinforced polypropylene increases the bonding between matrix and reinforcing material [4]. Carbon fiber (CF) is known for its high specific modulus, strength, stiffness etc. The thermal and chemical properties depend upon matrix material while mechanical properties depend on reinforcing material [5]. In addition to the high thermal and mechanical properties carbon fiber reinforced composites possess a reduced weight density of 20 – 30 percent compared to the conventional metals and alloys [6]. A review of literature from [1 – 6], showed that many studies have been performed to study effect of fiber reinforcements in polypropylene, however very scarce amount of work is reported on addition maleic anhydride with fibers in polypropylene. The aim of present work is study the mechanical properties of polypropylene reinforced with short carbon fiber and maleic anhydride.

II. MATERIAL AND METHODS

Commercially available Reliance REPOL H200 MA grade homopolymer propylene was used for the studies. Twin screw extruder was used prepare the pellets for injection moulding. Each batch requires minimum 2kg of material to be processed in the extruder. 2, 4, 6 and 8 percent of carbon fiber and 1 percent of maleic anhydride was added to pure polypropylene. The ratio was maintained such that each composition does not exceed 2kg. Table 6.1 gives the details of weights of different materials added to pure polypropylene.

Table 1: Weights of CF/MAH added to PP

PP : CF : MAH	Amount of PP (kg)	Amount of Carbon Fiber (kg)	Amount of MAH (kg)
100:0:0	2	0	0
97:2:1	1.94	0.04	0.02
95:4:1	1.90	0.08	0.02
93:6:1	1.86	0.12	0.02
91:8:1	1.82	0.16	0.02

Polypropylene is available commercially in form of pellets. Carbon fibers available in form of tow were chopped into short fibers. MAH was added its powdered form. All the compounds were weighed using an electronic weigh balance.

The compounds were first introduced into the twin screw extruder through the hopper. The material here gets melted in extruder due high temperature of more than 200°C. The melted material is obtained in the form of wires by pin holed size outlets. The extruded wires are cooled along the water bath solidified and then chopped to small pellets using pellet making machine. The pellets are then introduced into the Pneumatic injection moulding machine to prepare the standard test specimens. Fig.1 shows the standard test specimens prepared using injection moulding.

(a)

(b)

(c)

Figure 1: Standard test specimens for (a) Impact (b) Flexural and (c) Tensile tests prepared by injection moulding.

The notch for impact test specimen was made using the notch cutter equipment. Three specimens were prepared for each composition for all the three tests. The prepared specimens were tested for tensile and flexural using a light weight universal testing machine as per ASTM D638M and ASTM D790. Impact test was carried out using ASTM 256B standard. The average of the reported values for all the three specimens in each composition was taken.

III. RESULTS AND DISCUSSIONS

A. *Tensile Test*

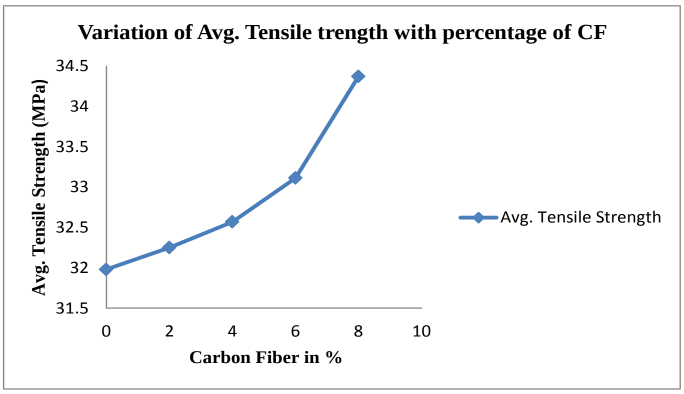

Figure 2: Variation of tensile strength with % of CF

It is observed that the average tensile strength increases with percentage of carbon fiber. Pure polypropylene has yield strength of 31.95 MPa which increases to 34.5MPa at 8 percent carbon fiber content. No significant increase in tensile strength is observed between 2 and 4 percent of carbon fibers. The increase in strength can be attributed to the axial load bearing capacity of the fibers which is distributed uniformly throughout the matrix of polypropylene. Further it was noted that there was an increse in the young's modulus with increase in the carbon fiber content.

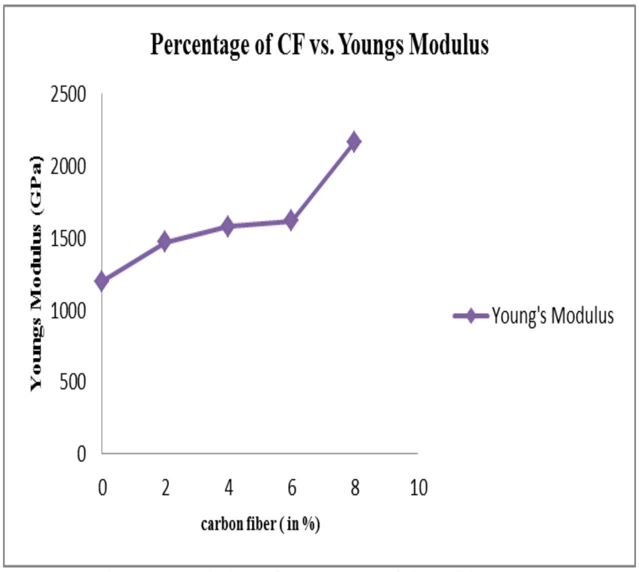

Figure 3: Variation of Young's Modulus with CF %.

B. *Flexural Test*

In flexural test the flexural strength increases with increase in carbon fiber content. This can be attributed to uniform load distribution between the fibers and the matrix. There is a change of as much as 11% noted in 2%fiber reinforced polypropylene compared to pure polypropylene. However there is no notable change observed between 4% composition to 6% composition. In 8% composition the strength increases notably by 48%.

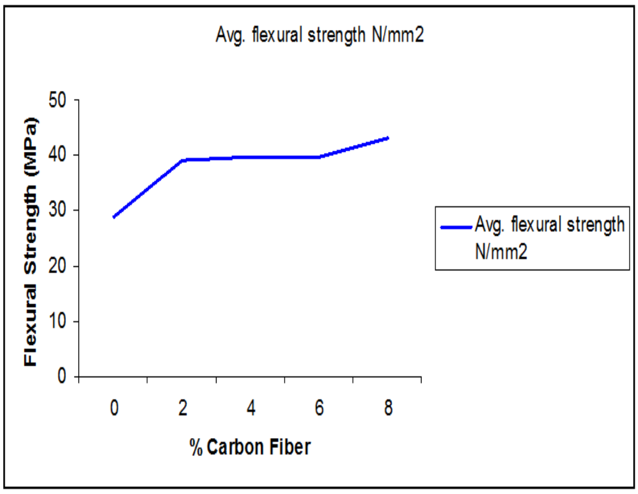

Figure 4: Variation of flexural strength with CF %.

C. IMPACT TEST

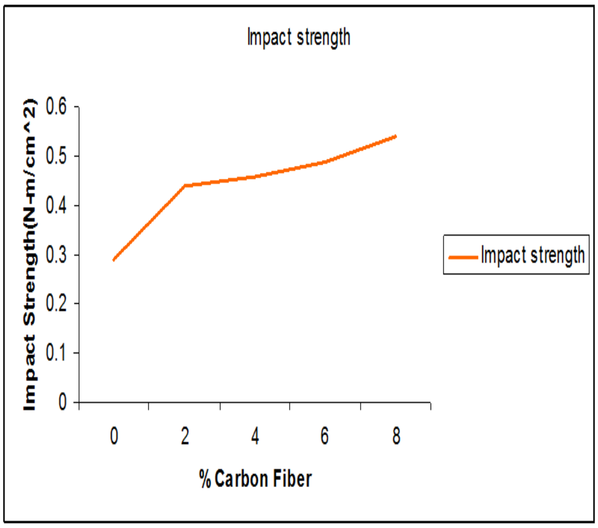

Figure 5: Variation of impact strength with CF%.

Impact Strength also increases considerably due to the reinforcement of the carbon fibers in polypropylene. This can be attributed to the highly ordered structure of atoms in carbon fiber and the cohesion between the matrix and the fiber

IV. CONCLUSIONS

It is observed that mechanical of the pure polypropylene increases with increase in carbon fiber percentage. The improved reinforced polypropylene can find its applications in automotive parts which require good impact strength such as bumpers, parts which require good tensile strength handles, dash boards etc. It can also find applications in areas where heat deflection is present, Eg. Pipes or ducts which carry hot water etc. Scope for further improvement on material can be achieved by incorporation nanofillers to improve the flame retardancy properties of this composite. Further nanofillers can be used to improve the strength even more along with carbon fibers and their effects can be studied.

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