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Injection molded carbon fiber reinforced polypropylene composites

[1]Bhakthavathsala. K.S, [2]Dr.Ravishankar. R

1Bhakthavathsala. K.S, Lecturer, Department of Mechanical Engineering JSS Polytechnic, JSS Technical Institutions Campus, Mysuru
2Dr.Ravishankar. R, Associate Professor, Department of Mechanical Engineering, SJCE, JSS Technical Institutions Campus, Mysuru

Abstract:

The mechanical properties of carbon fiber-reinforced polypropylene composites were identified by conducting suitable experiments. The main focus of this study the tensile strength, flexural strength, Hardness and Impact Strength as per ASTM standards. Specimens were prepared by injection molding process. The Results reveled that ultimate tensile strength, flexural strength, Hardness and Impact Strength of 20wt% of carbon fibers higher than the remaining compositers.

Keywords: Polypropylene, Carbon Fiber, Injection molding.

Introduction:

Composites are the combination of two or more materials with distinct physical and chemical properties. They have desirable physico-mechanical qualities, such as a high strength-to-weight ratio, greater thermal, corrosive, and abrasion resistance. The fibres are the primary sources of stiffness and are classified according to their composition, i.e., synthetic or natural. There are various kinds of these fibres, including woven, randomly oriented, and non-woven. The selection of fibre types for the production of FRP composites varies on the target use. Particularly synthetic fibres are used widely in several technical applications. Aramid, Carbon, Glass, and Kevlar are a few of the most common fibres utilised in load-bearing applications. Carbon fibre is the most common material owing to its technical compatibility. Due to the increasing interest in natural fibres in the current day, composite materials for commercial applications and basic research make substantial use of these fibres. Using this as an example, the benefits of synthetic fibres are given below: Most natural fibres, especially in their purest form, can be prohibitively costly, synthetic fibres provide more economical alternatives. Various synthetic materials mimic natural fibres, such as wool and silk. In this case, the distinction between thermoplastic and thermosetting polymers is made clear. Even though the phrases Thermoset plastics and Thermoplastics may seem to be synonymous, they are in fact entirely distinct substances with varying characteristics and uses . The difference between thermosetting and thermoplastic polymers is mostly determined by their molecular bonds and heat sensitivity. The primary difference between the two is that thermoplastic materials often have low melting points, enabling them to be easily remoulded or recycled. The thermosetting plastic material is the exact opposite. Once they have hardened, they are resistant to extremely high temperatures and cannot be reformed or regenerated, even when heated. Since the primary focus is on thermosetting polymers, the production procedures presented pertain to thermosetting polymers. Hand or spray layup is an open-mould process that involves the manual insertion of fibres (often glass fibres) and resins using hand tools.

Literature Review:

Bernd Wetzela.et.al,[1] Investigated the various amounts of micro- and Nano-scale particles (calcium silicate $CaSiO_3$, 4–15 mm, alumina Al_2O_3, 13 nm) were systematically introduced for reinforcement purposes. The influence of these particles on the impact energy, flexural strength, dynamic mechanical thermal properties and wear behaviour was investigated. If the nanoparticles were incorporated only, they yield an effective improvement of the epoxy resin at a nanoparticle content of already 1–2 vol. % Al_2O_3. Choosing the Nano composite with the highest performance as a matrix, conventional $CaSiO_3$ micro particles were further added in order to achieve additional enhancements in the mechanical properties. In fact, synergistic effects were found in the form of a further increase in wear resistance and stiffness. Several reasons to explain these effects in terms of reinforcing mechanisms were discussed..

RafahA.Nasif.et.al,[2] Investigated the effect of ceramic fillers (aluminium oxide Al_2O_3 and titanium TiO_2) and industrial wastes (red mud and copper slag) with weight fraction (10% wt)on the mechanical properties of composite material consist of epoxy reinforced with glass fiber with weight fraction (40/50)%wt .Impact strength, tensile strength and hardness and results have been compared with composite material reinforced only with glass fiber (50/50)%wt . The results show that the composite reinforced with TiO_2 had higher value of impact strength and lowest value of tensile strength compared with other composites.The composite material reinforced only with glass fiber had higher value of tensile strength And also all the hybrid composites have hardness values higher than that of composites material reinforced with Al_2O_3.

Bhadrabasol Revappa Raju1.et.al,[3] Studied the mechanical and two-body abrasive wear behaviour of alumina (Al_2O_3) filled glass fabric reinforced epoxy composites containing 0, 5, 7.5 and 10 wt% were prepared using the hand lay-up technique followed by compression molding. The mechanical properties such as tensile strength, hardness and tensile modulus were investigated in accordance with ASTM standards. Two-body abrasive wear studies were carried out using a pin-on-disc wear tester under multi-pass condition against the water proof silicon carbide abrasive paper. From the experimental investigation, it was found that the presence of Al_2O_3 filler improved the tensile strength and tensile modulus of the G-E composite. Inclusion of Al_2O_3 filler reduced the specific wear rate of G-E composite and in abrasion mode, as the filler loading increases the wear volume decreases and increased with increasing abrading distance. The excellent wear resistance was obtained for Al2O3 filled G-E composites. Furthermore, 10 wt% filler loading gave a very less wear loss. Finally, the scanning electron microscopic observations on the wear mechanisms Al2O3 filled G-E composites was discussed.

Ramesh K. Nayak.et.al,[4] developed epoxy matrix by Al2O3, SiO2 and TiO2 micro particles in glass fiber/epoxy composite to improve the mechanical properties. The composites are fabricated by hand lay-up method and It is observed that mechanical properties like flexural strength, flexural modulus and ILSS are more in case of SiO2 modified epoxy composite compare to other micro modifiers. This may be because of smaller particle size of silica compare to others. Alumina modified epoxy composite increases the hardness and impact energy compare to other modifiers. Agglomeration of Al2O3 micro particles in the matrix is observed in SEM. This may be because of bigger particle size of Alumina. SEM analysis clearly indicates the mode of failure is the combination of crack in matrix, matrix/fiber de-bonding and fiber pull out for all types of composites.

Md Nadeem M.et.al,[5] Studied, composite materials required for elevated temperature applications were fabricated using vacuum bagging technique. Epoxy Resin (ER-VP401) was used as the matrix and Glass fibre was used as reinforcement. SiC, Al2O3 and others were used as fillers to bring in elevated temperature resistance. These composites were subjected to mechanical tests like Tensile, Hardness and Impact test. Tribological tests like two body abrasion and Pin on disc (POD) were carried out. Tensile strength, hardness and impact energy were improved with increase in fillers content. Wear resistance also improved with increase in percentage of fillers substantially. SEM micrographs are used to explain the mechanism of the material strengthening at elevated temperatures.

S. Rajesh.et.al,[6] fabricated epoxy and polyester resin composites using aluminium oxide, silicon carbide with different proportion of Al2O3 and SiC along with GFRP. A mixing unit has been fabricated for making reinforcement mixtures. Mechanical testing like tensile, impact hardness shear bi axial are conducted in order to know the properties of fabricated composites. The result shows

Arun kumar Parida.et.al,[7] A attempt has been made to assess the influencing parameters on the machining of GFRP composites. Using Taguchi method, an L9 orthogonal array has been used for experimentation and the experiments were conducted on all geared lathe using carbide tool with three levels of input parameters such as cutting speed, depth of cut and feed rate. A procedure has been developed to assess and optimize the chosen factors to attain minimum surface roughness by incorporating: (i) response table and response graph; (ii) normal probability plot; (iii) analysis of variance (ANOVA) technique. It is found that the feed rate is the most significant parameter followed by the depth of cut for surface roughness.

Vijay Baheti.et.al,[8] The mechanical activation of fly ash was carried out using ball milling to promote adhesion with epoxy. The 5 h of wet pulverized particles of size less than 500 nm. The obtained nanoparticles were incorporated into epoxy to prepare three layered laminated composite of glass fabrics. The results revealed substantial improvement in mechanical properties of Nano composites as compared to neat and unmilled fly ash composites. Moreover, the storage modulus exhibited 85.71, 38.09, 104.76 and 80.95% increment over neat composites for 1, 3, 5 and 10 wt% of activated fly ash at 200 C.

Material and Methods

Commercially available 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 1kg of material to be processed in the extruder. 5, 10, 15 and 20 percent of carbon fiber and to pure polypropylene. Table 1 gives the details of weights of different materials added to pure polypropylene.

Table:1 Mass of Polypropylene and carbon fibers

Materials	**Density**	**5% Mass, gm**	**10% Mass, gm**	**15 % Mass, gm**	**20 % Mass, gm**
Carbon fiber	1.75	42	84	126	168
Polypropylene	0.905	412.68	390.96	369.24	347.52

Polypropylene is available commercially in form of pellets. Carbon fibers available in form of tow were chopped into short fibers. All the compounds were weighed using an electronic weigh balance. Through the hopper, the compounds were initially introduced to the twin screw extruder. The material is melted in the extruder owing to temperatures exceeding 200^0 Celsius. The molten substance is acquired in the form of wires through pin-sized holes. The extruded wires are chilled and solidified in a water bath before being chopped into pellets using a pellet making machine. The granules are then introduced into the pneumatic injection moulding machine in order to produce standard test specimens.

Results and Discussions

1. Ultimate tensile strength

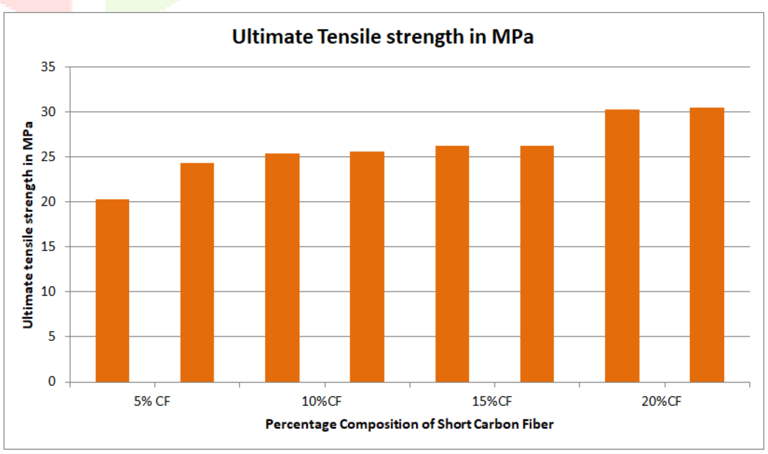

Figure: 1 Ultimate tensile strength of Polypropylene with different wt% of Carbon fiber

It is observed that the ultimate tensile strength increases with percentage of carbon fiber. Pure polypropylene with 5% Carbon Fiber has ultimate tensile strength of 20.3 MPa which increases to 32.5MPa at 20 percent carbon fiber content. No significant increase in tensile strength is observed between 10 and 15 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.

2. Hardness

The results indicate that composites with Higher Carbon fiber have greater hardness strength compared to remaining composite. The improvement in bonding, adhesion, and fibre dispersion in the matrix contributes to the increase in hardness, which in turn results in improved strength.

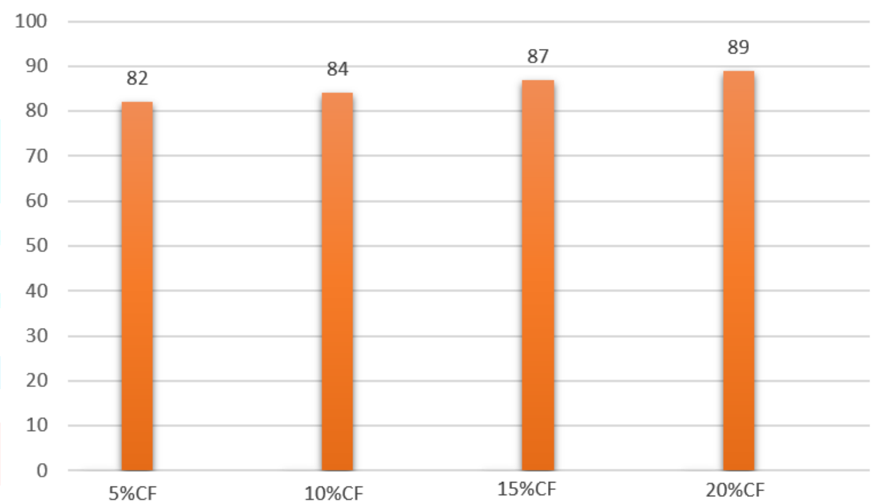

Figure: 2 Hardness of Polypropylene with different wt% of Carbon fiber

3. Impact Strength

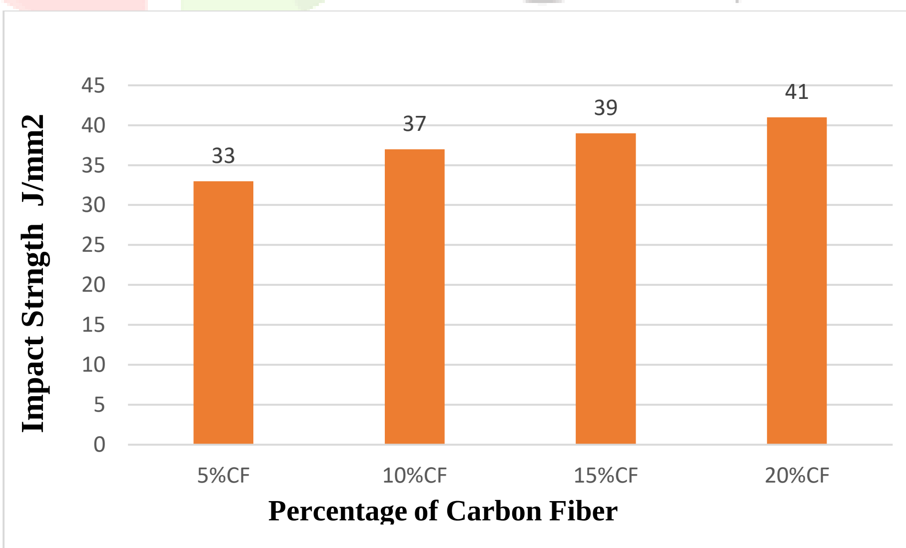

Figure: 3 Impact Strength of Polypropylene with different wt% of Carbon fiber

Impact Strength also increases considerably due to the reinforcement of the carbon fibers in polypropylene. Increased impact strength is the result of improved fiber bonding, adhesion, and matrix distribution.

4. Flexural Strength

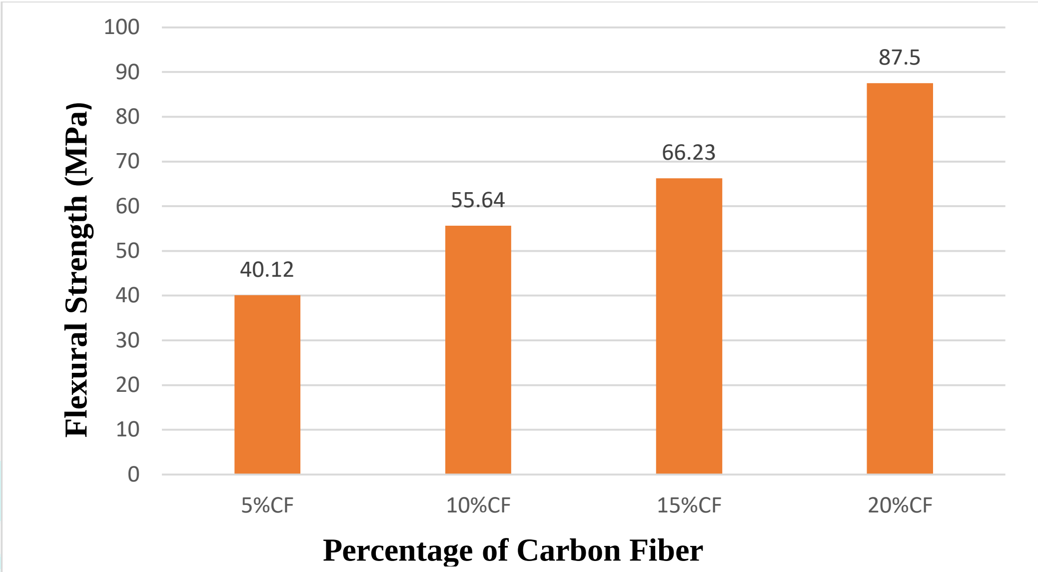

Figure: 4 Impact Strength of Polypropylene with different wt% of Carbon fiber

The results illustrate the average flexural strength of composite laminates. The findings indicate that carbon fiber composites have greater flexural strength than other composite laminates. Because the PP matrix exhibits superior adhesion and bonding with reinforcements. This indicates that the flexural strength of Unfilled 20% CF composite was 87.5 MPa. Due of the advantageous entanglement of the polymer chain with reinforcement, which overcomes the poor fibre matrix adhesion.

Conclusions

As a result of their recyclable nature, superior stiffness, and strength-to-weight ratio, thermoplastic composites reinforced with carbon fibre are quickly gaining ground as a viable alternative material for automobile parts. This research looked at the effects of de-sizing carbon fibre on the structural and mechanical properties of Carbon Fibre Reinforced Polypropylene (CFPP) composites moulded using Injection Moulding technology. The mechanical properties of pure polypropylene are found to improve as the carbon fibre content increases.

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