Evaluation of Mechanical characteristics of Nylon-6 reinforced with graphite and banana fiber

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Abstract: Banana fiber-based polymer composite with nylon 6 (polyamide 6) as matrix material and graphite as a tensile strengthening agent was synthesized using die casting process. The investigations exhibited that the addition of graphite powder in the nylon 6 material increases the hardness of the material but makes it more and more brittle by adding large amount of graphite powder. So, a specific amount of graphite that was 12% of graphite powder was showing better result. In this experiment hardness test and bending test was performed on the polymer composite material which showed a potential improvement than the basic nylon 6 materials. Therefore, all this improvement is acquired at a very less cost, thus nylon 6 materials are used in many applications such as aircraft industries, automobiles and many more. This composite can become convenient replacement without more investment.

Keywords: Polymer composites, Nylon 6, Die Casting

INTRODUCTION

Most basically produced composites used for a polymer-based matrix is mostly called a resin. There are many polymers that depends on the starting ingredients like polyester, epoxy, vinyl ester, phenolic, polyamide, polyimide, polypropylene, polyether or ketone (PEEK), and others. Fibers are incorporated as reinforcing agents. Vacuum infusion gives a final composite material with 35% of resin and 65% of fiber content. The tensile strength of the composite material is influential on the type of composition. Characteristics of various polymers will govern the suitable application and use. The main characteristics of polymers as matrix are less cost, chemical inertness, less specific gravity and easy process ability. However, its less modulus, less tensile strength and less working temperatures limits their applications. Varieties of polymers composites are thermosetting polymers, thermoplastic polymers, elastomers etc.

Mei Lv et al. Worked on simulated environment based on start stop friction and compared friction and wear characteristics. Further it was found that the addition of aramid fibers and carbon is beneficial for lowering coefficient of friction and increasing wear characteristics of PI based matrix, using carbon-fiber as reinforcements. UV rays affected the microstructure in PI based composites to some level. This further influenced wear and friction characteristics [1]. **Sanjay M Ra et al.** observed that the physical and mechanical characteristics varies from fiber to fiber in the developed composites. Composites fabricated by the inclusion of natural fibers as reinforcing agents have many industrial applications, due to their superior characteristics like low density, cheapness, specific tensile strength, better mechanical characteristics, bio-degradable characteristics and eco-friendly [2]. **Behrouz Arash et al.** worked on the fracture characteristic of PMMA polymer-based matrix. The influence of the carbon nano tube weight fraction on the critical strain, tensile strength, Elastic modulus of developed composites were observed. The simulated investigations

demonstrated that the uni-directional CNT notably improve mechanical characteristics of nano composites [3]. **P.J. Hine et al.** worked on the ideal temperatures needed for fabrication of hybrid composite material. Hot compaction is affected the orientation as well as size of reinforcements. For 22% weight fraction of fibers, a refined sample was developed at 176°C. At 178 degrees there is a phenomenon of disturbance in molecular orientation, hence it is well defended by keeping the temperature down by 2-degree Celsius [4]. **Deniz Aydemir et al.** worked on the investigation on the impact of heat-treated/ Untreated wood fibers on the rheological and mechanical characteristics of the nylon 6 matrix. The developed composites exhibited the enhancement in the flexural and tensile characteristics compared to pure nylon 6 [5]. **Nan Feng et al.** Worked on RCF surface-modified with the ether of bisphenol which is an integrating agent in the matrix of nylon 6 composites. The composited were developed using extrusion. A good reinforcing action was observed due to the improvement in adhesion between the fibers and matrix. This overall resulted in a considerable improvement in mechanical characteristics as well as in the thermal stability [6]. **Husna P. Nur et al.** studied various mechanical properties like tensile strength and elastic module of untreated banana fiber. Due to this, it was found that the fabricated PE composites have less-density. It can be enhanced further by inclusions of reinforcing fibers. It was analyzed that treated banana fiber PE composites performed better in comparison to the untreated ones [7]. **H. Liu et al.** worked on the synthesis of HDPE/Nylon-6 blends with banana fibers as reinforcing agents. Various blends were developed by varying reinforcements proportions. Morphology as well as microscopic characteristics were studied in the employed extrusion process. The existence of SEBS-g-MA was found to be beneficial as reinforcing agent in the developed composites [8]. **E.C. Botelho et al.** studied the mechanical characteristics of polyamide composites. Investigations were done in two modes i.e loading on tensile and compressive loading conditions. Three composites families were synthesized by amalgamating - interfacial compression and molding. The developed composites further revealed a homogeneous microstructure by scanning and optical electron microscopy methods. However, the composites that have been fabricated by implementing hot compression molding, have indicated higher tensile and better compression strength values. Also, there is improvement of these properties with increase in the proportion of fiber volume [9].

SPECIMEN PREPARATION

Fabrication of polymer composite was done using Extrusion based process. It is a method that is employed to form objects of a set cross-sectional profile. A fabric is pushed through a die of bound crosswise. The chief advantage of this method in contrast to alternative producing processes is its ability to form a fancy crosswise, and to figure materials that are brittle, as a result of the fabric solely encounters shear and compression stresses. It conjointly forms elements with a superb surface end.

Material composition is shown in the table below.

Table1: Composition of materials in percentage

MATERIAL	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
NYLON 6	200gms	200gms	200gms	200gms

GRAPHITE	8%	10%	12%	14%
BANANA FIBER	10%	10%	10%	10%

The composition of the fiber is fixed to 10% because previous works has shown that the 10% composition of the fibers is the best composition so as to get the optimum possible result. So the fiber composition is fixed to 10%. The composition of the graphite powder is varied so as to get the better composition and the result. Adding of more graphite leads to brittleness in the material so the addition of graphite should in fewer amounts.

NYLON 6

Nylon 6 is the base polymer material used that is used in this experiment.

Figure1: Raw form of nylon 6

GRAPHITE POWDER

Graphite powder is also used in this experiment as a composition which helps to increase its hardness. This is raw form of graphite which is used in this experiment. Secondary synthetic powder is used in this experiment.

Figure 2: Raw form of graphite

BANANA FIBER

Banana fiber was used a fiber which holds the material together to get nice hold between the materials. Banana fiber was obtained from a local supplier in Andhra Pradesh.

Figure 3: Extracted banana fibre

RESULTS AND CONCLUSIONS

There are total of four compositions of material that were air cooled and two of the material was water quenched we will see the results of all 6 materials.

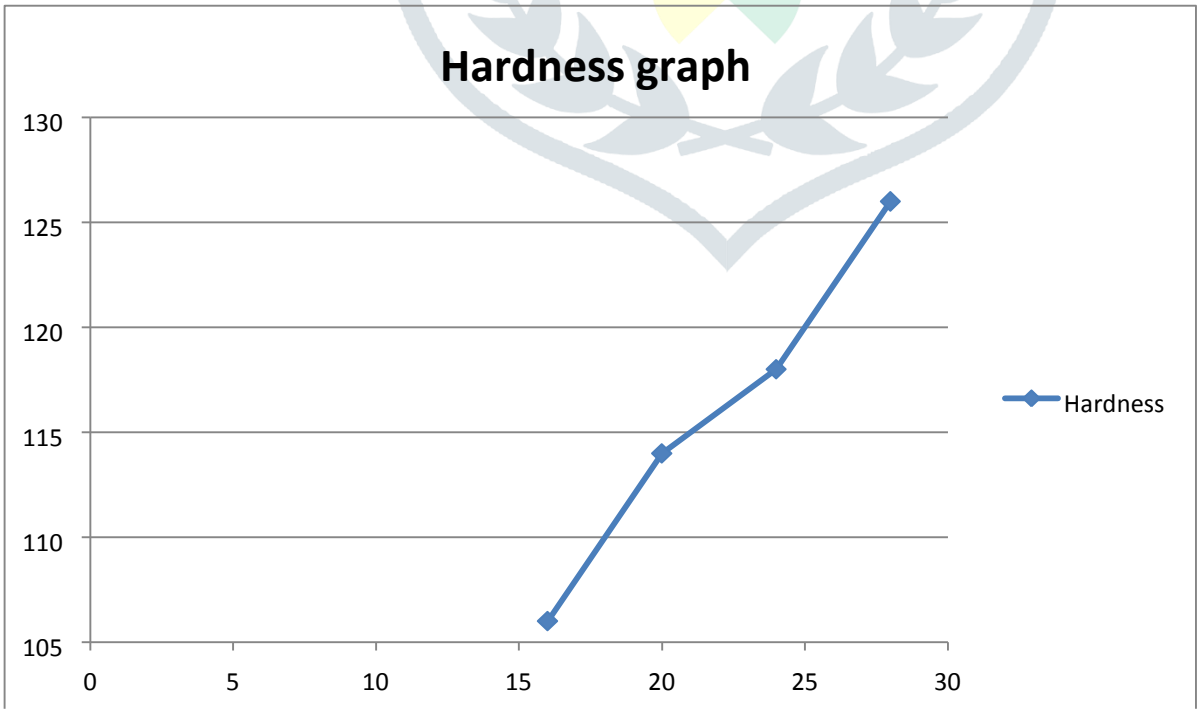
Table 2: Hardness of Air Quenched samples

S.NO	LOAD (Kg)	SAMPLE 1 HRC	SAMPLE 2 HRC	SAMPLE 3 HRC	SAMPLE 4 HRC	HRC BEFORE
1	150	110	112	115	132	95
2	150	106	117	119	121	95
3	150	101	113	120	125	95
Mean	150	106	114	118	126	95

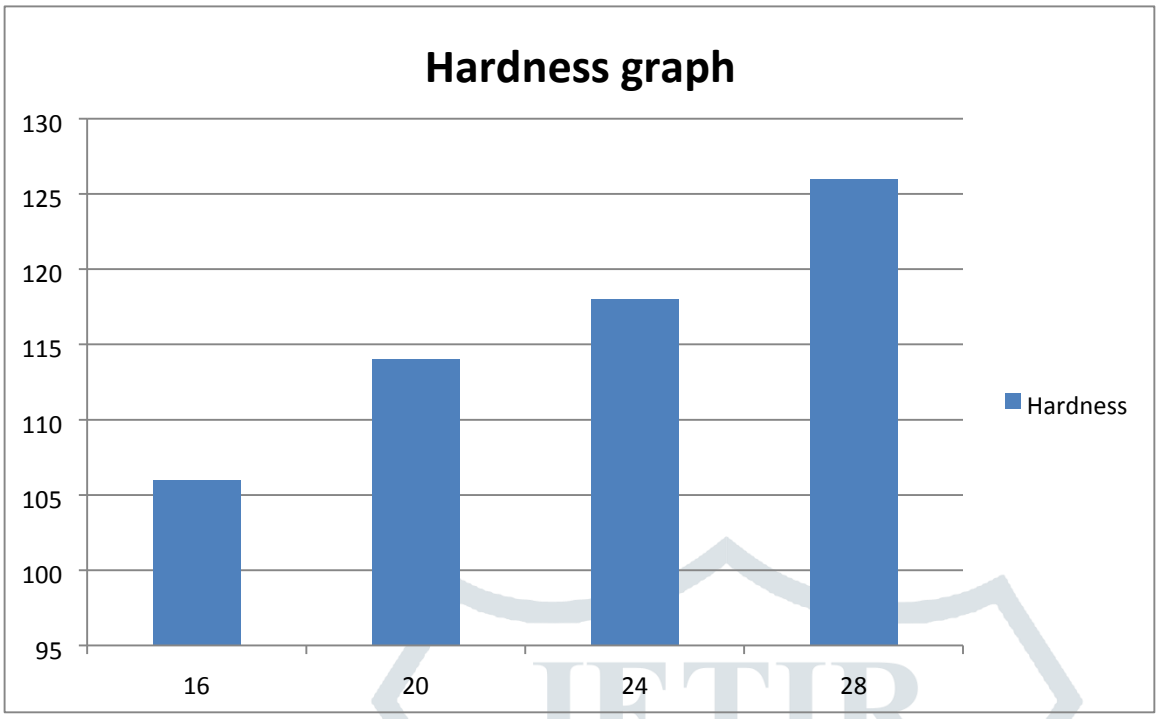
Table 3: Hardness of Water Quenched samples

S.NO	LOAD (Kg)	SAMPLE 2 HRC	SAMPLE 3 HRC	BEFORE HRC
1	150	135	155	95
2	150	141	161	95
3	150	142	154	95
Mean	150	139	157	95

Figure 4: Test Specimen



Graph 1: Hardness Vs Graphite composition



Graph 2: Bar graph of hardness Vs graphite composition

BENDING TEST

Specimen was loaded in universal testing machine and kept under compression at various loads this is done for one specimen and the values were noted.

Bending test deforms the test material at the center inflicting a concave-shaped surface or a bend to make while not the incidence of fracture and are usually performed to see the plasticity or resistance to fracture of that material.

Bending test was done to the specimen which had the best result in hardness and considerably ductile by manually verifying in hand. Composition 3 which was water quenched gave the best result and it was tested.

Table 4: Bending test result

LOAD	50KN
FLEXURAL STRENGTH	80MPA

CONCLUSION

- It has been observed addition of graphite powder increases the hardness of the nylon 6 material.
- Exactly it was noted that 12% of graphite on the base material which is nylon 6 material increases the hardness with water quenching as cooling method.

- Natural fiber was also added which helps to combine the material that is banana fiber. Natural fibers are eco-friendly and which costs very less. Natural fibers can be used as an alternative for synthetic fiber with suitable combinations an proper method of preparation.
- It was found that on further addition of graphite it increases the hardness but it cause material to break due to high brittleness.
- By performing hardness test and bending it was concluded that 12% of graphite and 10% of banana fiber gave the best possible result.
- This polymer material is a rust proof material it can also be used to get a coat on the metal as coating.
- The weight if this composite material is very less so it can be used in the application on automobiles.

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