Mechanical Properties of HDPE Reinforced with carbon fiber Powder with and without filler addition

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Abstract- *In this study we fabricated a composite material where High Density Polyethylene (HDPE) is reinforced with carbon fiber powder and aluminium oxide is used as filler. The properties of individual material used for the are studied. Also, the process of formation of composite material is given in brief. Composite material is prepared by injection moulding process. The mechanical properties of this material are tested and the obtained results are tabulated. The purpose of this study is to find composite materials with similar properties so that it can be used for total joint replacement of our body. The cost of composite materials is very less compared to materials like iron, gold, zinc, steel and titanium. The successful use of composite materials may increase the popularity of artificial joint replacement.*

Keywords- HDPE, Carbon fiber, Aluminium oxide, Injection moulding, Total joint replacement

1. INTRODUCTION

Over a decade's Synthetic fibers are eco-friendly had been proven, by virtue of its several attractive attributes that includes lower density, low price, non-toxicity easy processing. Fiber reinforced polymer composite material used in medical application. Such as orthopedic implants, bone implants.

Natural plants have their own medical values such as biological photo chemical is normally present in the leaves, root, barks and flower. Synthetic fiber has good advantages towards small density, proper rigidity & having mechanical properties, biodegradable, Synthetic fiber reinforced polymer composite material are less rigid compare to metals and are best alternatives having properties are closer to the mechanical properties of bone. It helps to avoid stress shielding and gradually helps to build bone remoulding.

Synthetic fiber reinforced polymer in bio industrial has initiate to overcome problem sort by medical practitioners. Orthopedic surgeon is using metallic plates, bone plates for human bone fracture. Usage of metals in bone fixation such as stainless steel and titanium alloy causes problems like metal incompatibility, corrosion and reduce in bone mass enhance bone porosity.

Fabrication of hybrid natural fiber reinforced polymer composite using HDPE resin, instead of using metal-based alloys namely titanium, cobalt chrome, stainless steel & zirconium Synthetic fiber used in favor of both inside and outside fixation of fractured human bone.

The word biomaterial is stated as natural or synthetic substance that has ability to interact with biological system to direct medical treatment. Biomaterial should have biocompatibility nature and they have appropriate host response with living tissue to meet the basic needs of biomedical community.

Composite has several aspects in bio medical application such as drug/ gene delivery, cosmetic orthodontics, tissue engineering application etc. they often to imitate the existing structural materials concerned in the event towards produce result.

1.2 NEED OF COMPOSITE AS A BIOMATERIAL

Bones as a hard tissue are solid and hardened and obviously have high elastic modulus. Human bones are normally and fundamentally composite material made of collagen fiber and nano crystal of hydroxyapatite which are sediment in collagen fiber.

The elastic modulus of collagen fiber is low and hydroxyapatite have high elastic modulus which contains 70% weight of the dry bone and match the stiffness of the bone. With this reality, composite material has good biocompatibility.

1.3 COMPOSITE MATERIAL

Composite material is naturally available material made of two or more being a part of material. Composite material has two phases namely Matrix phase and Reinforced phase. The reinforcement phase held firmly with matrix phase which gives more strength and stiffness.

2. OBJECTIVES AND SCOPE

2.1 OBJECTIVES OF THE PRESENT WORK

1. **Fabrication of unsaturated HDPE resin reinforced with Carbon fiber powder with and without filler additions.**
2. **To evaluate the Mechanical characteristics of the prepared composite materials.**
   a) Mechanical characteristic like tensile strength, compression, flexural strength.
   b) To study effects of incorporation of with and without filler addition
   c) To know the optimum composition of fillers with carbon fiber powder reinforced HDPE composite.

2.2 SCOPE OF THE PRESENT WORK

Literature on hand reveals that no single group of researchers has completely characterized the mechanical characteristic of Hybrid synthetic fiber reinforced HDPE polymer by adding fillers material.

The current work is an attempt to make use of the natural recycled resources to develop bio composite material for biomedical applications such as bone Plates, bone screws material for both internal, external fixations. The synthetic fibers are used as reinforcement in HDPE resin matrix and aluminium oxide and titanium oxide is used as fillers. Hence Aluminium oxide is used as a stabilizer to a predictable synthetic matrix, the polymer get in touch with the earth or water is assault through the microbes. The microbes absorb the fine powdered aluminium oxide exit after a permeable, spongy like structure by means of a high interfacial region, and less structural potency. This behavior of bio composite is useful for bone fixation devices.

3. METHODOLOGY

The Methodology used in this work is shown in the flow chart below

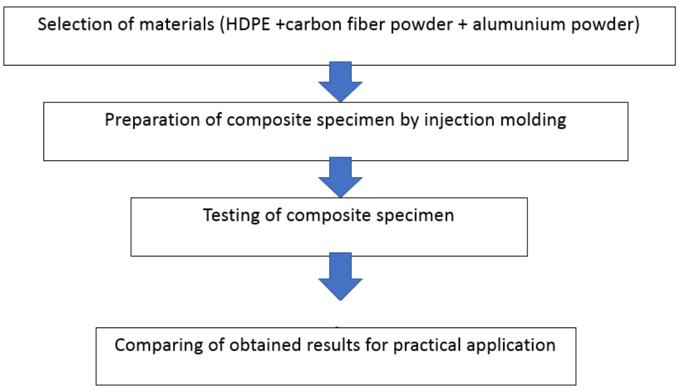

Figure 3.1: Methodology flow chart

3.1 SELECTION OF MATERIALS

Material selection play a good role in the engineering field for structure or device thus developed to perform satisfactorily. Working environment, function of the part, mechanical strength, formability, cost, availability etc., are the parameters that need to be considered in selection of material.

Bio-compatibility is very important parameter in the selection of materials for biomedical application. Biocompatibility is the capability of the material to carry out required genetic response in particular application. The completed medical device or component while interacting with living system or tissue doesn't have chemical reaction, irritation, and doesn't harm the patient

3.1.1 SELECTION OF RESIN

The word matrix refers to binder since they bind the reinforcement together. It gives outline to the combined material and guard strengthening material from unfavorable environments. Therefore, in this current work Unsaturated HDPE resin is selected as matrix material.

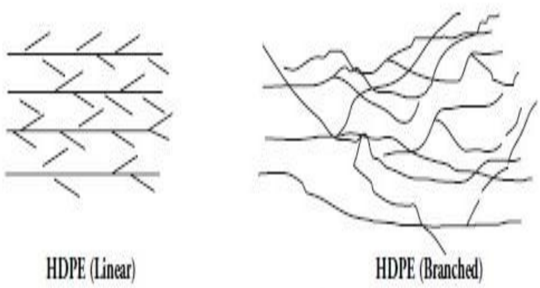

Figure 3.2: Schematic of linear and branched HDPE

High Density Polyethylene (HDPE)

High Density Polyethylene is a polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes, and plastic lumber. HDPE is commonly recycled and has the number "2" as its resin identification code. HDPE is known for its large strength to density ratio. The density of HDPE can range from 0.93 to 0.97 g/cm^3 or 970 kg/m^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/ 248 °F for short periods).

The physical properties of HDPE can vary depending on the molding process that is used to manufacture a specific sample; to some degree a determining factor are the international standardized testing methods employed to identify these properties for a specific process. For example, in Rotational Molding, to identify the environmental stress crack resistance of a sample, the Notched Constant Tensile Load Test (NCTL) is put to use.

Owing to these desirable properties, pipes constructed out of HDPE are ideally applicable for potable water, and waste water (storm and sewage) force mains across multiple municipalities, namely Toronto Water.

Figure 3.3: High Density Polyethylene

3.1.2 Carbon fiber

Carbon fibers or carbon fibers (alternatively CF, graphite fiber or graphite fiber) are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

Figure 3.4: Carbon fiber powder

To produce a carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio (making it strong for its size).

3.1.3 Aluminum oxide

Aluminum oxide is the amphoteric oxide of aluminum with the chemical formula Al_2O_3. It is also commonly referred to as alumina or aloxite in the mining, ceramic and materials science communities. There are two forms of anhydrous Al2O3, namely, α- Al2O3 and γ- Al2O3. α- Al2O3 is stable at high temperatures and also indefinitely metastable at low temperature. It occurs in nature as the mineral corundum and prepared by heating γ- Al2O3 or any hydrous oxide above 1000°C. α- Al2O3 is hard and is resistant to hydration and to attack by acids. The density of α- Al2O3 is only about 0.595 g/cm3 with a hexagonal close packed, HCP array of anions. Although the anions are topologically arrayed as if they rare in closest packing, they are really not contacting with one another.

Figure 3.5: Aluminium oxide

3.2 SAMPLE PREPARATION CALCULATION

- Density of HDPE resin = 0.93-0.97gm/ cm^3
- Density of Carbon fiber Powder = 2.1 g/cm^3
- Density of aluminum oxide = 3.95 g/cm^3
- Volume of the mould, V =12.0x12.0 x 0.3 =43.2 cm^3

Formulae used

$A_C = A_{HDPE} + A_{carbon\ fiber} + A_{aluminium\ oxide}$ → (1)

Where

A_C = mass / density of the composite

A_{HDPE} = mass/ density of the resin

$A_{carbon\ fiber}$ = mass / density of the carbon fiber

$A_{aluminium\ oxide}$ =mass/ density of the aluminium oxide

$W_c/\rho_c = W_{HDPE}/\rho_{HDPE} + W_{carbon\ fiber}/\rho_{carbon\ fiber} + W_{aluminium\ oxide}/\rho_{aluminium\ oxide}$ → (2)

Where

W_C = mass of the composite

W_{HDPE} = mass of the matrix

$W_{carbon\ fiber}$ = mass of the reinforcement

Similarly, $W_{aluminium\ oxide}$ = mass of the filler

For Sample: 1 (HDPE 100%)

$A_C = A_{HDPE} + A_{carbon\ fiber} + A_{aluminium\ oxide} \rightarrow (1)$

$W_c/\rho_c = W_{HDPE}/\rho_{HDPE} + W_{carbon\ fiber}/\rho_{carbon\ fiber} + W_{aluminium\ oxide}/\rho_{aluminium\ oxide} \rightarrow 2$

$1/\rho_c = (1/0.945) + (0/1.7) + (0/3.95)$

$1/\rho_c = 0.945$

$\rho_c = 0.945$gm/cc

$W_c = \rho_c \times v$

$W_c = 0.945 \times 43.2$

$W_c = 40.824$gm of composite plate

For sample: 2 (HDPE 90%, carbon fiber 10%, aluminium oxide0%)

$A_C = A_{HDPE} + A_{carbon\ fiber} + A_{aluminium\ oxide} \rightarrow (1)$

Where

A = mass / density

$W_c/\rho_c = W_{HDPE}/\rho_{HDPE} + W_{carbon\ fiber}/\rho_{carbon\ fiber} + W_{aluminium\ oxide}/\rho_{aluminium\ oxide} \rightarrow 2$

$1/\rho_c = (0.9/0.945) + (0.1/1.7) + (0/3.95)$

$1/\rho_c = 1.011$

$\rho_c = 0.989$gm/cc

$W_c = \rho_c \times v$

$W_c = 0.989 \times 43.2$

$W_c = 0.989 \times 43.2 = 42.72$gms of composite plate

To find mass of the HDPE, carbon fiber and filler

$W_{HDPE} = 42.72 \times 0.9 = 38.45$ grams

$W_{carbon\ fiber} = 42.72 \times 0.1 = 4.27$ grams

$W_{aluminium\ oxide} = 42.72 \times 0 = 0$ grams

For sample: 3 (HDPE 88%, carbon fiber 10%, aluminium oxide2%)

$A_C = A_{HDPE} + A_{carbon\ fiber} + A_{aluminium\ oxide} \rightarrow (1)$

Where

A = mass / density

$W_c/\rho_c = W_{HDPE}/\rho_{HDPE} + W_{carbon\ fiber}/\rho_{carbon\ fiber} + W_{aluminium\ oxide}/\rho_{aluminium\ oxide} \rightarrow 2$

$1/\rho_c = (0.88/0.945) + (0.1/1.7) + (0.02/3.95)$

$1/\rho_c = 0.995$

$\rho_c = 1.004$gm/cc

$W_c = \rho_c \times v$

$W_c = 1.004 \times 43.2$

$W_c = 0.989 \times 43.2 = 43.39$gms of composite plate

To find mass of the HDPE, carbon fiber and filler

$W_{HDPE} = 43.39 \times 0.88 = 38.18$ grams

$W_{carbon\ fiber} = 43.39 \times 0.1 = 4.339$ grams

$W_{aluminium\ oxide} = 43.39 \times 0.02 = 0.8679$ grams

For sample: 4 (HDPE 86%, carbon fiber 10%, aluminium oxide4%)

$A_C = A_{HDPE} + A_{carbon\ fiber} + A_{aluminium\ oxide} \rightarrow (1)$

Where

A = mass / density

$W_c/\rho_c = W_{HDPE}/\rho_{HDPE} + W_{carbon\ fiber}/\rho_{carbon\ fiber} + W_{aluminium\ oxide}/\rho_{aluminium\ oxide} \rightarrow 2$

$1/\rho_c = (0.86/0.945) + (0.1/1.7) + (0.04/3.95)$

$1/\rho_c = 0.979$

$\rho_c = 1.02$gm/cc

$W_c = \rho_c \times v$

$W_c = 1.02 \times 43.2$

$W_c = 1.02 \times 43.2 = 44.064$gms of composite plate

To find mass of the HDPE, carbon fiber and filler

$W_{HDPE} = 44.064 \times 0.86 = 37.895$grams

$W_{carbon\ fiber} = 44.064 \times 0.1 = 4.406$ grams

$W_{aluminium\ oxide}$= 44.064× 0.04= 1.763 grams

For sample: 5 (HDPE 84%, carbon fiber 10%, aluminium oxide6%)

$A_C = A_{HDPE} + A_{carbon\ fiber} + A_{aluminium\ oxide}$ → (1)

Where

A = mass / density

$W_c/\rho_c = W_{HDPE}/\rho_{HDPE} + W_{carbon\ fiber}/\rho_{carbon\ fiber} + W_{aluminium\ oxide}/\rho_{aluminium\ oxide}$ → 2

$1/\rho_c = (0.84/0.945) + (0.1/1.7) + (0.06/3.95)$

$1/\rho_c = 0.963$

$\rho_c = 1.038$gm/cc

$W_c = \rho_c \times v$

$W_c = 1.038 \times 43.2$

$W_c = 1.02 \times 43.2 = 44.864$gms of composite plate

To find mass of the HDPE, carbon fiber and filler

W_{HDPE}=44.864× 0.84= 37.685 grams

$W_{carbon\ fiber}$ =44.864× 0.1 = 4.486 grams

$W_{aluminium\ oxide}$=44.864 × 0.06= 2.691 grams

SAMPLE	HDPE (%)	CARBON FIBER (%)	ALUMINIUM OXIDE (%)	MASS OF HDPE (gms)	MASS OF CARBON FIBER (gms)	MASS OF ALUMINIUM OXIDE (gms)	TOTAL MASS (gms)
1	100	0	0	40.824	0	0	40.824
2	90	10	0	38.45	4.27	0	42.72
3	88	10	2	38.18	4.339	0.8679	43.39
4	86	10	4	37.895	4.406	1.763	44.064
5	84	10	6	37.685	4.486	2.691	44.864

Table 4.1: Sample preparation calculation

Figure 4.6: Injection moulding machine

3.3 SPECIMEN PREPARATION

3.3.1 INJECTION MOULDING

Injection moulding is manufacturing process for producing parts by injecting molten material into a mould. It consists of a material hopper, an injection ram or screw-type plunger, and a heating unit. Material for the part is fed into a heated barrel, mixed, and injected into a mould cavity, where it cools and hardens to the configuration of the cavity. This process is used to create many things such as wire spools, packaging, bottle caps, automotive parts and components, gameboys, pocket combs, some musical instruments.

3.4 SPECIMEN PREPARATION STEPS

The steps involved in preparation of treated hybrid natural fiber reinforced HDPE composites laminates with injection moulding process is as follows:

STEP 1

A mild steel plate mould is prepared for our required dimension 120 × 20 × 3 mm. with soft brush using acetone to remove dust. A layer of wax is coated to the cleaned surface to remove laminate after curing.

Figure 4.7: NC machining

Figure 4.8: Fabricated mild steel die

STEP 2

Wax is applied to the steel die before material is poured in the metal die.

STEP 3

Weighed quantity of carbon fiber (reinforced) aluminium oxide (filler), are added to HDPE resin taken in the bowl and stirred well for uniform distribution. The hardener is added in promoter &catalyst of 10:1000 into the HDPE resin.

STEP 4

Mixed liquid resin is poured into the steel die and allowed to cure for required period of time.

STEP 5

By following the same procedure as said above bio-composite material having with filler & without filler composition of Sample 1,2,3,4,5 is prepared.

Figure 4.9: final product is prepared.

STEP 6

The prepared Bio-Composite materials are cut into standard ASTM Dimensions using abrasive water jet machine.

Figure 4.10: Abrasive water jet cutting machine

Figure 4.11: Cut sections

Figure 4.12: Required specimen

3.5 EXPERIMENTATION

Purpose of Testing Composite Materials

- To ensure quality of raw materials.
- Evaluate and optimize materials.
- Evaluate and optimize manufacturing process available.
- To determine the effect of equipment's and tool design.
- To establish engineering design information.
- To measure quality and reproducibility of end products.

Causes for Failure of Products

The causes of failures are imperfection in design, method, excellence and part application, which are the primary reason for the failure.
Four main causes of failure of products are

- Improper application of product.
- Poor design.
- Inadequate control of materials.
- Poor manufacturing techniques and misapplication of materials.

3.5.1 TENSILE TEST

The tensile test is also called as tension test is almost certainly primary type of mechanical test that could be carry out on a material. Tensile tests are uncomplicated, comparatively inexpensive, and entirely identical test. Tensile test was conducted on specimens cut from fabricated composites.

APPARATUS

A testing machine of the stable speed of the cross-head motion and consist of basically of the following:

- Fixed member- a rigid or fundamentally motionless member carrying the grip.
- Movable member- a variable portion carrying the opposite grip.
- Grips- the function grip is to hold the specimen firmly

The Fixed grips are firmly joined to the rigid and variable member of the testing machine. The rigid and variable grips are parallel to each other of the testing machine in such a way to facilitate any load can be applied.

3.5.1.1TENSILE TEST SETUP

Name: SJCIT universal testing machine

Model: EZ20 easy test

No. of samples tested: 12

Max load: 20KN

Speed: 5 mm/min

Gauge Length:36 mm

Figure 4.13: UTM for tensile test

3.5.1.2. SPECIMEN DIMENSIONS

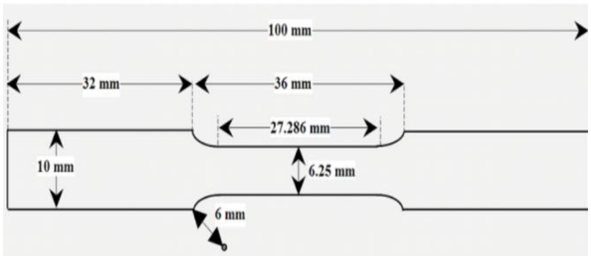

Figure 4.14: Tensile test specimen

Figure 4.15: Tensile specimen after testing in UTM

3.5.1.3PROCEDURE

- Tensile test is done as per ASTM E-8.
- The test sample is cut as per ASTM E-8(Fig 6.3)
- Universal testing machine is checked with standards before test conducted
- Specimen plate is enclosed between the grippers of universal testing machine.
- Constant Load applied to deform the sample.
- Note down the readings with respect to load vs length

- Then stress strain corresponding load and corresponding deformation are calculated.
- Procedure is repeated for different trials.

3.5.2 COMPRESSION TEST

Mechanical test evaluates the highest quantity of compressive load on material can tolerate before fracture. The test sample, generally in the kind of a regular polyhedron, polyhedron with parallel ends, or cylinder, is compress between the platens of a compressive testing apparatus by a steadily applied load.
The characteristic of tensile test is quite differing to the compression test Nature of change shape and apparatus break is just dissimilar compare to tensile test. Compression load can be inclined to press the sample. Breakable materials are normally feeble in tension but tough in compression. The cast iron and concrete are used to test compression rather than other. The ductile material such as aluminium & mild steel having good tension strength can also be tested to know the compression strength. The compression test specimen prepared as per ASTM D-3410 of size (155×25×3.17)

Figure 4.16: Compression test apparatus

3.5.2.1 COMPRESSION TEST SETUP

Name: SJCIT universal testing machine

Model: EZ20 easy test

No. of samples tested: 12

Max load: 20KN

Speed: 2 mm/min

3.5.2.2. SPECIMEN DIMENSIONS

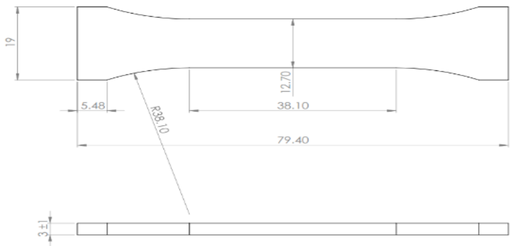

Figure 4.17: Compression test specimen

Figure 4.18: Compression specimen after testing

3.5.2.3. PROCEDURE

- Compression test was conducted on specimens prepared to ASTM D-695
- Dimensions of test sample are considered at three dissimilar places beside its height/length to find out the average cross-sectional area.
- The test sample ends must be plane.
- Sample is positioned centrally among the 2 compression plates, so as to center of moving head is perpendicularly exceeding the center of sample.
- The load is gradually applied to the test sample.
- The load & the corresponding contraction readings are note down at dissimilar period.
- Load is applied to the test sample sustain up to maximum limit.

3.5.3 FLEXURAL TEST

The 3 Pt bending flexural test gives values in favor of flexural stress, flexural strain & the flexural stress-strain reply of the sample. The major benefit of a 3-pt. flexural test is the simplicity of the sample preparation & analysis.

Figure 4.19: Flexural test apparatus

3.5.3.1 FLEXURAL TEST SETUP

Name: SJCIT universal testing machine

Model: EZ20 easy test

No. of samples tested: 12

Max load: 20KN

Speed: 2 mm/min

3.5.3.2. SPECIMEN DIMENSIONS

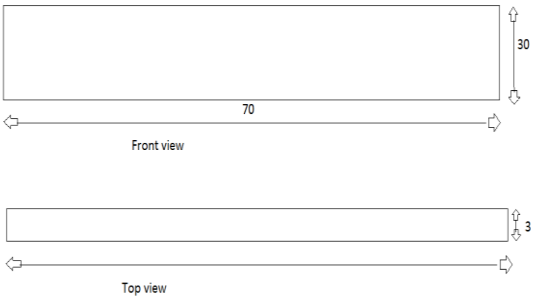

Figure 4.20: Flexural test specimen

Figure 4.21: Flexural specimen after testing

3.5.3.3 PROCEDURE

- Flexural test is carried out as per ASTM D - 790
- The test sample cut as per ASTM D-790
- Dimensions of test sample are considered at three dissimilar places beside its height/length to find out the average cross-sectional area.
- The sample ends must be plane.
- The test sample is positioned on the apparatus as shown in Figure 6.5.
- The load is gradually applied to the test sample
- The load & the consequent deflections were calculated on different instant.
- Load is applied to the test sample sustain up to maximum limit.

4 RESULT AND DISCUSSION

In this chapter the results obtained from tension, Compression, Flexural and Hardness tests are tabulated and represented graphically to analyse the behavior of composites.

4.1 TENSILE TEST

Table5.1: Tensile results

Sample No.	Composition	Break load (N)	Peak load (N)	Ultimate tensile strength (N/mm^2)	Young's modulus (N/mm^2)
1	HDPE (100%)	3.13	280	15.56	164.38
2	HDPE (90%) +Carbon fiber (10%)	3.13	305	16.95	193.76
3	HDPE (88%) +carbon fiber (10%) + aluminium oxide (2%)	6.37	193	10.71	273
4	HDPE (86%) +carbon fiber (10%) + aluminium oxide (4%)	7.44	172	9.54	151.86
5	HDPE (84%) +carbon fiber (10%) + aluminium oxide (6%)	7.79	157	8.72	139.98

From these results we found that addition of reinforcement increases the tensile strength of the composite material compared to pure HDPE. But the addition of filler decreases the tensile strength of material and the strength goes on decreasing with increase in filler proportion. The highest strength obtained was 16.95 MPa with 90% HDPE and 10% carbon fiber powder. The tensile strength can be further increased with increase in proportion of carbon fiber powder.

4.2 FLEXURAL TEST

Table5.2: Flexural results

Sample No.	Composition	Peak load (N)	Break load (N)	Flexural Strength (N/mm^2)
1	HDPE (100%)	90	0.94	25.11
2	HDPE (90%) + Carbon fiber (10%)	86	0.94	24.53
3	HDPE (88%) +carbon fiber (10%) + aluminium oxide (2%)	83	0.94	23
4	HDPE (86%) +carbon fiber (10%) + aluminium oxide (4%)	69	0.94	19.04
5	HDPE (84%) +carbon fiber (10%) + aluminium oxide (6%)	56	0.95	15.56

From these results we found that addition of reinforcement and filler decreases the flexural strength of the composite material compared to pure HDPE and the strength goes on decreasing with increase in filler proportion. The highest strength obtained was 25.11 MPa with 100% HDPE. The flexural strength of pure HDPE is highest than its composites.

4.3. COMPRESSION TEST

Table 5.3: Compression results

Sample No.	Composition	Peak load (N)	Compressive Strength (N/mm^2)
1	HDPE (100%)	234	6.2
2	HDPE (90%) +Carbon fiber (10%)	250	6.6
3	HDPE (88%) +carbon fiber (10%) + aluminium oxide (2%)	281	7.3
4	HDPE (86%) +carbon fiber (10%) + aluminium oxide (4%)	289	7.6
5	HDPE (84%) +carbon fiber (10%) + aluminium oxide (6%)	297	7.8

From these results we found that addition of reinforcement increases the compressive strength of the composite material compared to pure HDPE. Also, the addition of filler further increases the compressive strength of material and the strength goes on increasing with increase in filler proportion. The highest strength obtained was 7.8 MPa with 84% HDPE and 10% carbon fiber powder and 6% aluminium oxide. The compressive strength can be further increased with increase in proportion of carbon fiber powder and also with increase in filler proportion.

5. CONCLUSION

From the test we determined the tensile, compression and flexural strength of the pure HDPE, HDPE reinforced with carbon fiber powder and also HDPE reinforced with carbon fiber powder with aluminium oxide as filler material. Also, their corresponding peak load and break load are determined.

For practical application this composite can be successfully used in replacement of fractured bone instead of metals. They are comparatively cheaper and can have higher strength and stiffness than that of metals. Carbon fiber if directly use for implant is poisonous to body. Hence the material must be first coated with hydroxyapatite. Hydroxyapatite (HA), is a naturally occurring mineral form calcium apatite with the formula $Ca_5(PO_4)_3(OH)$. Up to 50% by volume and 70% by weight of human bone is a modified form of hydroxyapatite, known as bone mineral.

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