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Evaluation of Mechanical Properties of Polyamide-Egg Shell Powder Composite Materials

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Abstract:
A composite is a structural material which consists of two or more constituents. The constituents are combined at a macroscopic level and are not soluble in each other. One constituent is called the Reinforcing Phase and the one in which it is embedded is called the Matrix Phase. The reinforcing material may be in the form of fibers, particles or flakes. The matrix phase materials are generally continuous. Fibers are used to carry the load and matrix is used to bind and transmit the load to fibers. Fibers can be produced with various materials, such as metals, glass and plastics etc. Now a day's natural fibers like animal feathers, plant fibers are used to produce the composites.
In the present work polyamide is used as a matrix materials, the egg shell particles are used as reinforced material to produce the composites. The mechanical properties such as tensile strength, impact strength, flexural strengths have to be tested.

Keywords: *component; Egg shell powder, Polymer matrix composite mechanical properties*

1. Introduction

A material is called composite if it has two or more distinct phases and the properties vary largely from the individual phase. Composites contain two phases.

- Matrix phase
- Dispersed phase

The primary phase is called matrix phase, this phase is continuous and it is more ductile and less harder it holds the secondary phase and shares the load with it. The secondary phase is in continuous form and is called dispersed phase. Usually this phase is harder than primary so it is also called reinforced phase
Though many common materials contains dispersed phases like metal alloys, ceramics etc. They are not considered composite materials as their physical properties are very much similar to the properties of their base materials.

1.1. Polymer Matrix Composites (PMC)

Composite materials are classified based on two types of criteria they are based on matrix material and based on dispersed phase structure. Classifications of composites based on matrix material are three types they are

- Metal matrix composite (MMC)
  MMC consists of a metallic matrix and a dispersed ceramic or a metallic phase
- Ceramic matrix composite (CMC)
  CMC phase consists of ceramic matrix phase and a dispersed phase of ceramic
- Polymer matrix composite (PMC)
  PMC consists of a unsaturated polyester or thermoplastic and glass, carbon, steel in dispersed phase .Composites Based on dispersed or reinforced phase are two typed they are Particulate composite and fiberous composite

- Particulate composite: The matrix phase consists of a dispersed phase in particular form (a) Dispersed phase of unoriented particles (b). Dispersed phase of two or more particles of particular orientation
- Fibrous composite: These are Short fiber-consists of discontinuous fibers .It have random fiber orientation. Composite of designated fiber orientation It have long fiber orientation

2. Preparation of Eggshell Powder

In the present work we used eggshell powder as a reinforced material to produce composite. the growing environmental awareness in recent times has urged for the need of non-conventional and environmental friendly (organic etc) materials in industries like automotives , packing construction etc against the conventional inorganic and plastic materials.

The mineral fillers are incorporated into thermoplastics widely in industries to enhance and extend certain properties desired. Fillers improve the performance of polymer products. These improvements depends on filler origin , particle size and shape, the fraction of fillers and the surface treatment involved in the process . this is a fast and cheap method to increase the properties of base material . This made particulate filling in polymers a very increasing interest in both industry and research. These material fillers help to increase strength , stiffness ,electrical and thermal conductivity, hardness and dimensional stability as to required values .these mineral fillers in thermoplastics help to achieve a certain degree of compatability in the system through modification of interfacial and interphase properties of polymer composites.

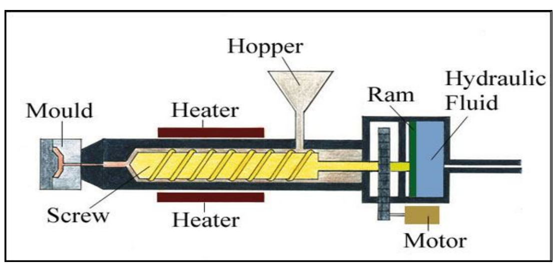
The empty eggshells are washed, dried and grounded using a mill so that the practical size of eggshell powder is 100µm . This powder is dried in a vacuumed oven at 140˚C until constant weight is obtained.

3. Injection Moulding Process

Injection molding is a thermal process in which requires material is injected into a desired mould. Injection molding is generally used on metals, glasses, elastomers, confections, thermoplastics and thermosetting polymers.

The required material is heated and fed into a mold through a heat barrel in which it is mixed. This injected material is left to settle and cool in the mould to get it hardened. The moulds are made after a product is designed. Materials like steel, aluminum etc. are used and precision machined to get desired molds.

Modern technology has allowed making complex molds through 3D printing with photopolymer which do not melt at high temperature. Injection molding is used to make a variety of components ranging from simple screw to entire body of complex designs.



The injection molds are very carefully designed to get the required shapes and features by taking into account processes, materials, and properties of molding material.

4. Tests

4.1. Tensile Test

The tensile test evaluates the behavior of material under load. The test is represented by a stress strain graph . This graph gives the material deformation at different loads which will help to assess the material physical properties at different loads. Thus the suitable material can be found by testing under required loads. The material are usually tested at work temperature to study the physical properties at work environment. The data obtained from stress strain diagram gives the suitable conditions under which the material can be used it also gives tensile modulus which gives maximum load the material can withstand until breaking point
.

4.1.1. Test Procedure

The test specimens are placed under the grip of the universal testing machine and known load is applied. The load is applied till the specimen fails. The specimen is uniformly marked before the commencement of test and when load is applied the deformation in the specimen is noted for respective load, these reading give stress strain diagram

After a specific load on the specimen the deformation is absorbed at a specific point where neck is formed leading to failure. These points are important in determining maximum load and yield point of the material . A strain gauge or extensometer is used to measure the elongation in the specimen.

4.2. Flexural Test

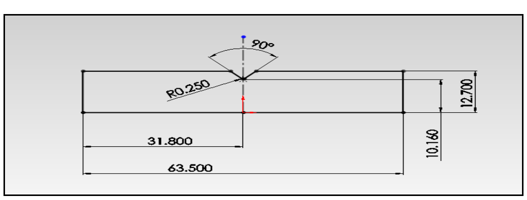
The flexural test is done to determine the flexural properties like strength, stiffness and deflection behavior of material. A bar of rectangular shape is placed on two supports like a beam and subjected to load in two procedures

- Load is applied on midway to beam by means of a loading nose
- Load is applied on the beam at two points equidistant from the beam resting points ,the distance between the loading noses should be one half of the beam support spanForce applied on the beam are noted and deflection of the is also noted. The force is applied till the beam fails or it reaches a predetermined deflection. The main difference between three points and four point load procedure is location of maximum bending moment and maximum flexural moment. In the four point configuration the bending moment is constant between the central force application points and maximum flexural moment is constant between the force application members.

In three point configuration the maximum flexural moment is directly under the central force applying point . In three point configuration the resultant vertical shear force is present everywhere in the beam except directly under the central force applying member, where as in four point configurations the vertical shear force is not present between the central force applying members.

4.3. Impact Test

The impact test or charpy test is used to test the impact strength of the material. It consist of a pendulum mounted weight which can be dropped from height . The pendulum initially consists of potential energy but while falling gains kinetic energy gradually, if nothing comes in its path pendulum reaches maximum height and a material kept in the test apparatus experience impact load. Thus the pendulum doesn't go high, a meter is fixed to measure the height of pendulum. The difference from between the ideal height and height with specimen gives the energy absorbed by the specimen. Thus the impact strength of the material can be calculated



The charpy test is generally implemented in metals but is also used for polymers, ceramics etc. This is used in quality testing as it is very economical and fast . Charpy impact test is a comparative test rather than definitive test. It is useful in finished product testing. The test specimen is generally 55 *10*10 mm dimensions and a notch is made on the specimen where the impact is taking generally a V notch or a key notch is made on the surface of the specimen

5. Results and Discussion

5.1. Tensile Test

INPUT DATA	RESULTS
specimen type :Flat	Ultimate load :2.92KN
specimen width :13.44mm	UTS:25.352N/mm^3
specimen thicknes:8.57mm	Elongation :3.34%
C/A area :115.181 mm^2	-
original gauge length:50mm	-
Final gauge length:51.67mm	-

Table 1

Note :(UTS) Ultimate Tensile Strength

INPUT DATA	RESULTS
specimen type :Flat	Ultimate load :2.880KN
specimen width :13.02mm	UTS :25.368N/mm^3
specimen thickness:8.72mm	Elongation :0.640%
C/A area :113.534mm^2	-
Original gauge length:50mm	-
Finalgaugelelength:50.32mm	-

Table 2

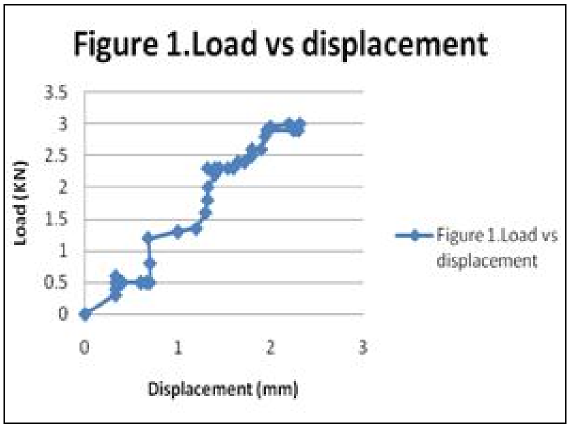


Figure 1

Polyamide nylon 66 +Egg shell powder 10%

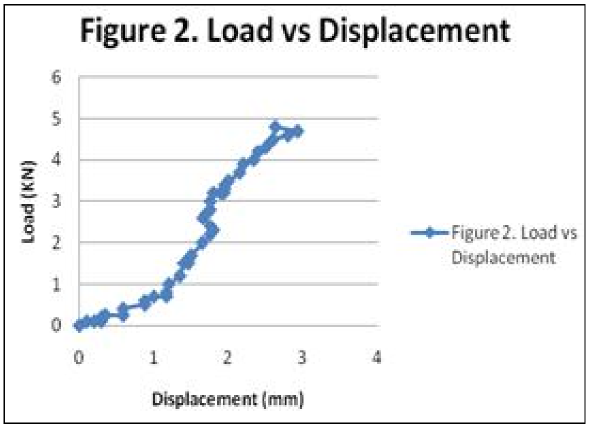


Figure 2

Polyamide nylon 66+ Egg shell powder 20%

5.2. Flexural Test

S .NO	SAMPLE ID	FLEXURAL LOAD	FLEXURAL STRENGH
1	Polyamide+Eggshell 10%	320N	15.44N

Table 3

S .NO	SAMPLE ID	FLEXURAL LOAD	FLEXURAL STRENGH(N)
1	Polyamide + Egg Shell 20%	200N	20.79N

Table 4

5.3. Impact Test

S.NO	SAMPLE DETAILS	IMPACT VALUE (J)	AVERAGEIMPACT VALUE (J)
1	Polyamide + Egg Shell 10%	5,5,4	4.7

Table 5

S.NO	SAMPLE DETAILS	IMPACT VALUE (J)	AVERAGE IMPACT VALUE (J)
1	Polyamide + Egg Shell 20%	6,6,4	5.3

Table 6

5.4. Density Test

S.NO	SAMPLE ID	DENSITY
1	Polyamide+ Egg Shell Powder 10%	1.108g/cm^3

Table 7

S.NO	SAMPLE ID	DENSITY
1	Polyamide + Egg shell Powder 20%	1.139g/cm^3

Table 8

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7. Conclusion
The following conclusions can be drawn from the results of this research:

- Polyamide eggshell composites were successfully produced by injection moulding.
- The tensile stress of the Polyamide eggshell composite increase with increasing eggshell powder percentage.
- The flexural strength of the Polyamide eggshell composite increase with increasing eggshell powder percentage.
- The impact strength of the Polyamide eggshell composite increase with increasing eggshell powder percentage.
- The density of the Polyamide eggshell composite increase with increasing eggshell powder percentage.

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