Modeling and Statistical Analysis of Ultimate Tensile Strength of LDPE/Groundnut Shell Flour Composites

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***Abstract*– This paper presents modeling and statistical analysis of ultimate tensile strength of LDPE/ groundnut shell flour composites. A two-series factorial model which shows that the ultimate tensile strength of Groundnut shell flour-Low density polyethylene composites can be predicted by substituting particle size and filler content .This model was formulated using experimental data in this research and with the aid of software C-NIKBRAN DATA analytical memory. The formulated model was validated using deviational and statistical Analysis. The maximum deviation (from experimental results) evaluated from the Model was 2.41 %.This gave confidence level of 97.59 %. The correlations between particle size and UTS for the Model as obtained were 0.948 and 0.978 as obtained from experiment and derived model respectively. Similarly, correlation between filler content and UTS for the same model also gave 0.989 and 0.981 as obtained from experiment and derived model respectively. Based on the foregoing, it is strongly believed that the proximity of deviation and correlations from experiment and model-predicted results are indicative of the model validity.**

***Keywords*– Analysis, Ultimate Tensile Strength, Results and Groundnut Shell Flour**

I. INTRODUCTION

The groundnut shells are used in the manufacture of plastic, wallboard, abrasive, fuel, cellulose and mucilage [3].

Large quantities of groundnut shell can be obtained very cheaply from companies involved in manufacture products with groundnut shell. Groundnut shell is a low lost substrate, easily available and suitable for solid-State cultivation of filamentous fungi. Groundnut shell is used in industrial applications. It is sometimes used for stock feed, although not as popular cereal straw [7].

In previous years, inorganic materials have been used as fillers in polymer industry for production of composites. This inorganic materials includes: titanium dioxide, calcium carbonate, zinc oxide etc [1].

This material faces some problems such as:

- high density
- high cost of production
- high cost of raw material procurement
- not easily available
- abrasive to the processing equipment
- low specific properties
- Low insulating properties

This is why the research on use of natural fibers (organic fillers) as a substitute was discovered to counter the defects of conventional material use in production of polymer composites [5].

Fillers find application in the polymer industry, almost exclusively to improve mechanical, thermal, electrical properties and dimensional stability [4].

The use of natural Fiber such as different plant Fibers (Fillers) and wood Fibers (Organic fibers) have the following advantages when compare with the inorganic fillers: Low density, low-cost, non-abrasive, availability from natural resources, relatively high strength and stiffness [2].

Reinforcement is generally responsible for strengthening the composite and improves its mechanical properties. All of the different fibers used in composites have different properties and so affect the proprieties of the composite in different ways. This also provides stiffness to the composites [5].

II. MATERIALS AND METHODS

A. Collection and Preparation of Groundnut Shell Flour

The groundnut shell was obtained at Oba in Udenu Local Government Area of Enugu State. The shell was sun-dried, Crushed and grind. The grind wood was sieved using a mechanical sieve of size 150, 212, 250 and 300µm.

The crushing and grinding operations were done using wood log crusher (Model no. FSJ I manufactured by Anyang GEMCO Energy Machinery Company Limited, China) and ball mill (model no.MQG manufactured by Shangai Tian Jin Machinery Company Ltd, China) respectively in Kenyetta Timber market Agbani Road, Enugu.

B. Collection and Preparation Recycled Low Density Polyethylene

The recycled low density polyethylene (LDPE) plastic container was obtained from the refuse bin. The plastic was washed and sun- dried to remove impurities. The (LDPE) materials were cut to small sizes to enable the crushing machine accept the material after drying.

C. Methodology

The Groundnut shell flour was the filler examined. The Groundnut shell flour of different weight percent were filled with remaining percentage of low density polyethylene

(LDPE) respectively. The particle sizes of 150, 212, 250 and 300 µm were used to examine the size effect of groundnut shell flour as filler in the properties of LDPE.

The Groundnut shell flour was filled at 4, 8, 12, and 30% by weight of the filler content.

Each of the filler and polyethylene were mixed at the different percentage composition of the flour at the corresponding particle size. The mixture was injection molded using injection molding machine at Ekenedilichukwu workshop, Onitsha. The composites which were produced were allowed to cool at room temperature before taking for ultimate tensile test.

D. Testing of Tensile Specimen Properties

The tensile test was carried after conditioning to relative humidity 65% and room temperature of 23°C using universal tensile matest machine manufactured by Richard parker Ltd, Sheffield, England (model no. INSTRON 3366) located at Socotherm Nigeria Ltd, Onne Rivers State accordance with ASTM D638.The test was performed at cross-head speed of 5mm/min.

The dimensions of tensile test specimen size for ASTM used were 3mm x 12.5mm x 60mm. The specimen were placed in the grips of the machine and pulled until there was failure. The ultimate tensile strength was determined.

E. Modeling of the Experimental Results

This was done using the software C-NIKBRAN Analytical Data memory.

III. RESULTS AND DISCUSSION

Modeling of the Ultimate Tensile Strength (UTS) for LDPE/Groundnut shell composite Flour varies with filler content and particle size.

Table 1: Model Formulation

Filler Content (%)	Particle Size (µm)	Exp (MPa)
4	150	8.53
8	212	8.76
12	250	8.8
30	300	8.25

$$\beta = -Ne\,x2 + Se\,x - Ke\,r2 + Cr + I \qquad (1)$$

This model was formulated using experimental data in Table 1 and with the aid of software C-NIKBRAN. $Where\ Ne, Se, Ke, C\ are\ equalizing\ constants$ 0.00004,0.0162,0.0013,0.0378 $respectively$ and I is idealing constant obtained from the software.

$Introducing\ the\ values\ of\ Ne, Se, Ke, C\ and\ I\ gives$:

$$\beta = -0.00004x2 + 0.0162x - 0.0013r2 + 0.0378r + 6.8273 \qquad (2)$$

$\beta = the\ model\ for\ the\ ultimate\ tensile\ strength\ for\ Groundnut\ flour$

$Where\ \beta = UTS, x = particle\ size, r = filler\ content.$

The model is an expression which shows that the ultimate tensile strength of flour could be obtained by substituting particle size and filler content. This is two-series factorial model. By considering the particle size and filler content, the ultimate tensile strength (UTS) of the material can be predicted.

Comparison of UTS as obtain from experimental and model-predicted - Results Groundnut shell flour (Model)

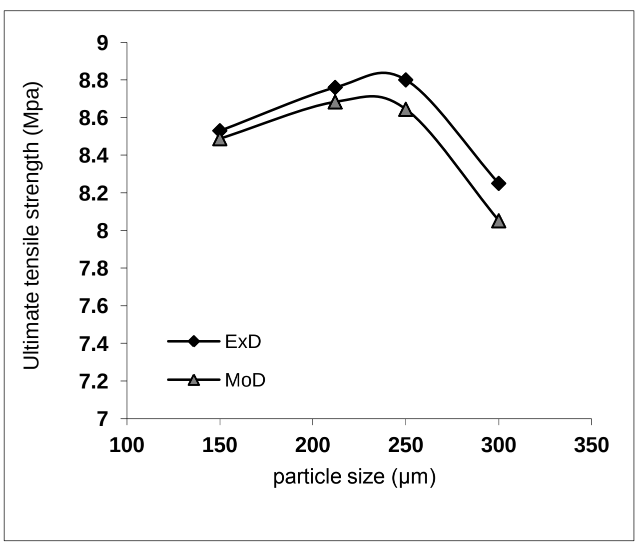

Fig. 1: UTS for experimental and Model-predicted on particle size

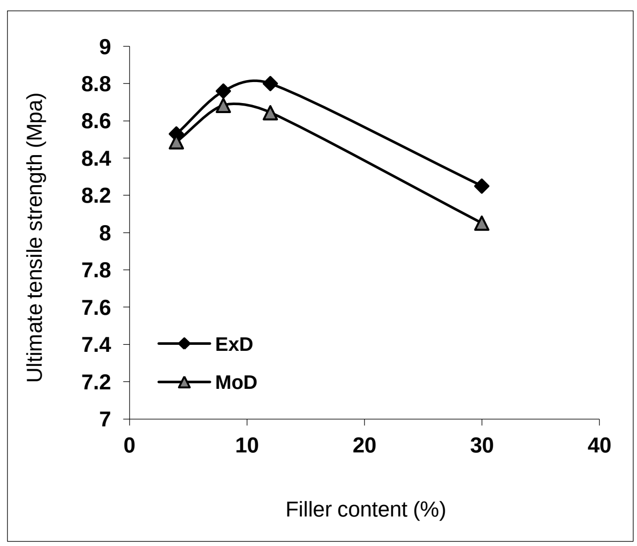

Fig. 2: UTS for experimental Model-predicted on filler content

Fig. 1 and Fig. 2 showed ultimate tensile strength as obtain from experimental and model- predicted on particle size and filler content respectively on Groundnut shell flour (Model) obtained using Table 2.

A. Model Validation

The formulated model was validated using deviational and statistical Analysis. Deviational analysis involves direct analysis and comparison of model-predicted values and those obtained from experiment for equality or near equality. Statistical analysis involves evaluated the correlations between process variables.

B. Deviational Analysis

Deviation (Dv) (%) of model-predicted values from the experimental values is given by:

$$Dv = \left[\frac{MoD - ExD}{ExD}\right] \times 100 \quad (3)$$

Where

$MoD = Model - predicted\ values$

$ExD = Experimental\ results$

Correction factor (Cf) is the negative of the deviation i.e.,

$$cf = -Dv \quad (4)$$

Therefore,

$$cf = -100\left[\frac{MoD - ExD}{ExD}\right] \ [6] \quad (5)$$

Introduction of the corresponding values of cf from eq. (5) in Table 2 into the model gave exactly the corresponding experimental values. Results of deviational analysis were shown in Table 2 shows that the derived model valid since the model deviations from experimental values are generally quite within the acceptable range.

Analysis and comparison between these values reveal deviation of model-predicted values from those of the experiment as in Table 2. The maximum deviation (from experimental results) evaluated from the Model was 2.41 %.This was found to be very low and generally quite within the acceptable range. This gave confidence level of 97.59 %. This necessitated the introduction of correction factor as in Table 2 to bring the model-predicted values to those of the experimental values.

Table 2: Comparison of UTS as obtain from experimental and model-predicted results on Groundnut shell flour

Filler Content (%)	Particle Size (µm)	Exp(MPa)	MoD(MPa)	DV(%)	CF(%)
4	150	8.53	8.4877	-0.50	+0.50
8	212	8.76	8.6831	+0.88	-0.88
12	250	8.8	8.6437	-1.78	+1.78
30	300	8.25	8.0513	-2.41	+2.41

C. Statistical Analysis

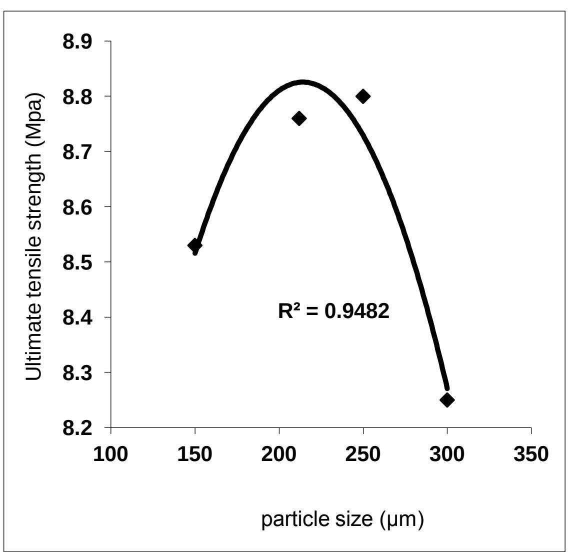

Fig. 3: Experimental

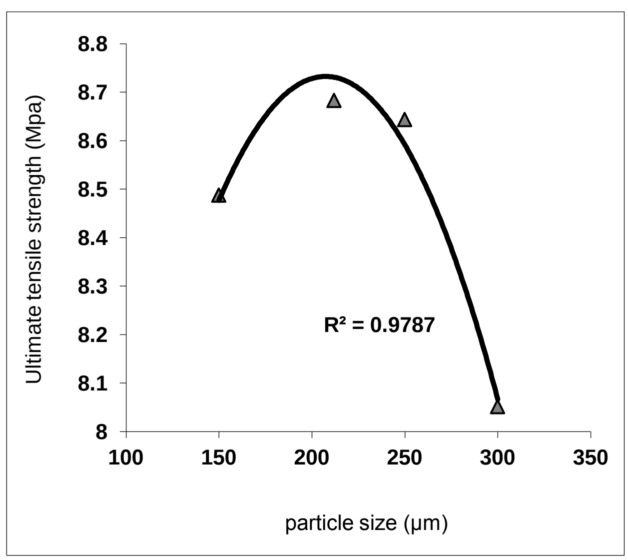

Fig. 4: Model

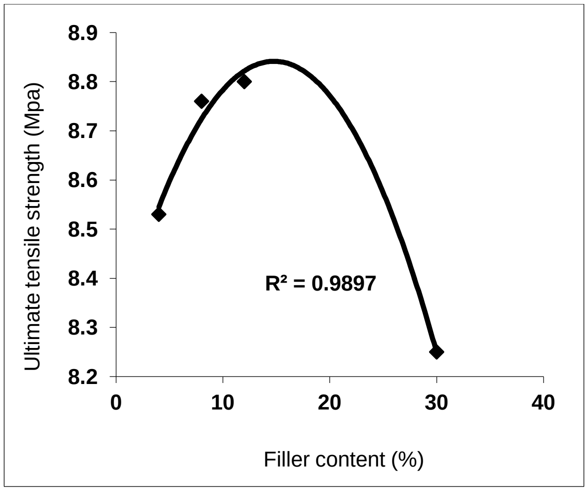

Fig. 5: Experimental

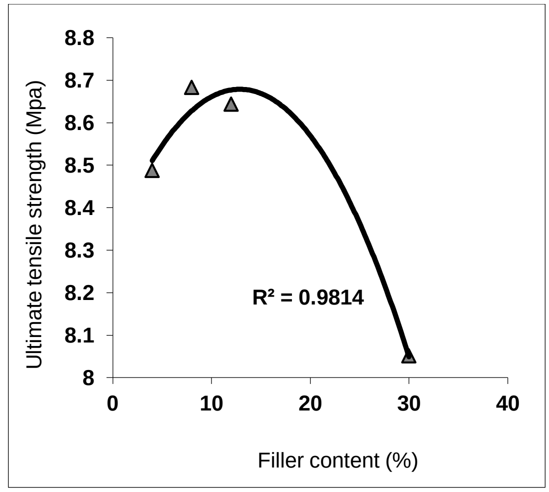

Fig. 6: Model

Fig. 3 and Fig. 4 showed correlations between particle size and UTS (ultimate tensile strength) as obtained from experiment and derived model respectively using Table 2.

Fig. 5 and Fig. 6 showed correlations between filler content and UTS for the model as obtained from experiment and derived model respectively using Table 2. The correlations between particle size and UTS for the Model as obtained were 0.948 and 0.978 as obtained from experiment and derived model respectively. Similarly, correlation between filler content and UTS for the same model as obtained in Table 2 also gave 0.989 and 0.981 as obtained from experiment and derived model respectively. Based on the foregoing, it is strongly believed that the proximity of correlations from experiment and model-predicted results are indicative of the model validity.

IV. CONCLUSION

The ultimate tensile strengths of LDPE/Groundnut shell flour composites were a function of filler content and particle size. Since the Model and experiment results for ultimate tensile strength of LDPE/Groundnut shell flour composites were in total agreement. This means that the model equation was valid.

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