Evaluation of Mechanical Properties of Rice Straw Fibre Polypropylene Composites

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Abstract:
Rice straw fibre can also be considered as important potential reinforcing filler for thermoplastic composite because of its lingo cellulosic characteristics. By appropriate usage of these rice straw fibers, physical and mechanical properties of conventional polymer materials can be enhanced. The main objective of present work is to investigate the mechanical properties of rice straw fibre reinforced polypropylene composites at different weight fractions (0%, 5%, 10%, 15%, 20% and 25%) of rice straw fibre. Rice straw fibre reinforced polypropylene composites were manufactured according to ASTM standards using injection moulding technique. The developed composites were then tested for their tensile, bending and impact properties. The standard test methods ASTM-D638M for tensile properties, ASTM-D790M for flexural properties and ASTM-D256M for impact properties of rice straw fibre composites, were used. The effect of change in percentage weight on the mechanical properties is studied for rice straw fibre under different tests like tensile, bending and impact. From the results it is observed that incorporation of rice straw fibre into the polypropylene matrix, results in moderate improvement in the tensile, bending and impact properties of the composites. Therefore rice straw fibre reinforced polypropylene composites can be regarded as a useful light weight engineering material and its manufacturing cost is less compared to synthetic fibre composites. Rice straw based composites have the potential to be used as a core material for structural board products.

I. INTRODUCTION

The first uses of composites date back to the 1500s BC. when early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats. Later, in 1200 AD, the Mongols invented the first composite bow. Using a combination of wood, bone and “animal glue,” bows were pressed and wrapped with birch bark. These bows were extremely powerful and accurate. Global polymer production on the scale present today began in the mid 20th century, when low material and productions costs, new production technologies and new product categories combined to make polymer production economical. The industry finally matured in the late 1970s when world polymer production surpassed that of Steel, making polymers the ubiquitous material that it is today. Fibre reinforced plastics have been a significant aspect of this industry from the beginning. There are three important categories of fibre used in FRP, glass, carbon, and aramid. Glass fibre reinforcement was tested in military applications at the end of World War II, Carbon fibre production began in the late 1950s and was used, though not widely, in British industry beginning in the early 1960s, aramid fibres were being produced around this time also, appearing first under the trade name Nomex by DuPont. Today each of these fibres is used widely in industry for any applications that require plastics with specific strength or elastic qualities. Glass fibres are the most common across all industries, although carbon fibre and carbon fibre aramid composites are widely found in aerospace, automotive and sporting good applications.

II. PROBLEM STATEMENT

A concerted research effort should be made to promote the diversification and new uses of different vegetable fibres and expand its national and international market possibilities.For natural fibres, investigation parameters should include thickness and characteristics of the bark, mainly the number, length, and distribution of cells and fibre bundle structure, as well as the extraction methodology, fibre percentage, and fibre-to-wood relationship of the product. Lastly, fibre quality, extraction time, and methods of improvement of the extraction process should be considered.

The proposed research work is intended to exploit the advantages of using natural fibres as reinforcement material in composites. The work provides basic understanding of the behaviour and response of new natural fibres and lightweight materials. Under the proposed research work the following aspects of natural fibres and composites have been studied.

1. Identification of matrix material.
2. Extraction of natural fibre.
3. Preparation of natural fibre reinforced composite specimens.
4. Tensile, Bending and Impact testing of natural fibre reinforced composites at various weight fractions.

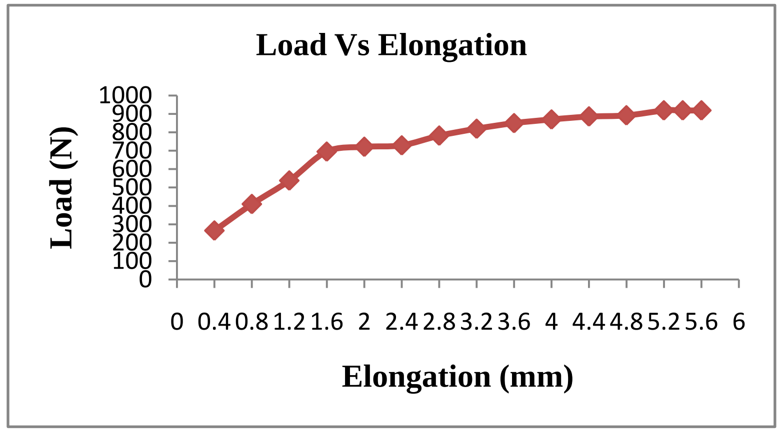
III. TESTING OF COMPOSITES

A 2 ton capacity - Electronic tensometer METM 2000 ER-I model (Plate II-18), supplied by M/S Microtech Pune, is used to find the tensile strength of composites. Its capacity can be changed by load cells of 20Kg, 200Kg & 2000 Kg. A load cell of 2000 Kg. is used for testing composites. Self-aligned quick grip chuck is used to hold composite specimens. A digital micrometer is used to measure the thickness and width of composites. The gauge length, thickness and width are measured with 0.001 mm least count digital micrometer. The electronic tensometer is fitted with load and extension indicators, which has a least count of 0.01 kg and 0.01 mm, respectively. The tensometer is fitted with a fixed self aligned quick grip chuck and other movable self aligned quick grip chuck to accommodate 16 mm wide and 8mm thick specimen. The specimen was held in fixed grip and the movable grip is manually moved until the specimen is held firmly without slackness. The power supply is switched on to measure the load and extension of the specimen. The movable chuck is further moved such that the load indicator just starts giving indication of loading on the specimen. At that instant the extension meter is adjusted to read zero, when the load on the specimen is zero. The speed reduction pulleys are chosen such that a cross head speed of 0.2mm/min. is applied on movable grip. Then the electric motor fitted to tensometer is started. Starting from zero, at every 0.5 mm extension the load indicated are noted until the specimen breaks. At the end of the test, the final load and elongation is also noted from the electronic indicator display. It is also confirmed that the specimen failed at a section within the gauge length of all the specimens. For each specimen the type of failure and any other such observations pertaining to failure are noted. The tests are conducted at 24°c and 50% relative humidity in the laboratory atmosphere.

IV. RESULTS AND DISCUSSION

The composites are moulded with polypropylene resin matrix and reinforced with different weight fractions (0.5, 10, 15, 20, and 25 %) of Rice Straw fiber. Five specimens are prepared for each weight fraction and are tested as per the methods and the results are plotted in the graphs and discussed below.

Discussion on Tensile properties



Load Vs Elongation for pure polypropylene

The results of tensile test for five specimens of Rice Straw PP composites for each weight fraction are shown below Average tensile strength and modulus is calculated from the Stress-strain graphs using following relations.

Tensile strength = Maximum Load (N) / cross - sectional area (mm^2)

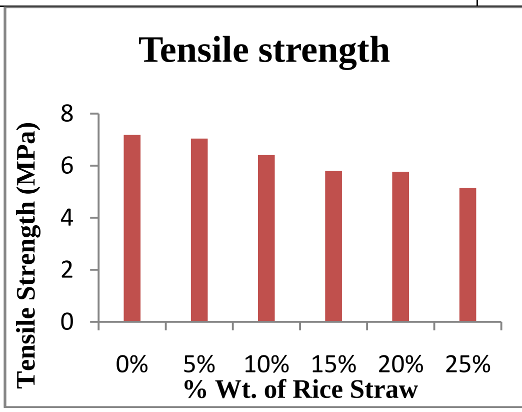
Tensile Modulus = Stress / strain

The tensile strength and modulus of the pure polypropylene are determined as 7.181 MPa and 0.0021 GPa, respectively. The average tensile strength and modulus of Rice Straw PP composites of the present work calculated from stress strain curves and plotted with respect to fiber weight fraction are shown in Figure.

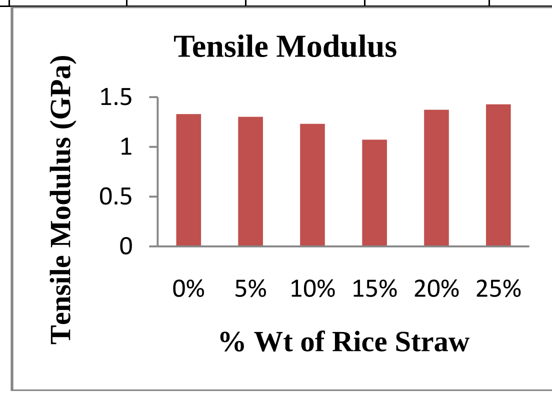
Tensile strength Vs Percentage Weight of Rice Straw:

% Wt of Rice Straw	0%	5%	10%	15%	20%	25%
Tensile strength (MPa)	7.181	7.04	6.40	5.799	5.767	5.144
Tensile Modulus (GPa)	1.33	1.30	1.231	1.073	1.373	1.428

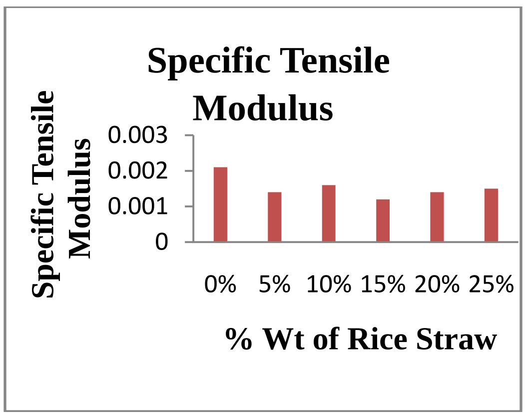
Specific Tensile Strength (MPa/kgm-3)	0.0116	0.008	0.0085	0.0069	0.0061	0.0057
Specific Tensile Modulus (MPa/kgm-3)	0.0021	0.0014	0.0016	0.0012	0.0014	0.0015



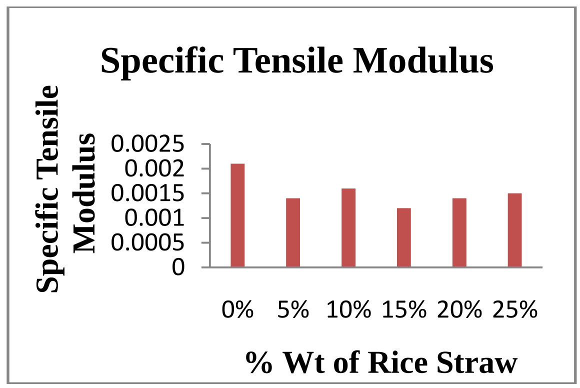
Tensile strength Vs Percentage Weight of Rice Straw



Tensile Modulus Vs Percentage Weight of Rice Straw



Specific Tensile strength Vs Percentage Weight of Rice Straw

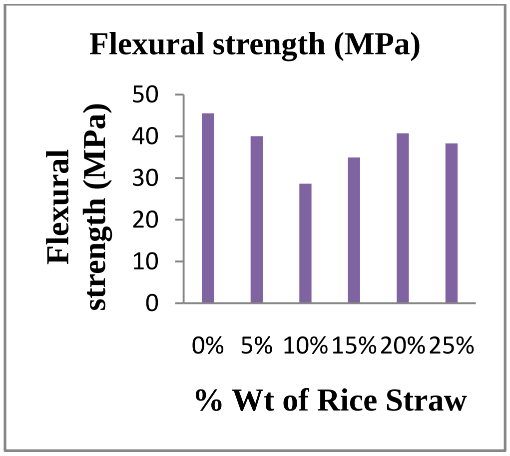


Specific Tensile Modulus Vs Percentage Weight of Rice Straw

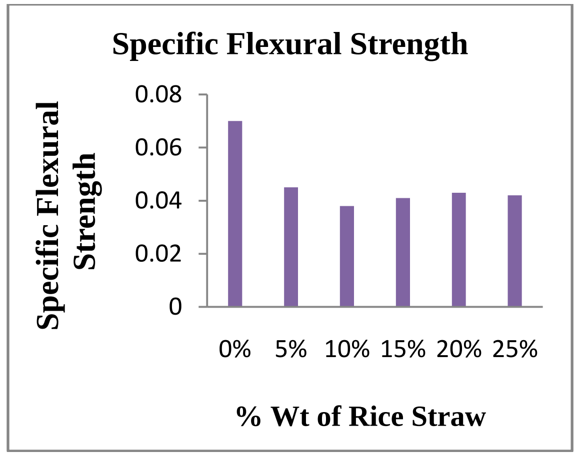
V. DISCUSSION ON FLEXURAL PROPERTIES

The load verses deflection curves for pure polypropylene are shown below the results of flexural test for 5 specimens of Rice Straw PP composites for each weight fraction are shown in Fig. Average flexural strength and modulus at each weight fraction of fiber are calculated from the load-deflection curves of five specimens in flexural testing using following relations. Where L is the support span (64mm), 'b' is the width and't' is the thickness of the specimen, 'P'is the maximum load and 'm' is the slope of the initial straight line portion of the load-deflection curve. Flexural strength of the rice straw fiber reinforced polypropylene composites at different percentages of fiber loading is shown in Figure. The flexural strength decreased with fiber loading up to 15% weight fraction of the fiber, and there was a increment after 15% fiber loaded composites. The bond between fiber and matrix often dictates whether the fiber will improve the properties of composites by transferring the applied load. The load transfer between matrix and fibers in a composite is not only determined by the intrinsic properties of the fiber and matrix, but also affected by the geometric parameters and fiber arrangement within the matrix such as fiber distribution. Figure shows the Flexural Modulus as a function of % weight fraction of the fiber for rice straw fiber composites. The flexural modulus increases with the fiber loading. Since, higher fiber concentration demands higher stress for the same deformation due to increase in the degree of obstruction, the modulus values has increased with the fiber content. Increased fiber-matrix adhesion provides increased stress transfer between them.

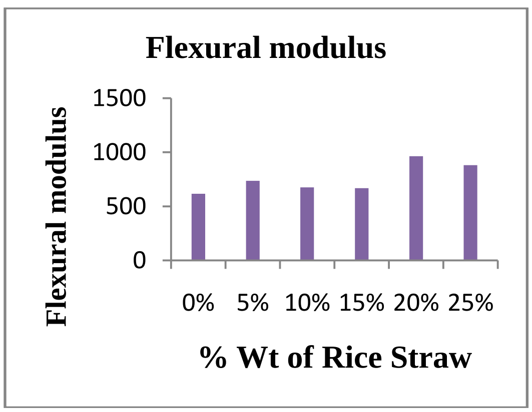
% Wt of Rice Straw	0%	5%	10%	15%	20%	25%
Flexural strength (MPa)	45.53	40.04	28.645	34.919	40.713	38.298
Flexural modulus (MPa)	0.07	0.045	0.038	0.041	0.043	0.042
Specific FlexuralStrength (MPa/kgm-3)	0.07	0.045	0.038	0.041	0.043	0.042
Specific Flexural Modulus (MPa/kgm-3)	0.07	0.045	0.038	0.041	0.043	0.042



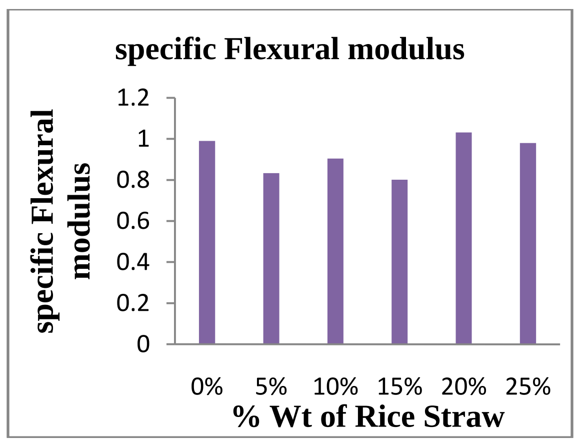
Flexural strength Vs Percentage Weight of Rice Straw



Specific Flexural strength Vs Percentage Weight of Rice Straw



Flexural Modulus Vs Percentage Weight of Rice Straw



Specific Flexural Modulus Vs Percentage Weight of Rice Straw

VI. CONCLUSIONS

The main objective of this investigation is to gauge the possibility of utilizing the Rice Straw which is abundantly available as an alternative filler material in a polypropylene matrix. The following conclusions are made based on the experimental investigation of rice straw fiber composites. The incorporation of Rice Straw Fiber into the polypropylene matrix has resulted in a moderate improvement in the tensile, bending and impact properties of the composites. It has been observed that the pure polypropylene has got a tensile strength of 7.181MPa and there is a decrease in tensile strength for increase in the weight fraction of rice straw fiber PP matrix. The tensile modulus of pure polypropylene is 1.33 GPa. It is observed that the tensile modulus decreases up to a fiber weight fraction of 20% and a maximum tensile modulus of 1.42 GPa is obtained at 25% of rice straw/PP composites The flexural strength for pure polypropylene is 45.53 MPa and the maximum flexural strength of the rice straw fiber polypropylene composite is 40.71 MPa occurring at 20% fiber fraction. The flexural modulus of pure polypropylene is 615.65 MPa and is observed that the maximum flexural modulus of the rice straw fiber polypropylene composite is 963.34 MPa occurring at 20% fiber fraction. The composite can be regarded as a useful light weight engineering material and also the manufacturing cost of the composite can be reduced considerably by adding Rice Straw as filler to the matrix.

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