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Research article

Mechanical properties of bi – axial glass fiber and pistachio shell reinforced polyester composites

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Abstract

Textile structures nowadays are widely used in technical application. Textile structures have many application areas because of their low density, low cost and high strength. Bi-axial warp knitted fabrics have excellent properties to improve the mechanical properties of composite structures because of various fiber direction opportunities. Glass fiber is the mostly used reinforcement material for composites. It is well known that glass fiber reinforced polymer matrix composites have good mechanical properties. The aim of this study is to use waste materials for producing reinforced composite structures. Composite layers produced with bi-axial knitted fabrics, pistachio's shell and thermoset polyester resin.

Keywords: *Bi-axial knitted fabrics, composite materials, pistachio's shell and polyester composites.*

1. Introduction

Over the past two decades plant fibers have been receiving considerable attention as substitute for synthetic fiber reinforcements such as glass in plastics. The advantages of plant fibers are low cost, low density, acceptable specific strength, good thermal insulation properties, reduced tool wear, reduced dermal and respiratory irritation, renewable resource and recycling possible without affecting the environment. Some of the plant fiber based thermoplastic composites have already found applications in furniture, packaging, building and automobile industries [1].

Polymer waste is disposed in large landfills causing serious problems on the environment, while biodegradable materials are envisaged to be an excellent alternative to tackle this problem, by reducing the waste volume. Hence, for these reasons it has not been surprising that the use of cellulosic materials in the production of composites has gained significant importance [2].

Multi axial non-crimp fabric (NCF) is a relatively new class of textile performs for polymer composites that consists of multiple layers of fibrous yarns stitched together by warp knitting. The most commonly used types of NCF s are biaxial, tri axial and quad axial fabrics in which straight, un crimped yarns are aligned in the warp (0°), bias

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(30°<θ<90°) and/or weft (90°) directions to provide multidirectional in-plane properties. In addition, chopped fiber or fleece mat can be incorporated into the fabric, although their use is usually confined to the surface layer to provide a high quality finish to a composite product. The yarn layers and mats are bound together by warp knitting with a chain or tricot stitch pattern using polyester thread or (less often) aramid or glass yarn [3, 4]. Glass fibers are used to improve mechanical properties of composites fibrous reinforcement materials are used glass fiber. It is known that glass fibre reinforced polymer matrix composites have good mechanical properties. And fiber reinforced composites are the main group over all composites [5, 6].

The combination of stacked fiber layers into a single, thick fabric overcomes the high cost and long production time often incurred with the manual hand lying of thick performs using conventional single layer fabric and tape. A further advantage is that composites reinforced with NCF generally exhibit higher in-plane mechanical properties than conventional woven fabric composites because the yarns are not crimped. In addition, the interlaminar shear resistance, delamination toughness and impact damage tolerance of NCF composites is superior to conventional tape laminates because of the through-thickness reinforcement provided by the stitches [7, 8].

2. Experimental

2.1. Materials and Composite Production

2.1.1. Multi Axial Non – Crimp Fabrics

The extension properties of a variety of biaxial NCF's consisting of continuous E-glass yarns stitched together with 0.14 mm diameter polyester thread were evaluated. Biaxial fabrics (Fig.1) manufactured by Metyx (TURKEY) using a Liba multi axial warp-knitting machine were studied, and these are described in Table 1.

Table 1
Specifications of biaxial non-crimp fabrics

Sample type	Description	Orientation of tows (deg)	Total weight (g/m^2)
Biaxial non-crimp fabrics	E-glass	0^0, 90^0	700
E- glass	E- glass	-	300

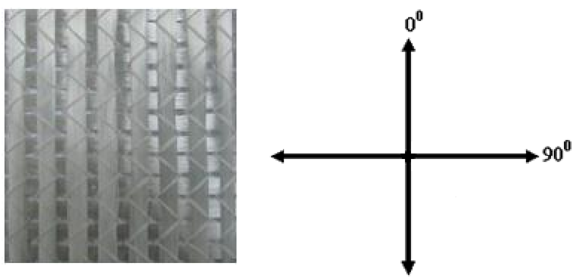
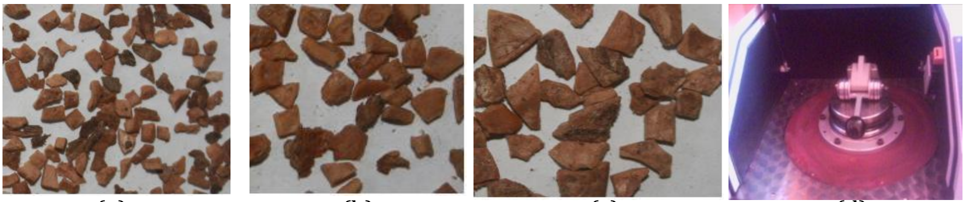


Fig. 1 Picture of biaxial non-crimp fabrics

2.1.2. Waste Materials

In our study, natural waste material pistachio shell was used to produce composite structure. Pistachio shell broke into pieces of three kinds of size by centrifuge machine as seen in Fig. 2 (c). Then nine different kinds of composites were produced with them.



(a) (b) (c) (d)

Fig. 2 (a) Picture of pistachio shell (12 mesh), (b) Picture of pistachio shell (8 mesh), (c) Picture of pistachio shell (4 mesh), (d) Centrifuge machine

2.1.3. Manufacturing of Composite Structures

Matrix resin which is thermoset polyester (Polipol 351) manufactured by Poliya (TURKEY) were used to fabricate composite structures. Thermoset polyester resin was chosen to fabricate composite because of its low price.

Thermosetting polyester was applied as a resin. There are several major manufacturing methods in fiber-reinforced polymer industry. Composite structures were fabricated by hand Lay up method. Stacking of the plies was continued until a certain thickness was obtained. After lamination procedure, composites were cured at room temperature under the settled pressure for 24 hours. Properties of reinforced composites are given in Table 2.

Table 2
Properties of composite structures for [M/BF/PS/BF/M]* for configuration

SAMPLE CODE	Thick. (mm)	Total weight (g/m^2)	Particle Size (mesh)	Fabric/Resin/Pistachio cell (%)		
SAMPLE 1	7.2	8800	12	22	63	15
SAMPLE 2	8.5	10080	12	20	55	25
SAMPLE 3	9.5	11360	12	18	47	35
SAMPLE 4	7.2	8800	8	22	63	15
SAMPLE 5	8.5	10080	8	20	55	25
SAMPLE 6	9.5	11360	8	18	47	35
SAMPLE 7	7.2	8800	4	22	63	15
SAMPLE 8	8.5	10080	4	20	55	25
SAMPLE 9	9.4	11360	4	18	47	35

*M: Mat, BF: Bi-axial fabric and PS: Pistachio shell

2.2. Mechanical Property Characterization

Tensile test technique, ASTM D3039/ 3039M-07 was used to determine the tensile strength of the composite laminates. The specimens were tested using Devotrans Universal test machine at a crosshead speed of 10 mm/min. At least five specimens for each composition were tested. Impact strength was checked by means of CHEAST charpy impact resistance based on ISO 179-1 standard. Mechanical properties results of were given in Table 3.

3. Results

Mechanical test results are given in Table 3. These tests were performed on reinforced composite laminates at each of 0° and 90° directions. All performed tensile and impact test results indicate that the mechanical properties of 0° directions are higher than 90° direction in composite laminates as shown in Fig. 3-8.

Table 3
Mechanical test results

SAMPLE CODE	Test Direction	Tensile Strength (MPa)	Impact Strength (KgJ/mm²)
SAMPLE 1	0	15558	111.82
	90	15448	96.82
SAMPLE 2	0	14990	105.98
	90	14673	70.40
SAMPLE 3	0	14433	85.55
	90	14216	64.63
SAMPLE 4	0	15112	101.14
	90	14695	90.14
SAMPLE 5	0	14920	90.84
	90	14467	68.00
SAMPLE 6	0	14047	77.06
	90	13794	61.64
SAMPLE 7	0	14704	96.66
	90	14472	76.04
SAMPLE 8	0	14363	80.70
	90	14256	66.58
SAMPLE 9	0	13268	73.02
	90	12733	52.44

Fig. 3 and Fig. 4 show the variation of Tensile Strength and impact strength of sample 1, sample 4 and sample 7, respectively. Among all the three samples, sample 1 displayed the highest both tensile strength and impact strength whereas the sample 7 displayed lowest tensile strength and impact strength, as well. Tensile and impact strengths increase with decreasing of particle size. This can be explained due to particle size of pistachio. Similar tensile and impact strength results are shown in Fig. 5, 6 and Fig. 7, 8, respectively. When examining of Fig. 3-8, tensile and impact strengths of composite decrease with increasing of pistachio cell rate.

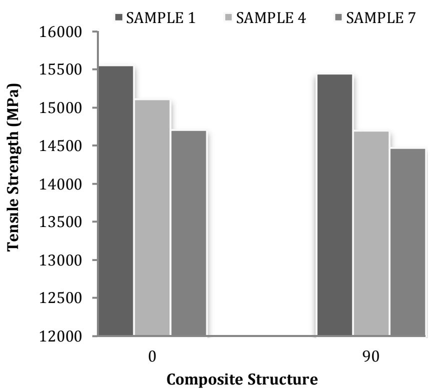


Fig. 3 Effect of particle size reinforced composites with 15% pistachio cell on tensile strength

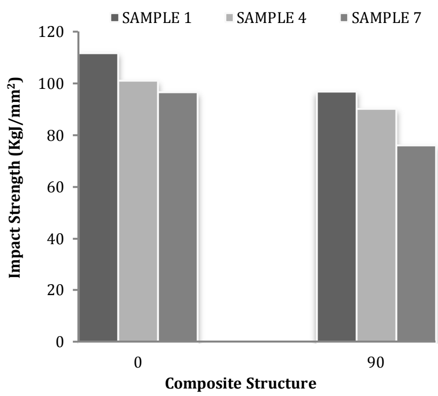


Fig. 4 Effect of particle size reinforced composites with 15% pistachio cell on impact strength

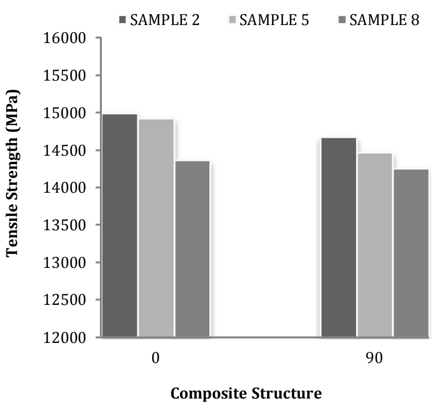


Fig. 5 Effect of particle size reinforced composites with 25% pistachio cell on tensile strength

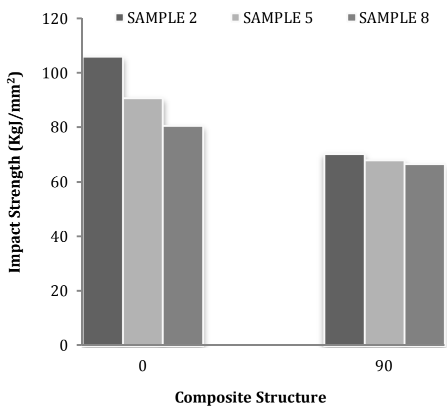


Fig. 6 Effect of particle size reinforced composites with 25% pistachio cell on impact strength

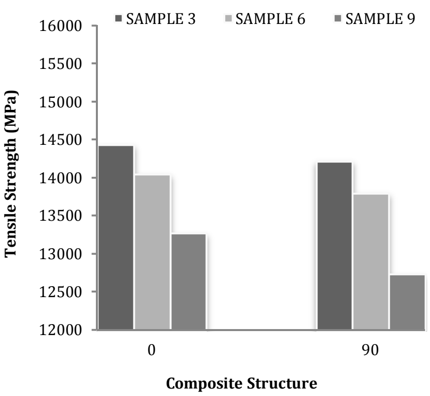


Fig. 7 Effect of particle size reinforced composites with 35% pistachio cell on tensile strength

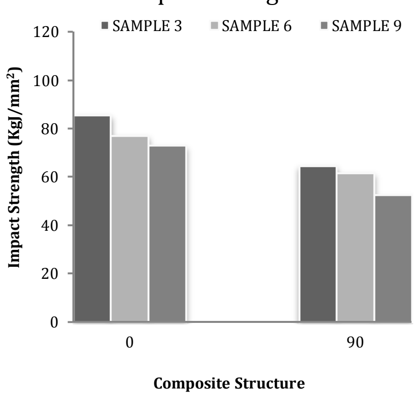


Fig. 8 Effect of particle size reinforced composites with 35% pistachio cell on impact strength

4. Conclusion

The study has shown that the mechanical properties of composite laminates are affected from the direction of Bi-axial glass non-crimp fabric, particle size and rate of pistachio shells. All performed tensile and impact test results indicate that the mechanical properties of Bi-axial glass non-crimp fabric reinforced composite laminates with 0° directions are higher than 90° directions. The size of pistachio shell effects the mechanical properties of composite structure. Sample 1 has better mechanical properties than the others.

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