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Improvement of Mechanical Properties of Jute/E-glass Fabric Reinforced Hybrid Composites

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Abstract: Composite structures, that are one of the most critical materials of today, are being improved day by day with high performances besides their lightness. Textile reinforced composite structures constitute a key share among all composite forms. In these structures, textile components provide strength and dimensional stability to the composite material. In this study, the effects of different types of Multi-walled carbon nanotubes (MWCNT, MWCNT-OH, MWCNT-COOH) on mechanical properties (tensile strength and impact strength) of jute/E-glass fabric reinforced hybrid composites were examined. Unsaturated orthophthalic polyester resin was used as the matrix material. Vacuum assisted resin transfer molding technique was utilized for the preparation of four-plied composite specimens. In sample codes, J and G refer to jute and E-glass fabrics, respectively.

Keywords—Composites, E-glass, jute, mechanical properties, multi-walled carbon nanotube.

I. INTRODUCTION

During the last four decades, polymer matrix composites are gaining importance in both conventional and high technology application areas due to their high specific stiffness and strength, low cost, corrosive resistance and high dimensional stability properties [1]. Polymer matrix composites are mostly reinforced with textile structures. The utilization of textile materials in composite structures is increasing day by day under favour of excellent merging of their relative low costs and high performance [2–5].

Composite materials are subjected to very different loading conditions and this situation sometimes forces the researchers to utilize various types of reinforcement materials in the composite structure. Such composites, which are reinforced with two or more types of materials, are known as hybrid composites. By using two or more types of reinforcement materials, better mechanical properties and reduced material costs compared to the conventional composites can be achieved [1, 6–9]. These hybrid composite structures combine the beneficial properties and eliminate the undesirable properties of each component [4, 10].

Nanofillers are privileged filler materials to develop the properties of composite structures. They have very high specific surface areas (more than 1000 m²/g) and aspect ratios compared to micro-scaled fillers [11]. Nanoclays, nanofibers and nanotubes are the forms of nanofillers that are used in composite industry [12].

II. EXPERIMENTAL STUDY

A. Materials

Jute and E-glass plain weave fabrics were used as the reinforcement materials. Fabric parameters are given in Table 1.

| TABLE 1 | FABRIC PARAMETERS |
|---------|-----------------|
|         | Jute            | E-glass         |
| Areal density (± SD) (g/m²) | 200 (±15.2) | 200 (±5.3) |
| Thickness (± SD) (mm) | 0.99 (±0.10) | 0.41 (±0.01) |
| Fabric count (e.p.c. x p.p.c) | 4 x 4 | 4 x 3 |
| Warp yarn count (± SD) (Tex) | 375 (±36.3) | 288 (±10.3) |
| Weft yarn count (± SD) (Tex) | 234 (±25.8) | 409 (±11.5) |
The matrix system consists of unsaturated orthophthalic polyester resin. Also, cobalt was used as accelerator, methyl ethyl ketone peroxide (MEKP) was utilized as hardener in the resin system.

Three different types of MWCNTs (pristine MWCNT, MWCNT-OH and MWCNT-COOH) were added to the matrix material to enhance the mechanical properties.

B. Methods

Vacuum assisted resin transfer molding technique (Fig. 1) was used for the preparation of four-plied composite specimens. Composite fabrication was realized at room temperature (20°C±2°C).

Mixing of the MWCNT and polyester was performed by ultrasonic mixer. Table 2 shows the specimen codes and layer sequences of composite samples.

Tensile strength tester and impact strength tester were used to evaluate the mechanical properties of fabric reinforced composites. Tensile testing was realized by Shimadzu AG-IS test machine according to ASTM D638-10 standard. Devotrans Charpy Impact Test Machine was utilized to evaluate the impact resistance of the composite samples according to BS EN ISO 179:1997 standard.

| Specimen Code | Layer Sequence | Filler Type |
|---------------|----------------|-------------|
| JGGJ          | Jute/E-glass/E-glass/Jute | -           |
| JGGJ-MWCNT    | Jute/E-glass/E-glass/Jute | MWCNT      |
| JGGJ-MWCNT-OH | Jute/E-glass/E-glass/Jute | MWCNT-OH   |
| JGGJ-MWCNT-COOH | Jute/E-glass/E-glass/Jute | MWCNT-COOH |
| GJJG          | E-glass/Jute/E-glass     | -           |
| GJJG-MWCNT    | E-glass/Jute/E-glass     | MWCNT      |
| GJJG-MWCNT-OH | E-glass/Jute/E-glass     | MWCNT-OH   |
| GJJG-MWCNT-COOH | E-glass/Jute/E-glass     | MWCNT-COOH |
| JGJG          | Jute/E-glass/Jute/E-glass | -           |
| JGJG-MWCNT    | Jute/E-glass/Jute/E-glass | MWCNT      |
| JGJG-MWCNT-OH | Jute/E-glass/Jute/E-glass | MWCNT-OH   |
| JGJG-MWCNT-COOH | Jute/E-glass/Jute/E-glass | MWCNT-COOH |
III. RESULTS

A. Tensile Strength Results

The tensile strength results of jute/E-glass fabric reinforced composite samples are given in Figure 2. When the effect of fabric stacking sequence on the tensile strength of composite structures were investigated, it was seen that samples which have jute fabrics at the inner layers (GJJG) had the lowest strength.

When the effect of addition of different types of MWCNTs to the tensile strength was considered, it was revealed that all types of MWCNTs had increasing effect on the tensile strength values of samples. In these samples with different fabric sequences, the highest values were obtained with pristine MWCNT treated samples (JGGJ-MWCNT, GJJG-MWCNT and JGGJ-MWCNT) at all three fabric stacking sequences.

Moreover, it come in sight that samples that taken from warp direction reached higher tensile strength values than the weft direction samples.

![Fig. 2. Tensile strength results of composite samples.](image)

B. Impact Strength Results

Figure 3 indicates the impact strength results of jute/E-glass fabric reinforced hybrid composite samples. The effect of the various fabric stacking sequences on the impact strength of hybrid composite structures is obviously seen from the Figure. While samples which have E-glass fabrics at the outer layers of the structures reached the highest impact strengths, samples which have E-glass fabrics at the inner layers had the lowest impact strengths among all samples. Besides, like the tensile strength results, warp direction samples reached higher impact strengths than the weft direction samples.

![Fig. 3. Impact strength results of composite samples.](image)

When three groups with different fabric sequences were examined, it was found that the highest impact strengths were obtained with pristine MWCNT treated specimens in the groups with JGGJ and JGGJ fabric sequences,
whereas the impact strength values of the MWCNT and MWCNTCOOH reinforced specimens in the GJJG specimens were very close to each other and found higher than those of MWCNT-OH sample. As a result, it can be said that all MWCNT types show increasing effects on impact strengths of hybrid composite samples.

IV. CONCLUSION

It can be concluded that;

- The specimens taken from the warp direction showed comparatively higher mechanical properties than the samples taken from the weft direction.
- Addition of MWCNTs (MWCNT, MWCNT-OH and MWCNT-COOH) to the composite structure enhanced the mechanical properties of composite materials.
- Among MWCNT types, the best results were achieved with pristine MWCNT treated composite samples.
- High impact strength values were obtained by placing the high strength fabrics (E-glass) on the outer layers of the composites, while the lowest tensile strengths were obtained at the same sequences.

REFERENCES

[1] K. S. Pandya, C. Veerraju and N. K. Naik, "Hybrid composites made of carbon and glass woven fabrics under quasi-static loading," Mater. Des., vol. 32, no. 7, pp. 4094–4099, 2011.
[2] M. Bodaghi, C. Cristóvão, R. Gomes and N. C. Correia, "Experimental characterization of voids in high fibre volume fraction composites processed by high injection pressure RTM," Compos. Part A Appl. Sci. Manuf., vol. 82, pp. 88–99, 2016.
[3] Y. Q. Ding, Y. Yan, R. McIlhagger and D. Brown, "Comparison of the fatigue behaviour of 2-D and 3-D woven fabric reinforced composites," J. Mater. Process. Technol., vol. 55, no. 3, pp. 171–177, 1995.
[4] K. F. Hasan, M. Islam, M. N. Morshed, M. I. I. Iqbal and J. H. W. Wu, "Dynamic mechanical behavior & analysis of the jute-glass fiber reinforced polyester hybrid composites," Am. J. Appl. Phys., vol. 1, no. 1, pp. 1–12, 2016.
[5] V. Mishra and S. Biswas, "Physical and Mechanical Properties of Bidirectional Jute Fiber Epoxy Composites," Procedia Eng., vol. 51, pp. 561–566, 2013.
[6] G. Agarwal, A. Patnaik, R. Sharma and J. Agarwal, "Effect of stacking sequence on physical, mechanical and tribological properties of glass/carbon hybrid composites," Friction, vol. 2, no. 4, pp. 354–364, 2014.
[7] M. Jawaid and H. P. S. Abdul Khalil, "Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review," Carbohydrate Polymers, vol. 86, no. 1, pp. 1–18, 2011.
[8] D. Romanzini, A. Lavoretto, H. L. Ormaki Jr., S. C. Amico and A. J. Zattera, "Influence of fiber content on the mechanical and dynamic mechanical properties of glass/ramie polymer composites," Mater. Des., vol. 47, pp. 9–15, 2013.
[9] H. Szigin and O. B. Berkalp, "The effect of hybridization on significant characteristics of jute/glass and jute/carbon-reinforced composites," J. Indus. Text. https://doi.org/10.1177/1528083716644290, 2016.
[10] T. Hamouda, A. H. Hassanin, A. Kilic, Z. Candan and M. S. Bodur, "Hybrid composites from coir fibers reinforced with woven glass fabrics: Physical and mechanical evaluation," Polym. Compos., 2015.
[11] F. H. Goiny, M. H. G. Wichmann, B. Fiedler, W. Baushofe and K. Schulte, "Influence of nano-modification on the mechanical and electrical properties of conventional fibre-reinforced composites," Compos. Part A Appl. Sci. Manuf., vol. 36, no. 11, pp. 1525–1535, 2005.
[12] V. C. S. Chandrasekaran, S. G. Advani and M. H. Santare, "Role of processing on interlaminar shear strength enhancement of epoxy/glass fiber/multi-walled carbon nanotube hybrid composites," Carbon, vol. 48, no. 13, pp. 3692–3699, 2010.