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TECHNICAL NOTE

Production and characterization of basalt fiber/pet composites

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Abstract

The use of fiber-reinforced thermoplastic composite materials is increasing day by day due to their high strength and recyclability. In addition to these superior advantages, high melt viscosity is among the disadvantages of these materials because it makes reinforcement absorption difficult. This problem can be solved by using hybrid yarns in which reinforcement and thermoplastic fibers are homogeneously mixed for the production of thermoplastic composites. This study, it was aimed to prepare basalt fiber/PET hybrid yarns containing basalt fiber in different volume ratios by air-jet mixing method and to prepare thermoplastic composite materials by pressing from fabrics woven from hybrid yarns. By determining the mechanical properties of basalt fiber/PET thermoplastic composites prepared to contain basalt fiber in different proportions by volume, the effects of basalt fiber amount in hybrid yarn blends on the mechanical properties of the composite material were examined and the most appropriate basalt fiber amount was determined.

1. Introduction

Polymer-based composites are divided into two thermoplastic and thermoset composites. Thermoplastic composites have begun to be used instead of thermosets due to the limited shelf life, long production times, and no recycling of thermoset-based composites [1]. Thermoplastic composites can be recycled and reshaped by heating, but the use of thermoplastics introduces the problem of insufficient resin penetration for the fiber.

Thermoplastic melts, in contrast to thermoset resins, have a significantly higher viscosity. Injecting the resin into a tightly woven textile structure is very difficult due to the high viscosity. This problem increases the void content in the composite material, which must be overcome by using higher injection pressure and heavier molds. The formation of voids in the composite product and the misalignment of the reinforcing fibers during consolidation are other problems caused by high matrix viscosity. Reducing the mass transfer distance by using hybrid yarns is one of the solutions to this problem [2].

Thermoplastic polymers such as polypropylene (PP) and polyethylene (PE) as matrix materials and glass fibers as reinforcement elements have been widely used in studies for the production of thermoplastic composites [3-5]. Basalt fiber has better tensile strength compared to e-glass fibers, and excellent thermal stability and chemical stability properties make the use of basalt fiber widespread. In addition, many studies have been carried out on the mechanical properties of polymer matrix composites containing basalt fibers. Zhang et al. [6] used polyimide resin and basalt fiber for composite production, the obtained composites

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showed excellent wear properties. Ronkay and Czigány [7] produced basalt/polyethylene terephthalate (PET) and glass/PET composites and compared their tensile, bending, and impact strengths. The test results of the basalt/PET composite were better than the E-glass/PET composite. Liu et al. [8,9] investigated the mechanical strength of basalt fiber-reinforced composite materials. Epoxy resin was used as matrix material, basalt fibers, and E-glass fibers were used as reinforcement materials, and although their mechanical strengths were similar, basalt/epoxy composites retained their resistance to water absorption.

In this study, it was aimed to produce basalt fiber/PET hybrid yarns containing basalt fiber in different volume ratios (45%, 50%, 55%, 60%) and to examine the mechanical properties of thermoplastic composite samples formed by using the produced hybrid yarns.

2. Experimental study

The materials and methods are explained in detail below.

2.1. Design stages for flexural strengthening

In this study, to produce hybrid yarn, continuous basalt fiber that is compatible with polyethylene terephthalate (PET) from Kamenny Vek and ecru PET yarn from KORTEKS Mensucat Sanayi ve Ticaret A.Ş. were supplied and the properties of these materials are shown in Table 1.

2.2. Method

Basalt fiber/PET (BF/PET) hybrid yarns containing 45%, 50%, 55%, and 60% basalt fiber by volume were prepared using the air-jet mixing method. In the air-jet mixing method, BF reinforcement and PET matrix fibers were dispersed with the help of compressed air in the air jet, and the fibers were mixed. The basalt fiber/PET hybrid yarns with different volume ratios were woven in 2/2 fabric construction and converted into thermoplastic composite materials under a hot press. An example of the composite materials obtained is shown in Figure 1. To examine the mechanical properties of these samples, ISO 527-4 Tensile, ISO 14125 3-point bending, and ISO 6603-2 impact tests were carried out.

3. Results

To see the mechanical properties of 45% Basalt fiber/PET (BF45/PET), 50% Basalt fiber/PET (BF50/PET), 55% Basalt fiber/PET (BF55/PET), and 60% Basalt fiber/PET (BF60/PET) thermoplastic composite materials obtained by using basalt fiber/PET hybrid yarns containing basalt fiber in different proportions by volume (45%, 50%, 55% and 60%), test specimens were prepared in accordance with ISO 527-4 tensile, ISO 14125 3-point bending and ISO 6603-2 impact test standards and tests were carried out. Test results are shown in Table 2, Table 3, and Table 4.

As seen in Table 2, according to ISO 527-4 tensile test results, the most durable sample was the BF50/PET thermoplastic composite sample. As the basalt volume ratio increased, the tensile strength initially increased but decreased after the basalt volume ratio in the material exceeded 50.

Table 1. Properties of basalt fiber and PET yarn

	Basalt Fiber	Pet Yarn
Yarn Count (TEX)	150	33
Density (g/cm^3)	2.67	1.38

Fig. 1. Thermoplastic composite plate.

Table 2. Tensile test results

	F_{Max} (N)	Tensile strength (MPa)	Elongation at break (%)
BF45/PET	14740	287.1	1.8
BF50/PET	14724	321.6	1.7
BF55/PET	10754	293.8	2.4
BF60/PET	8540	238.4	1.9

Table 3. 3-Point bending test results

	F_{Max} (N)	Bending tension (MPa)	Module (MPa)
BF45/PET	493	414	17566
BF50/PET	397	420	20424
BF55/PET	215	348	21522
BF60/PET	176	314	21987

Table 4. Impact test results

	F_{Max} (N)	Energy at hole (J)
BF45/PET	11330	81,6
BF50/PET	11174	78,2
BF55/PET	7929	52,1
BF60/PET	7199	53,0

As seen in Table 3, according to ISO14125 3-point bending test results, the most durable sample was the BF50/PET thermoplastic composite sample. As the basalt volume ratio increased, the bending tension initially increased but decreased after the basalt volume ratio in the material exceeded 50. As seen in Table 4, according to ISO 6603-2 impact test results, the BF45/PET sample showed the best resistance. As the basalt volume ratio increased, the impact resistance of the material decreased.

4. Conclusion

In this study, basalt fiber/PET hybrid yarns containing basalt fiber in different volume ratios (45%, 50%, 55%, and 60%), fabrics woven from hybrid yarns, and thermoplastic composite samples were successfully produced. ISO 527-4 tensile, ISO 14125 3-point bending and ISO 6603-2 impact tests were performed to see the mechanical properties of the produced thermoplastic composite samples. According to tensile and 3-point bending tests, the BF50/PET sample showed the best mechanical strength property with values of 321.6 MPa and 420 MPa, respectively. According to the impact test, the BF45/PET sample showed the best resistance with a value of 81.6 J. The detailed examination of the mechanical effects of BF/PET thermoplastic composites prepared by using fabrics woven from basalt fiber/PET hybrid yarns containing basalt fiber in different volume ratios obtained within the scope of the study contributed to the literature as it is a comprehensive study that has not been done before.

Conflict of interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data availability statement

No new data were created or analyzed in this study.

References

[1] Alagirusamy R, Fangueiro R, Ogale V, Padaki N (2010) Hybrid yarns and textile preforming for thermoplastic composites. Textile Progress 38(4):1-71.

[2] Alagirusamy R (2005) Development and characterization of GF/PET, GF/Nylon, and GF/PP commingled yarns for thermoplastic composites. Journal of Thermoplastic Composite Materials 18(4):269-285.

[3] Gude M, Böhm R, Zscheyge M (2011) The effect of temperature on mechanical properties and failure behaviour of hybrid yarn textile-reinforced thermoplastics. Material Design 32 4278-4288.

[4] Long AC, Wilks CE, Rudd CD (2001) Experimental characterisation of the consolidation of a commingled glass/polypropylene composite. Composite Science and Technology 61:1591-1603.

[5] Abounaim M, Diestel O, Offmann G, Cherif C (2011) High-performance thermoplastic composite from flat knitted multi-layer textile preform using hybrid yarn. Composite Science and Technology 71:511-519.

[6] Zhang X, Pei X, Wang Q (2009) Friction and wear properties of polyimide matrix composites reinforced with short basalt fibers. Journal of Applied Polymer Science 111(6):2980-2985.

[7] Ronkay F, Czigany T (2006) Development of composites with recycled PET matrix. Polymers for Advanced Technologies 17(9-10):830-834.

[8] Liu Q, Shaw MT, Parnas RS, McDonnell A (2006) Investigation of basalt fiber composite mechanical properties for applications in transportation. Polymer Composites 27(1):41-48.

[9] Liu Q, Shaw MT, Parnas RS, McDonnell A (2006) Investigation of basalt fiber composite aging behavior for applications in transportation. Polymer Composites 27(5):475-483.