American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-7, pp-57-63
www.ajer.org
Research Paper Open Access

PVC Coated Glass Fiber Reinforced Composite Filament Material Production And Investigation Of The Mechanical Properties

Mehmet Kayrici[1], Ayten Nur Yüksel Yilmaz[2]
[1]*(Dept. of Mechanical Eng., Konya Necmettin Erbakan University, Seydişehir Ahmet Cengiz Faculty of Engineering, Seydişehir-Konya, Turkey)*
[2]*(Dept. of Fiber and Polymer Engineering,Bursa Technical University,Bursa, Turkey)*
Corresponding Author: Mehmet Kayrici

ABSTRACT:*In this work, the glass fiber filament was coated with PVC at the extruder in filament form. The filament material produced was woven with a weaving loom then pressed at 165 °C and 2.5MPa of pressure. In order to determine the distribution morphology of the matrix and reinforcement element in the composite fabric produced microstructure images were taken using Hardway brand optical microscope. As a result of the obtained microstructure studies, it was determined that the interphase surfaces in the composite body are stable. In addition, tensile tests were carried out on samples prepared according to ASTM D3039 standard using Shimadzu Ags-x brand testing machine.Composite filament behavior was investigated with the stress-strain and load-displacement diagrams obtained from the tensile tests.*

KEYWORDS: *Compositefilament, Glass fiber, Polymer, PVC, Thermoplastic composites, Weaving*

Date of Submission: 22-06-2018 Date of acceptance: 07-07-2018

I. INTRODUCTION

Use of thermosets for various application areas of polymer matrix composite materials; recycling, non-homogeneous production of materials, inability to adjust the matrix reinforcement ratios in production with the desired precision and inability to minimize the adverse effects such as voids reducing the strength of materials in the material have been bringing production-related disadvantages. Therefore, the production of thermoplastic matrix composite materials have become increasingly important in recent years. Fiber reinforced polymer composite materials are heterogeneous and anisotropic materials without plastic deformation. It is used in a wide range of contemporary applications, especially in the production of aerospace, automotive, marine,sports equipment, industrial fabric, fire equipment. Among other fiber reinforced materials, carbon fiber reinforced polymer and glass fiber reinforced polymer composite materials are gradually replacing conventional materials with excellent strength and low specific gravity properties. Their manufacturability in different combinations with customized strength properties, as well as high fatigue, toughness and high temperature wear and oxidation resistance properties, make these materials an excellent choice for engineering applications [1-2].Polymer matrices used as matrix elements in composite materials are divided into two parts as thermoplastic and thermosets. In the literature thermoset matrix composites have been studied more than thermoplastic matrix composites. However, the fact that thermoplastics have a high fracture toughness, a long shelf life of raw materials, a safe working environment due to the lack of organic solvents for recycling capacity and hardening process has increased the work done on thermoplastic matrix composites.George C. Jacob et.al. [3] summarizeda review survey of strain rate effects for the mechanical properties of polymer composite materials. An attempt was made to present and summarize much of the published work relating to the effect of strain rate studies done in the past on the tensile, shear, compressive, and flexural properties of composite materials to better understand the strain rate effects on these mechanical properties of fiber-reinforced polymer composite materials.Zhang et al. [4] studied the mechanical properties of PTFE (Polytetrafluoroethylene) coated fabrics used in the central axis of the Shanghai Expo. They formed groups of non-axial and biaxial tensile tests and studied failure mechanisms and strength criteria. They also examined the effect of temperature on mechanical properties. They found that PTFE fabric is typically orthotropic. Also found that with increasing bias angle away from the fiber directions, the tensile strength gradually decreases and the strain at break increases. They used the Tsai–Hill criterion for predict the failure strength of this material. With increasing strain rate, tensile strength increased slightly and strain rate decreased. The tensile strength and strain at break showed good linear format with the strain speed's logarithm. PTFE fabric remained unchanged in temperatures ranging from 20°C to 70°C.Herrera-Franco et.al. [5] worked on the mechanical behavior of high density polyethylene (HDPE) reinforced with continuous henequen fibers (Agave fourcroydes).Fiber-matrix adhesion was promoted by fiber surface modifications using an alkaline treatment and a matrix preimpregnation together with a silane coupling agent.He found that the use of the silane coupling agent to promote a chemical interaction, improved the degree of fiber matrix adhesion. However, it was found that the resulting strength and stiffness of the composite depended on the amount of silane deposited on the fiber. A maximum value for the tensile strength was obtained for a certain silane concentration but when using higher concentrations, the tensile strength was not increase.Chen et al. [6] investigated the mechanical propertiesof polyamide66/polyphenylene sulfide blendmatrix with different glass fiber volume contents such asrespectively 5%, 10%, 20% and 30%. The maximumtensile strength was found at 30% Vf of fiber and flexuralstrength was found at 25% Vf. The maximumimpact strength was found at 0% Vf of fiber compareto fiber incorporated composites. But the maximumimpact strength was found at 20% Vf offiber that was lower the above. Botelho et al.[7]researched the environmental behaviour of woven mat GF-reinforced polyetherimide thermoplastic matrix composites. The testing was conducted with varying temperature at relative humidity of 90% for 60 days under sea water. Moisture absorption behavior was mostly dependent on temperature and relative humidity.The moisture absorption curve reported that the weight gain was initially increased linearly with respect to time. After 25 days, maximum moisture absorption of 0.18% was found. Mohammad Torabizadeh[8] investigated the compressive, tensile, in-plane shear behaviour of unidirectional GF-reinforced epoxy matrix composites under static and low temperature (25°C, -20°C, -60°C) conditions.The tensile test result showed that the stress-strain curve decreased with increasing temperature.The maximum tensile strength (784.94 MPa), young's modulus (28.65 MPa), compression strength (186.22 MPa) and shear strength (1.33x 10^{-8} MPa) was found at 60°C.

In this work, glass fiber reinforced PVC matrix composite filament specimens were produced using 11.28% by weight of glass fiber. These filaments were weaved by the plain weaving method and pressed.The effects of manufacturing parameters on the microstructure and tensile strength of composite materials were investigated.

II. EXPERIMENTAL

In the scope of this study, PVC material and glass fiber were respectively used as matrix and reinforcement material for the production of polymer matrix composite materials. The PVC material used as the matrix material was supplied by ŞİŞECAM, the reinforcing material was obtained from the glass fiber material PETKİM, and the commercial and mechanical characteristics of these materials are respectively shown in Table 1 and 2.

Table 1. Mechanical and commercial properties of WR300Tex glass fiber

Glass fiber type	E
Texture of roving (g/1000m)	300 ± %7
Fiber Diameter (μ)	nom. 14
Amount of moisture (%)	max. 0,1
Bonding agentquantity(%)	0,55 ± 0,15
bonding agent type	Silane
Resin compatibility	Polyester , Vinylester , Epoxy
Specific weight (g/cm3)	2.54
Tensile strength (MPa)	3448

Table 2. Specific values of granule EN 43 PVC

Properties (Unit)	Values	Test Methods
Specific weight (g/cm^3)	1,28	ASTM D 792
Hardness (SHORE A)	85	ICI SOLVIC PCC152
Tensile stress at break (kg/cm^2)	138	ICISOLVIC PCC 160/67
Melting (ºC)	160	TEMPERATURE
Elongation at break (%)	200	ICISOLVIC PCC 160/67

Granular EN 43 PVC material placed in the extruder chamber was heated at a rate of 60 rev/ min and the first part temperature was 150 °C, the second part temperature was 162 ° C and the (T) head temperature was 173 °C. These temperatures were fixed and the melting of PVC was provided. The molten PVC material from the extruder was passed through special molds to cover the silane-based glass fiber.PVC coated glass fiber was cooled by passing through water cooling chamber. Then the cooled filament was wound into a bobbin at a speed of 44 rev/ min (Figure 1).Produced filament thickness is 1.60 mm.

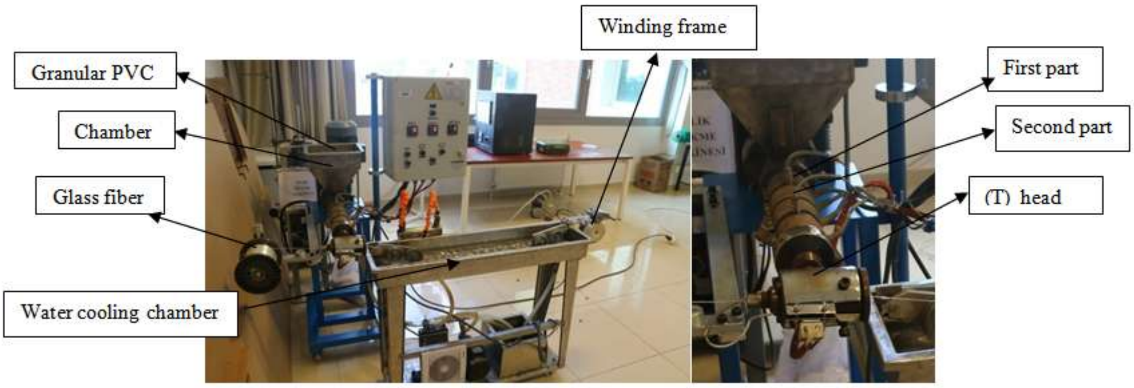

Figure 1.PVC coated glass fiber filament production

The PVC coated glass fiber filament wound into the spool was weaved by plain weaving method as 7 warp/19weftat 2.5 cm.Woven fabric and weaving properties are respectively shown in Figure 2(a) and Table 3.

Table3. Properties of woven fabric

PVC/ Glass fiber	7 warp/ 19 weft at 2.5 cm
Weaving type	Plain weaving
Weight	2575 g/m^2
Filament diameter	1.60 mm

The woven fabric was cut according to the size of 20*20*0.2 cm and placed in the mold.When the fabric was placed in mold, both sides of the fabric were covered with a vacuum bag capable of withstanding a temperature of 300 °C (Figure 2b).The aim is to achieve a smooth surface after pressing.The material ready for pressing (Figure 2c) was pre-heated without pressure for 15 minutes at 165 °C, then at a pressure of 2.5 MPa and held at 165°C for 1 hour.The press was turned off, stopped for 45 minutes without pressure, and then allowed to cool in the open air.After the material was cooled, it was removed from the mold(Figure 2d).

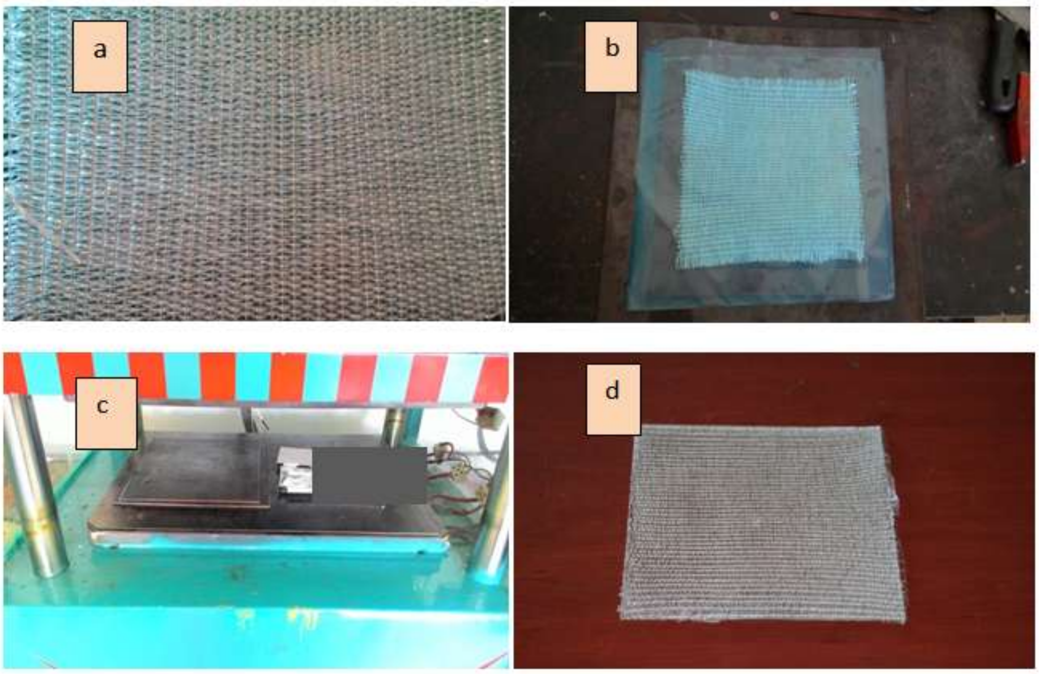

Figure 2. The production process of the composite sample;a)Weaving, b) Placing the mold, c) Pressing,d) Produced composite material

In order to observe the distribution morphology of the matrix and reinforcement element in the composite material produced microscopic images were taken using HARDWAY brand optical microscope. The samples prepared according to ASTM D3039standard were subjected to tensile test using SHIMADZU AGS-X brand testing machine (Figure 3)

Figure 3. Polymer matrix composite tensile specimen measurements according to ASTM D3039 standard. [9]

Figure 4.Tensile testing process for composite material samples

The fiber/matrix volume ratios of glass fiber reinforced composite material produced within the scope of the study were determined according to the burn-off method described in the ASTM D3171 test standard [9]. For the calculation of parameters according to this standard, the formulas given in 1-3 were used.

Percentof fiber weight (W_r);

$W_r = (M_f/M_i)x100$ (1)

M_i = initial mass of the specimen, M_f = final mass of the specimen after combustion

Percent of fiber volume (V_r);

$V_r = (M_f/M_i)x100x\ \rho_c/\rho_r$(2)

ρ_c= density of the reinforcement,ρ_r = density of the specimen

Percent of matrix volume (V_m);

$V_m = [(M_f-M_i) / M_i]\ x100x\rho_c/\rho_m$ (3)

ρ_m = density of the matrix

Table 4. Percent of fiber/matrix volume values determined by the burn-off method

Sample	Percent of fiber volume (%)	Percent of matrix volume(%)	Percent of fiber weight (%)
PVC coated glass fiber reinforced compositematerial	5.59	65.23	11.28

III. RESULT AND DISCUSSION

From the produced thermoplastic composite plate, six specimens were cut according to the ASTM D3039 standard (three samples weft direction- three sampleswarp directions).Tensile test was carried out at a speed of 5 mm/min according to this standard in Shimadzu AGS-X testing machine and the results were shown below.

Table5. Tensile test results in weft direction

Sample	Elasticity (N/mm^2) (350 - 500N)	Max. Load (N)	Max. Stress(N/mm^2)	Max. Displacement (mm)	Max. % Displacement	Max. Strain(%)
1	450.704	1768.65	34.6795	9.29153	8.44685	8.44685
2	431.643	1279.72	26.6608	7.51491	6.83173	6.83173
3	401.976	1405.41	28.5653	10.7374	9.76131	9.76131

Table6. Tensile test results in warp direction

Sample	Elasticity (N/mm^2) (350 - 500N)	Max. Load (N)	Max. Stress (N/mm^2)	Max. Displacement (mm)	Max. % Displacement	Max. Strain(%)
1	520.996	705.242	14.1048	3.53032	3.20938	3.20938
2	494.628	799.036	15.6674	4.52074	4.10977	4.10977
3	565.744	720.358	13.5406	3.40411	3.09464	3.09464

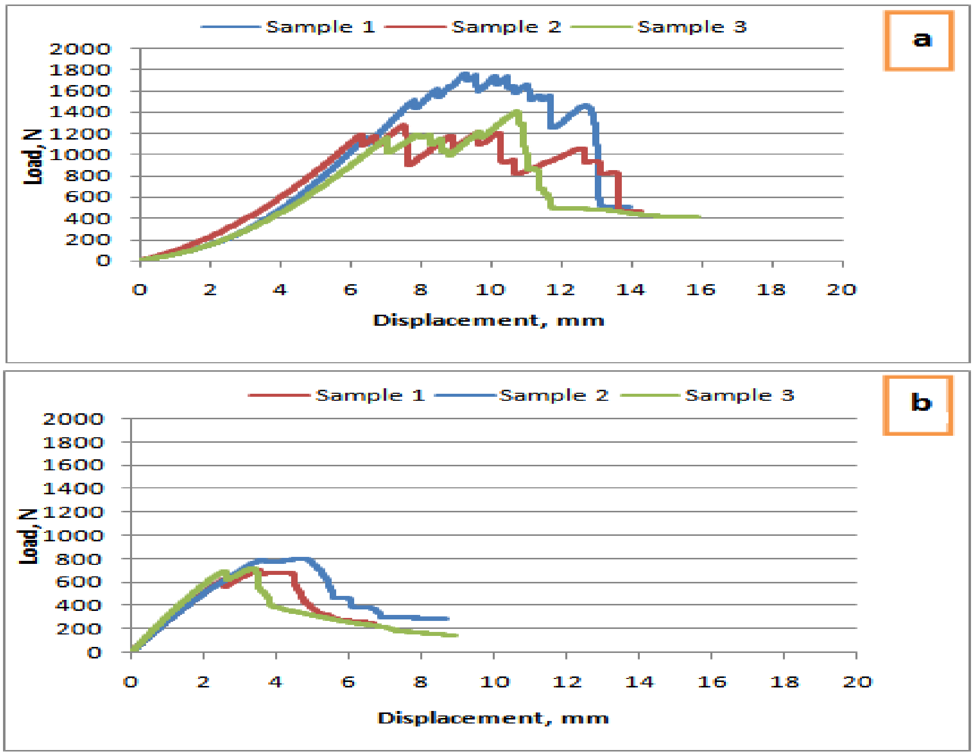

Figure 5.Load-displacement graphaccording to the tensile test results;a) in the weft, b) warp direction

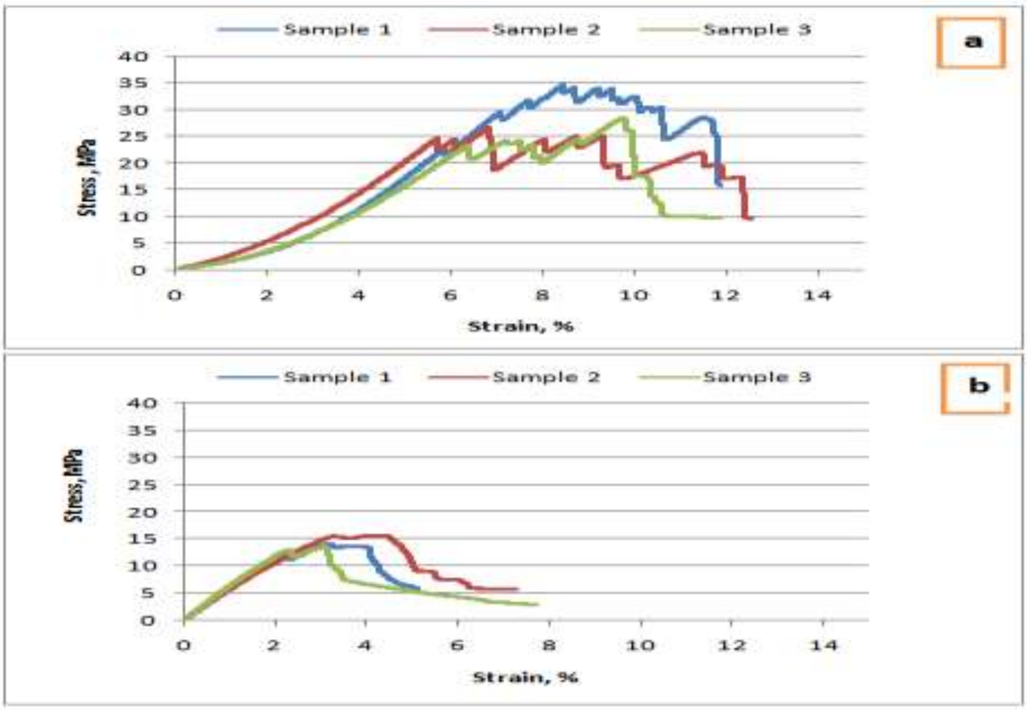

Figure 6.Stress- strain graphaccording to the tensile test results;a) in the weft, b) warp direction

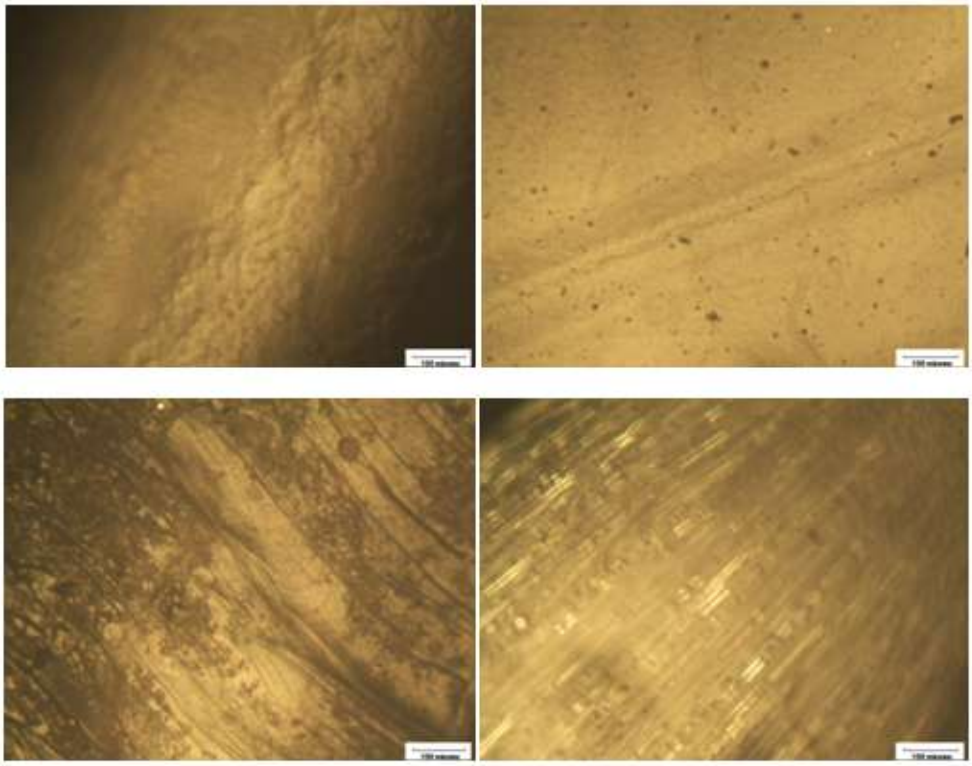

Figure 7.The microstructural images of PVC coated glass fiber reinforced composites

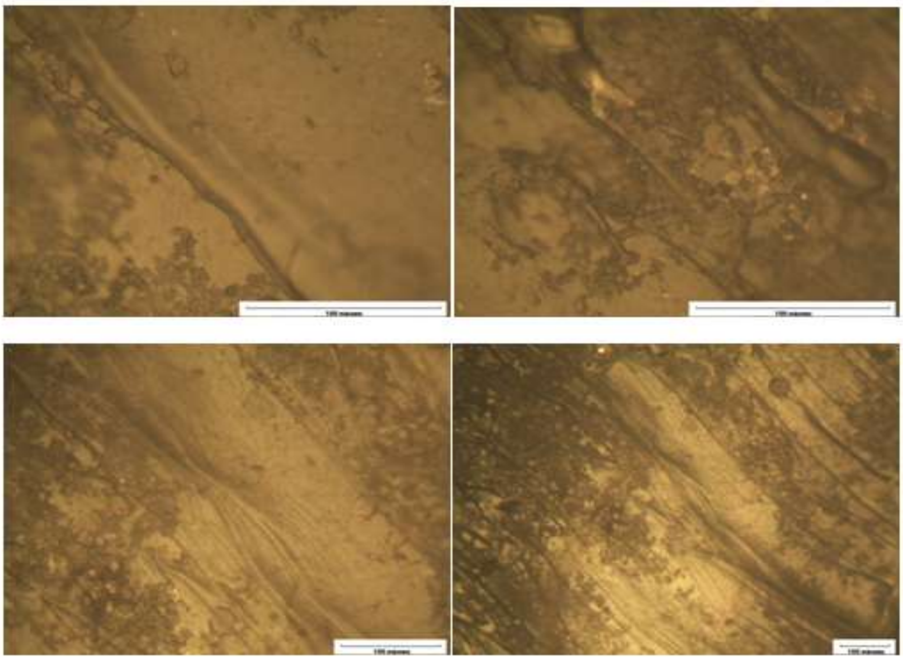

Figure 8.Axial microstructural images of PVC coated glass fiber reinforced composites

IV. CONCLUSIONS

- Due to the edge effect during the tensile test, the material started to yield from the edges of the sample (first fiber breaks) and moved towards the inner zone.This is because the notch and cutting tool damages occur on the cutting edge when the sample is obtained.Another reason is that fibers are pulled out of the matrix effect during power transfer.The fiber breaks in the tensile direction starting from the edges continue towards the inner regions of the sample when the load becomes stabilized.
- The effect of grip jaws and jaw connection accuracy is important in thermoplastic matrix composites.

- The force applied to the material in the direction of the weft was considerably higher than the direction of the warp due to the excess of the number of fibers in the weft direction and the instability of the weft length.As a result of, the warp is stable but the weft is unstable in weaving.
- Up to the starting yield point in the material, the reinforcement element carried out load transfer which was very compatible with the fiber matrix.As the damage to the fibers does not occur simultaneously, the period of yield region of the material is expansive.It is predicted that the load applied to the end of the last fiber is the load applied to the matrix.
- In this study, mechanical strengths were calculated by calculating volume and weight of fiber and matrix.Higher mechanical strengths can be obtained by increasing the fiber volume ratio.
- The composite plate obtained has an easily formed structure due to the flexibility property of PVC.
- When the microstructures of the microscope image are examined, it is observed that the glass fiber and the PVC matrix are very well matched, the interphase region is stable, and there is no gas and air space in this region.
- The obtained material can be used in industry where electrical and sound insulation are aimed, and where resistance to acid and corrosive environments is required. This material also can used in technical textile as industrial cover and agricultural use.

REFERENCES

[1]. M Altin Karataş¸ H Gökkaya , A review on machinability of carbon fiber reinforced polymer (CFRP) and glass fiber reinforced polymer (GFRP) composite materials, *Defence Technology(2018)* , https://doi.org/10.1016/j.dt.2018.02.001

[2]. Mallick PK, Fiber-reinforced composites.,In: Materials, manufacturing, and design. Third ed. Boca Raton: Taylor & Francis; 2008.

[3]. Rafael Celeghini Santiago ,Ricardo Lessa Azevedo , Antônio F. Ávila , Marcílio Alves, George C. Jacob, J. Michael Starbuck, John F. Fellers, Srdan Simunovic, Raymond G. Boeman „Mechanical characterization of glass/epoxy composite material with nanoclays‟, *Wiley InterScience*, Received 4 November 2003; accepted 16 March 2004, DOI 10.1002/app.20901,

[4]. Y Zhang, Q Zhang, C Zhou , Y Zhou , Mechanical properties of PTFE coated fabrics , *Journal of Reinforced Plastics and Composites* 29(24) , 3624–3630, 2010

[5]. P Herrero Franco, A Valadez, M Cervantes, Mechanical properties of continuous natural fibre- reinforced polymer composites, *Composites Part A Applied Science and Manufacturing,* 35(3):339-345,2004

[6]. Chen Z, Liu X, Lu R, et al., Mechanical and tribological properties of PA66/PPS blend. III. Reinforced with GF. J Appl Polym Sci 2006; 102: 523–529.

[7]. Botelho EC, Bravim JC, Costa ML, et al., Environmental effects on thermal properties of PEI/glass fiber composite materials., J Aerosp Techno Manag Sao Jose dos Campos 2013; 5: 241–254.

[8]. Mohammad Torabizadeh A.,Tensile, *compressive and shear properties of unidirectional glass/epoxy composites subjected to mechanical loading and low temperature services.* Ind J Eng Mater Sci 2013; 20: 299–309

[9]. ASTM D 3171, 2004. Standard Test Method for Constituent Content of Composite Materials, Space Simulation; Aerospace and Aircraft; Composite Materials, Annual Book of ASTM, Philadelphia.

Mehmet Kayrici. " PVC Coated Glass Fiber Reinforced Composite Filament Material Production And Investigation Of The Mechanical Properties."American Journal of Engineering Research (AJER), vol. 7, no. 07, 2018, pp. 57-63.