22nd International Conference
ENGINEERING MECHANICS 2016
Svratka, Czech Republic, 9 – 12 May 2016

TENSILE BEHAVIOUR OF NATURAL FABRIC REINFORCED COMPOSITE

J. Purdek*, S. Samal, D. Reichmann

Abstract: *Tensile behaviour of natural fabric reinforced composite were investigated in this work. Natural fabric such as flax and jute were considered in bi-axial plain reinforcement in matrix of acrylic resin. The composite are prepared in hand layup techniques. Fabric weight fraction of 7 % was used in the matrix of composite. The samples were treated at RT and 60 °C for the final fabrication. Tensile test were carried out on the samples with dimension 200x30x5.5 mm with span of testing 120 mm using instrument Instron 5967 / 30 kN. The speeds of measurement were considered 5 mm/ min. The result of flax reinforced composite shows better tensile strength of 12 MPa. Scanning electron microscope image analysis was carried out to examine the micro structure effect of composite in terms of tensile strength.*

Keywords: Flax, Jute, Acrylic resin, Tensile Behaviour, Composite

1. Introduction

Every substitution of heavy metal materials by light-weighted composites of the equivalent mechanical properties is desired in the field of mechanical engineering. Furthermore, natural fabrics are renewable thus environmentally more convenient and friendly in nature. Flax and jute fabrics are investigated to reinforce acrylic resin matrix. Tensile strength is the focus of this work. Jute and flax plain weave fabrics were tested for tensile strength using Instron 5967 and then compared to tensile strength of the reinforced composite. The composite samples were prepared by hand layup technique.

Aim of the investigation is on tensile behaviour of fabrics such as flax and jute with the reinforced composite respectively. The microstructural observations were carried out to correlate the mechanical properties of the material.

2. Methods

Samples for tensile strength of fabrics prepared from jute (437g/m2) and flax (270g/m2) with dimension 200x30x0.5 mm. Plain weave fabrics were used for the composite of dimensions 200x200x5.5 mm. Hand layup technique was used to prepare jute and flax reinforced in acrylic resin matrix composite. Matrix is a combination of two materials such as Acrylic One LP01 Catalyst (Liquid composition: Water 54.4-56.7%, Acrylic Polymer 43.3-45.6%) and powder (Calcium Sulphate: Relative Density 2.75 g/cm3, Melting point 1610°C). The mixture of the solution is prepared using powder and catalyst in the ratio of 2:1 (300g of powder, 150g of liquid). Thicknesses of the composites were 5.8 (±0.2) mm for flax and 5.5 (±0.2) mm for jute where 3 layers of flax and 2 layer of jute were implied. Weight fraction for jute composite is 7.2% and 6.7% for flax is shown in equation (1). For some samples, heat treating was performed in the laboratory furnace for 24hours at 60°C, the rest dried at the room temperature (RT) 25°C. Final dimension of the samples used for testing is 200x25x5.5 mm. In average 7 samples were prepared from the plate by cutting using a hand saw instrument. Tensile tests were carried out on fabric samples and composite samples using Instron 5967 with a video-extensometer.

* Jiri Purdek, Sneha Samal, David Reichmann, Katedra mechaniky, pružnosti a pevnosti, Technická univerzita v Liberci, Studentská 2; 46117, Liberec; Czech Republic; samasneha@gmail.com

Table 1. Final dimensions of tested samples and weight fraction in case of composites.

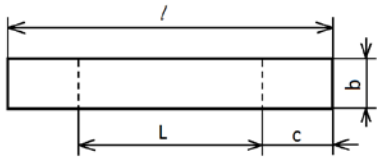
Samples	Fabrics [mm]	Composite [mm]	Weight fraction %
Flax	200x30x0,5	200x25x5,8	6,7
Jute	200x30x0,7	200x25x5,5	7,2

The weight fraction of fabrics in the composite is calculated using equation (1) below

$$W_f = \frac{m_{fabric}}{m_{composite}} = \frac{m_{Flax}}{m_{powder} + m_{liquid} + m_{Flax}} \cong 6,7\% \quad (1)$$

The schematic diagram of the sample dimension and pictorial presentation of sample testing is shown in Fig.1.

(a)



(b)

Fig. 1: (a) Schematic diagram of sample dimension (l – total length of the sample, L – measured length of the sample, b- width of the sample; (b), testing demonstration of composite sample using Instron 5967

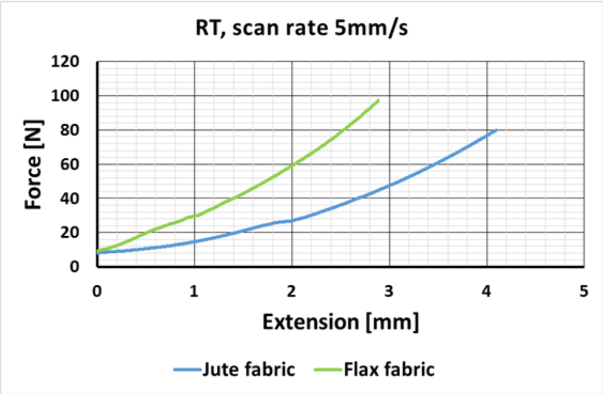
The testing parameters are represented in Table 2 for measurement of tensile strength of the fabric and composite samples.

Table 2. Parameters for tensile test

	l [mm]	L	c	b	Speed [mm/min]
Fabric (Jute, Flax)	200	120	40	30	5
Composites	200	120	40	25	5

3. Results and discussion

Fig. 2 displays the force - displacement relation of the fabrics such as jute and flax. Flax fabric withstand the force of 87 N before the tearing happens in the fabric. However, the jute fabric tears up at force of 70 N. The tensile test of the fabric shows tearing happens in the zone of the clamping area. Fig. 3 represents the force - displacement of composite reinforced with flax and jute fabrics at room temperature. Flax fabric reinforced composite shows 3.5 times higher force compared to the composite reinforced by jute fabric. Jute reinforced composite show failure of the material at the force of 400N with extension of 0.3 mm. Fig. 4 shows force – displacement relation of flax and jute reinforced acrylic resin composite at 60°C. Results of heated samples show the changes in both of the composites. The flax reinforced acrylic resin composite withstands a lower pulling force of 525 N before any plastic deformation. In contrary, the plastic deformation of jute reinforced acrylic resin composite occurs after the force increases above 840 N. This may be caused due to interfacial adhesion between fabric and matrix surface. This observation has been supported by microstructural images of the composite.



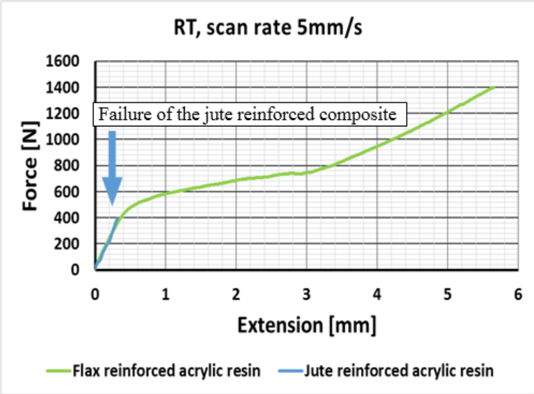


Fig. 2: Load vs displacement graph of fabrics

Fig. 3: Load vs displacement graph of composites

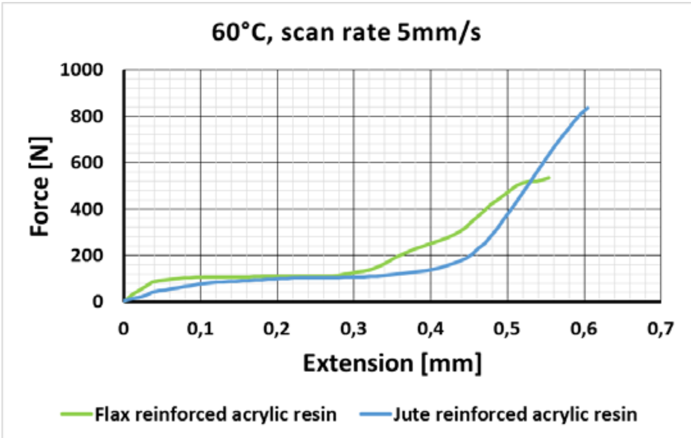
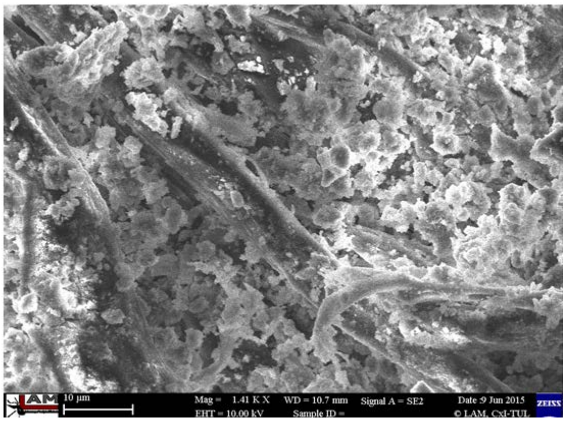


Fig. 4: Load vs displacement graph of composites at 60°C

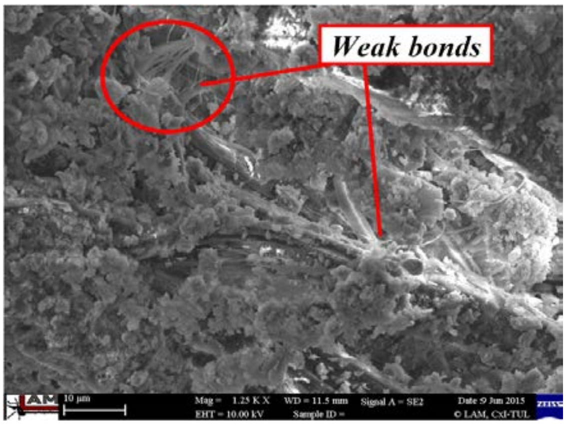
The correlation between tensile and microstructural properties of the composite is investigated using scanning electron microscope. The adhesion between the fabric and the matrix is observed from this analysis. Fig. 5 shows the microstructure of the composite with flax fabrics (Fig. 5 a) and jute fabric (Fig. 5 b) is shown below. Adhesion between jute and matrix at RT is weak, however the samples treated at 60°C (Fig. 5 c) created stronger bonds with matrix. On the contrary the structural change due to the treatment to 60°C of the matrix reinforced with flax caused decreased overall tensile strength.

4. Conclusions

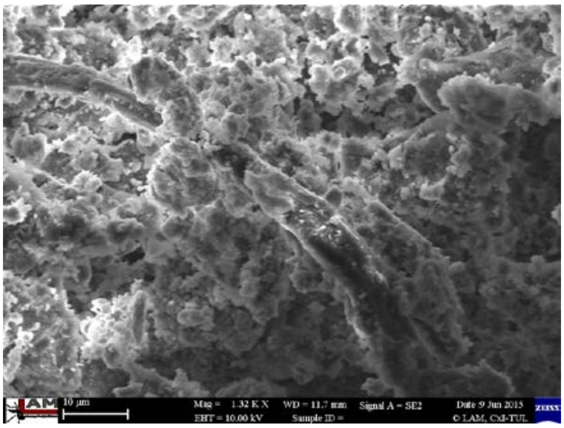
Flax fabric reinforced composite shows overall better tensile behaviour in comparison to jute reinforced acrylic resin composite. Despite the results with the heat treatment at 60°C at which point the jute reinforced acrylic resin composite reached the cracking point at the load of 840 N (tensile strength 6 MPa) , the flax reinforced acrylic resin composite reach the maximum value of 1390 N (tensile strength 10 MPa) at room temperature. This change of tensile behaviour may be caused by the microstructural changes. The bonds between the jute fibers and the matrix were weak at the room temperature. Heating helped matrix to bond with the jute fibers, however the structural change of the matrix reinforced with flax fabric weakened the overall tensile strength.



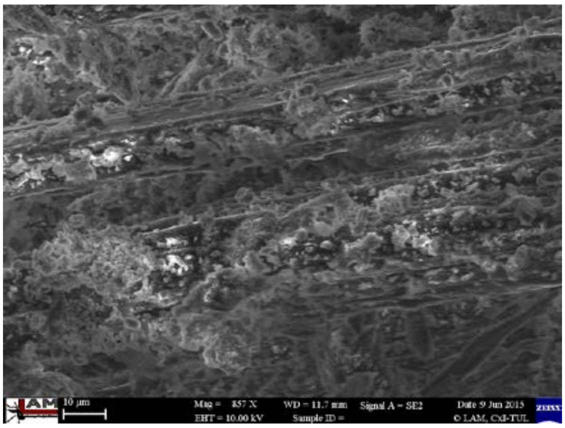
(a) Flax reinforced composite at RT



(b) Jute reinforced composite at RT



(c) Flax reinforced composite at 60°C



(d) Jute reinforced composite at 60°C

Fig. 5. Scanning electron microscope images for fabric reinforced composite at RT and 60 °C.

Acknowledgement

This work was supported by national financial resources of Ministry of Education Youth and Sports of Czech Republic for specific university research (SGS 21120).

References

Samal S., Nhan. P. T., Petrikova I. and Marvalova B. (2015) Improved mechanical proprties of various fabric-reinforced geocomposite at elevated temperature, JOM: The journal of the minerals, metals and materials society 67 ,7, pp. 1478-1485.

Samal S., Nhan P.T., Petrikova I., Marvalova B., Vallons K., Lomov S. V. (2015) Correlation of microstructure and mechincal properties of various fabric reinforced geo-polymer composites after exposure to elevated temperature, ceramics International 41, 9, pp. 12115-12129.

Zhu J., Zhu H., Njuguna J. and Abhyankar H. (2013), Recent Development of Flax Fibres and Their Reinforced Composites Based on Different Polymeric Matrices, Materials, 6, pp. 5171-5198, doi:10.3390/ma6115171.

Roe P. J., Ansell M. P. (1985) Jute-reinforced polyester composites, Journal of Materials Science, Volume 20, 11, pp 4015-4020.