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TENSILE MODULUS OF LAMINATE COMPOSITES

HALIL IBRAHIM KURT[*1], NECIP FAZIL YILMAZ[2] and MURAT ODUNCUOGLU[1]

[1]Department of Mechanical and Metal Technologies, Techical Sciences, Gaziantep University, 27310, Gaziantep, Turkey
[2]Department of Mechanical Engineering, Engineering Faculty, Gaziantep University, 27310, Gaziantep, Turkey
E-mail: hiakurt@gmail.com

Abstract

The influence of Borax/SiC content on the tensile modulus of Carbon/epoxy and Kevlar/epoxy composites was analyzed using artificial neural network approach with six neuron in one hidden layer in this study. The correlation coefficient, R2, mean square error and mean absolute error was used to state the performance and error evaluation criteria of the proposed model/system. Borax and SiC ratios was changed between 0 and 10%. Addition of SiC caused to an increase on the tensile modulus of Carbon/epoxy and Kevlar/epoxy composites but Borax addition induced the decrease of it of these composites.

Keyword: Tensile modulus, ANN, Composite, Kevlar, Carbon.

1.Introduction

Composite materials as inhomogeneous materials are a group of materials that come into being by bringing together at least two different materials and they are extensively used in structural applications due to their high strength and stiffness to weight ratio compared with conventional materials [1-5]. Polymer matrix composites are used in engineering applications and using ratio increases more and more [6-9]. SiC improved the modulus of carbon fiber reinforced epoxy composite [10]. Wood flour filled high density polyethylene composites with Borax and boric acid were produced. The addition of Borax enhanced the mechanical properties of the composites with compared to boric acid. The tensile modulus improved about 19% [11].

It was also stated that the ratio and size of the particle has an important effect on the microstructure and mechanical properties of the composite materials [12]. The addition of ash compared to Al_2O_3 and SiC to glass/polyester composites displayed more superior mechanical properties [13]. Tensile modulus measures the resistance to elastic deformation of a material exposed the deformation. Materials showing the large value of the tensile modulus are called as more stiffer have higher tensile strength. It is quite valuable to carry out the mechanical properties of polymer matrix composites. The aim of this study is to find out the effects of Borax and SiC ratios on the tensile modulus of Carbon/epoxy and Kevlar/epoxy composites.

2.Materials and Methods

The effect of reinforcement type and ratio on the tensile modulus of kevlar/epoxy and carbon/epoxy was theoretically researched [14-17]. Table 1 provides the minimum and maximum values of the used parameters.

Table 1. Minimum and maximum values of experimental parameters

	Epoxyi (%)	ASS (%)	**SiC (%)**
Minimun	0	0	0
Maximum	100	10	10

Data were normalized ranges 0.05 and 0.95 using Eq.1

$$\theta = 0.9\left(\frac{V-V_{min}}{V_{max}-V_{min}}\right) + 0.05 \qquad (1)$$

where V is the used variables, V_{max} and V_{min} are the maximum and minimum values of the variables, respectively. The sets were seperated in two sets as train and test. The former was used to train the model with six neurons numbers in one hidden layer and the later was used to test it with same condition. The correlation coefficient (R) and R^2 values were designated as performance evaluation and mean absolute error (MAE) and mean squared error (MSE) were specified as error measurement.

3.Results and Discussion

The performance criteria regarding the train and test sets were given in Table 2. The MSE is 0.000699 and 0.004511, for train and test, and MAE is 0.019342 and 0.040976 for them, respectively. The R value of two sets is0.995073 and 0.987886, respectively.

Table 2. System statistical parameter

	MSE	**R**	**MAE**
Train	0.000699	0.995073	0.019342
Test	0.004511	0.987886	0.040976

The criteria showed that the acceptable, performance and reliable of the model were quite high. The experimental and theoretical results of train set were illustrated in Figure 1. It is clear from the figure that the results are in a good agreement with each other. Figure provides the R^2 value which explain the reliability and accuracy of the system of for the train set. The value is 99.02 that means that all data points nearly align on the curve.

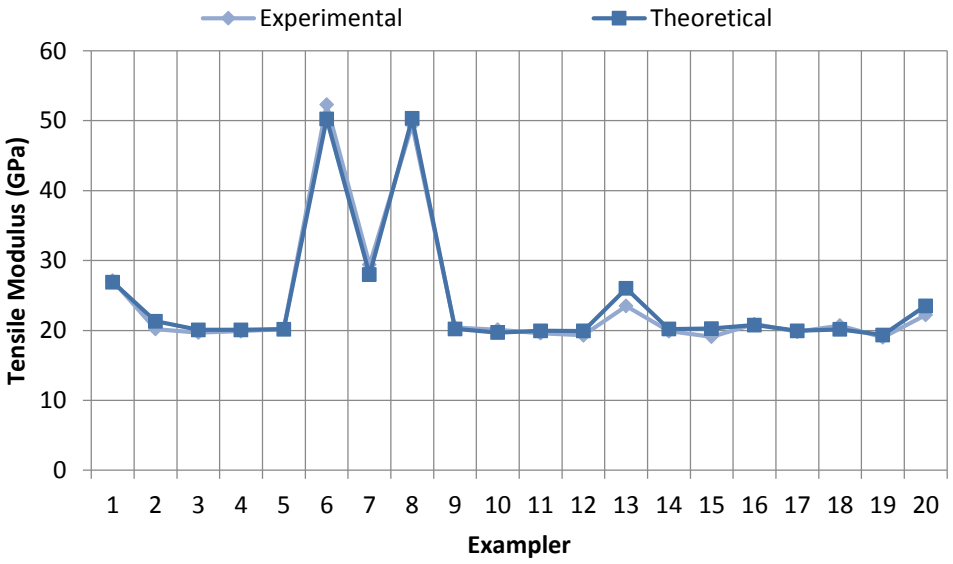

Figure 1. Experimental and theoretical results of train set

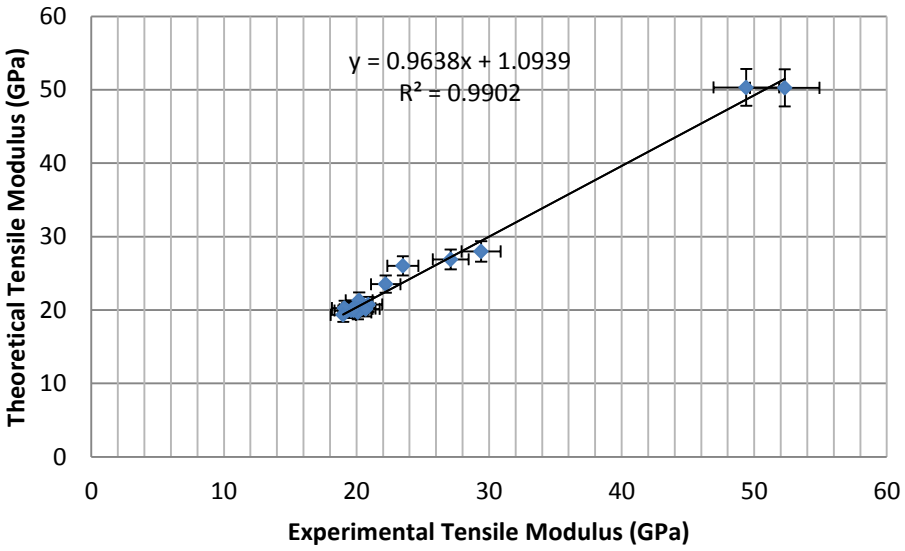

Figure 2. R^2 value of train test

Figure 3 compares the experimental and theoretical results for test set. The consistency of the results is very high. The correlation coefficient of the set is 0.987886 as expressed before. The R^2 is 0.9689 like showed in Figure 4. It can be said that the prediction rate of the model is 99.89% between given ranges. The error rate of the test set was found to be higher than the train data. Figures 5 and 6 demonstrate the effect of Borax/SiC content on the tensile modulus of carbon/epoxy and Kevlar/epoxy composites.

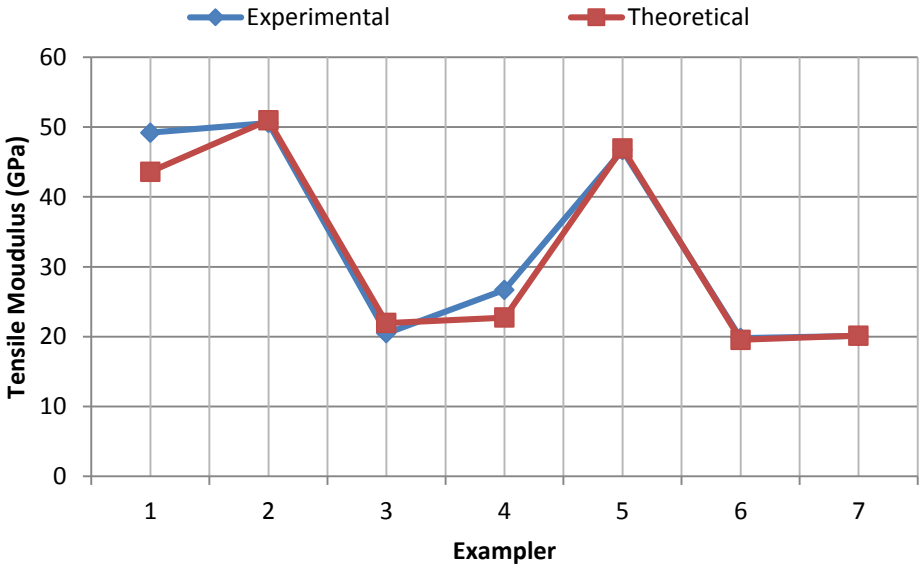

Figure 3. Experimental and theoretical results of test set

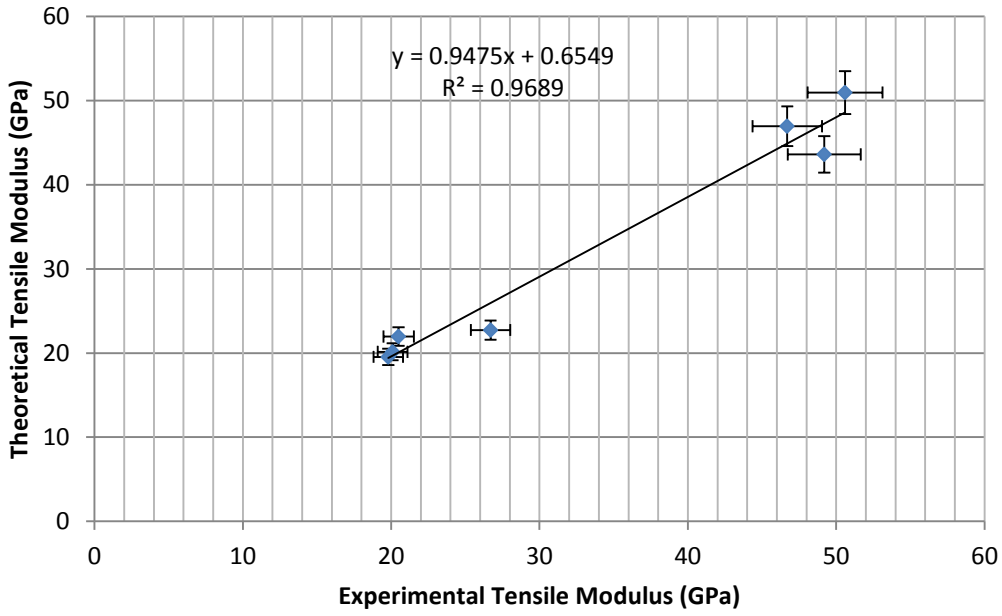

Figure 4. R^2 value of test set

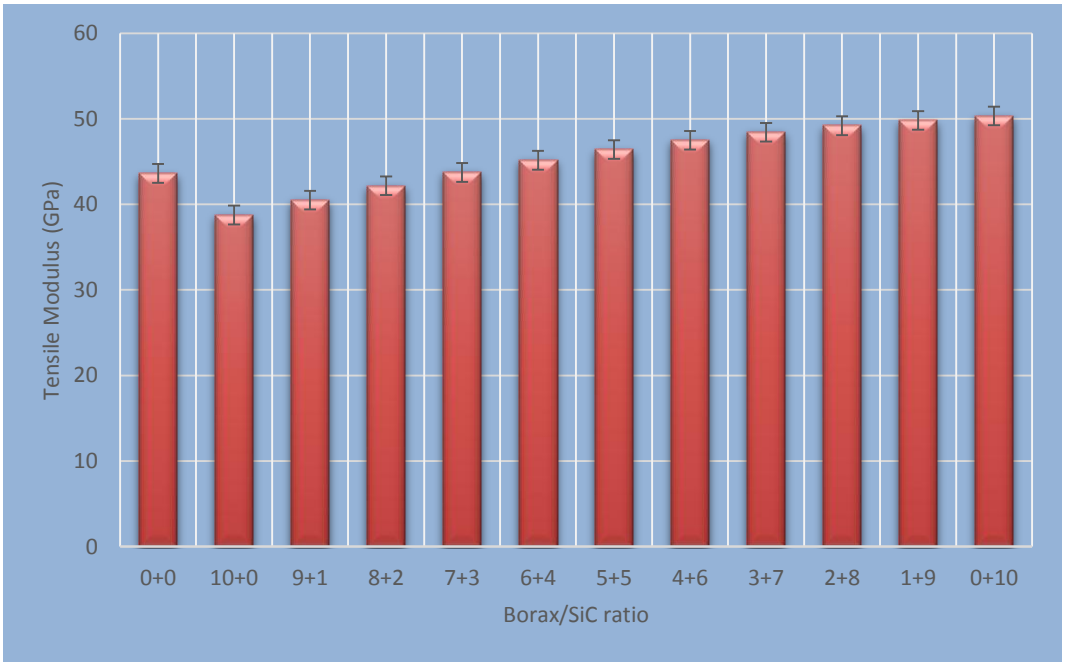

Figure 5. Carbon/epoxy composites

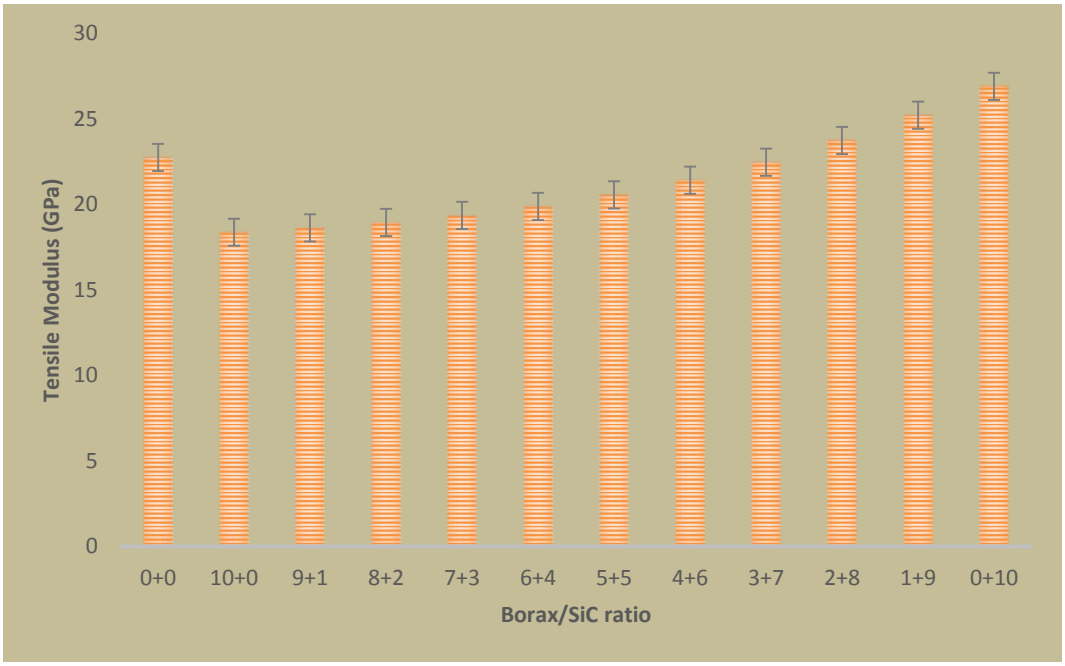

Figure 6. Kevlar/epoxy composites

The tensile modulus of these composites increases with the addition of SiC. The increase with addition of 10% SiC for Carbon/epoxy and Kevlar/epoxy composites is about %15 and 18%, respectively. The decrease with 10% Borax is about 11% for Carbon/epoxy composites and 19% for Kevlar/epoxy composites. The increase and decreasing can be attributed to load transfer strengthening mechanism and agglomeration of particle. [15,18]. Additionally, the interaction of SiC with matrix, interfacial relations, particle size and other factors related to manufacture parameters like temperature, press and environmental effects should be considered in detail.

4.Conclusions

The effect of Borax/SiC ratio on the tensile modulus of carbon/epoxy and Kevlar/epoxy composites was theoretically investigated in this work. The learning capacity and prediction rate of the system are rather high. The tensile modulus of the carbon/epoxy and Kevlar/epoxy composites can be increased about 15% and 18% with addition of 10% SiC, respectively. However, the modulus was decreased about 11% and 19% with addition of %10 Borax. It can be concluded that the used method is a good approach to analyze the experimental results, can be used to save time and cost.

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