The International Journal of
Materials and Engineering Technology
ISSN : ,
TIJMET, Vol. 01 (01),2018, (5 pages) ID: 180101002
Type of the Paper: Article
Received 29.06.2018; Accepted: 06.08.2018

# ANN IN ESTIMATION SHEAR MODULUS OF LAMINATE COMPOSITE

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**Abstract**

The shear modulus of the composite materials and the elastic properties of the fiber are similar to each other. In this study, the effect of reinforcing type and weight ratio on the shear modulus of carbon/epoxy and kevlar/epoxy composites was theoretically investigated and the average error rates and correlation values were analyzed. Artificial neural networks approach was used in the study. The ratio of Ssa/SiC was determined as minimum and maximum of 0 and 20, respectively. In artificial neural network method, 6 neurons one hidden layer were used. It was observed that SiC was an important reinforcing phase for kevlar/epoxy composites but it was not for carbon/epoxy composites.

**Keyword:** ANN, Composite, Kevlar, Carbon.

## 1.Introduction

Composite materials are a group of materials that come into being by bringing together at least two different materials for a specific purpose [1-4]. It was aimed to produce a material with superior properties by bringing the components together for the desired purposes. The use of composite materials is rapidly increasing due to their high strength/density and high elasticity modulus/density ratios. Composite composites do not mix with each other. The components with different properties together constitute the superior properties of the composite material. It has superior properties and advantages that add value compared to traditional materials such as metal and wood. These features and advantages increase the need for industrial composite materials and open new application areas. Composite materials consist of fiber and resin components. Nearly 90% of the composite materials are polymer-based matrices [5-8]. The product obtained by reinforcing thermosetting or thermoplastic resins with resin additives, fiber reinforcements (glass, carbon, aramid, etc.) or fillers and curing this mixture as a result of a certain process is called composite. For this reason

reinforced plastics and composite terms are synonymous [9]. Polymer materials are viscoelastic materials and their mechanical properties change with time. The difference between composites and other materials is between density and tensile - bending modules. The most prominent feature of the designs made with composites is the high specific strengths of the manufactured parts compared to pure materials. For these reasons, it is very important to investigate the long-term mechanical properties of polymer matrix composites. It is important to inform us about deformation when the material is exposed to the stress, and the shear stress is defined as the applied force in parallel with the unit field. The large value of the shear modulus indicates that the material behaves stiffer. Large shear stress causes a relatively small strain. On soft materials, a large shear stress causes a great strain. As can be seen, the shear stress is inversely proportional to the strain. The aim of the study is to application of artificial neural network approach to carbon/epoxy laminate composites and to investigate the properties of the composites.

## 2. Materials and Methods

In this study, the influence of reinforcement type and rate on the shear modulus of carbon/epoxy and kevlar/epoxy was investigated theoretically [10-13]. Table 1 shows the process parameters and Table 2 shows the minimum and maximum values of experimental parameters.

**Table 1.** Process parameters

| | **Carbon** | **Kevlar** |
|---|---|---|
| **Density (g/m$^2$)** | 200 | 173 |
| **Resin/Hardener** | 5/2 | 5/2 |
| **Press (MPa)** | 0.3 | 0.3 |
| **Temperature (ºC)** | 80 | 80 |
| **Time (h)** | 1 | 1 |

**Table 2.** Minimum and maximum values of experimental parameters

| | **Epoxyi (%)** | **ASS (%)** | **SiC (%)** |
|---|---|---|---|
| **Minimun** | 0 | 0 | 0 |
| **Maximum** | 100 | 20 | 20 |

Data were normalized ranges 0.05 and 0.95 using Eq.1

$$\Theta = 0.9x((V-V_{min})/(V_{mak}-V_{min}))+0.05 \quad (1)$$

where V is the variables used, $V_{max}$ and $V_{min}$ are the maximum and minimum values of the variables, respectively. Train and test sets were used. The system was trained and tested using input and test data, respectively. The performance and error ratio of the system were determined using correlation coefficient (R), mean squared error (MSE) and mean absolute error (MAE).

Sistemin performansı hata değerlendirme kriterleri kullanılarak belirlenmiştir. 6 neurons in one hidden layer was used.

## 3. Results and Discussion

Figures 1 and 2 illustrate the normalized train and test set results. SM and SM Output represent the experimental and theoretical results. Table 3 provides the system performance criteria. It is clear that the results are in compliance.

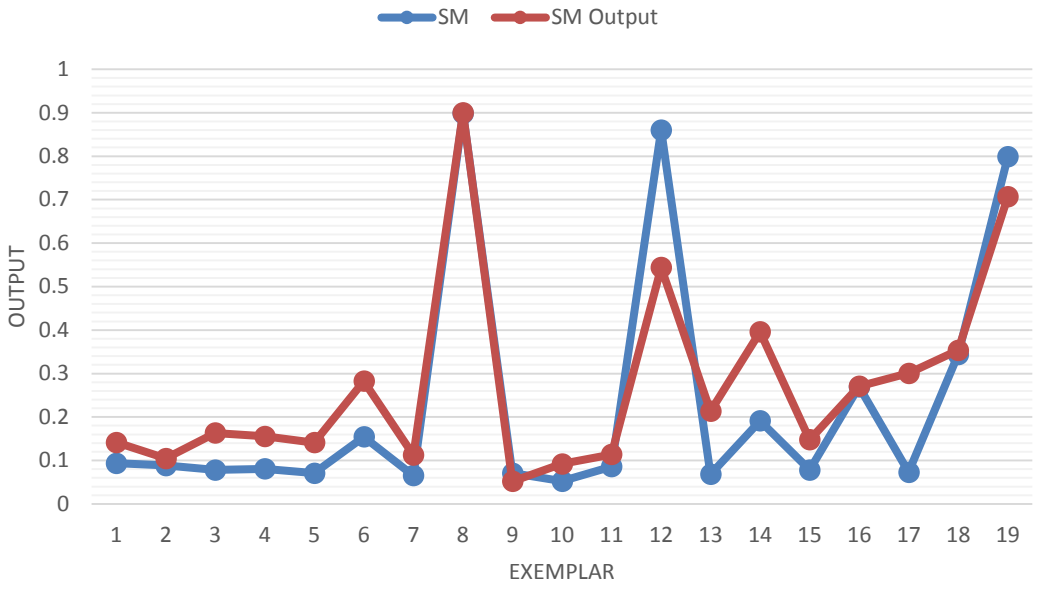


**Figure 1.** Training test result

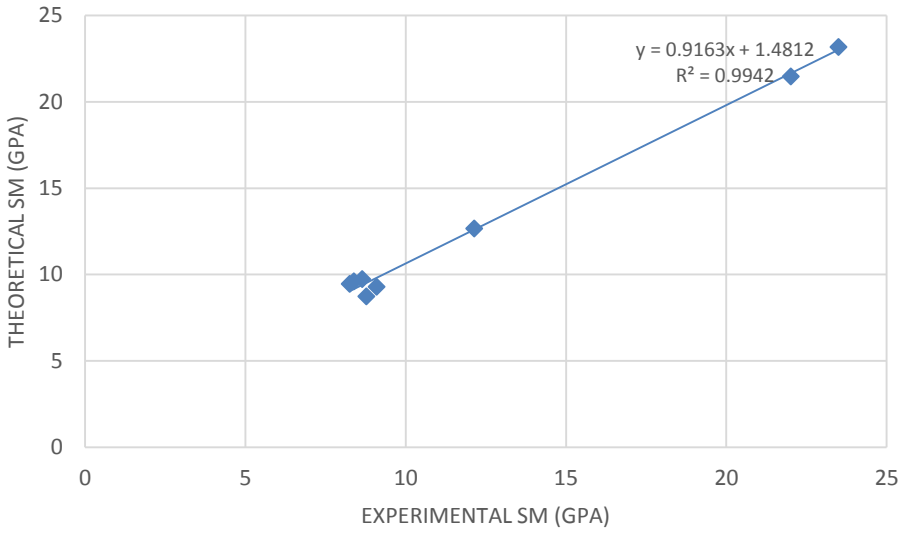


**Figure 2.** Test set result

**Table 3.** System statistical parameter

| | MSE | R | MAE |
|---|---|---|---|
| **Train** | 0.014193 | 0.925995 | 0.085383 |
| **Test** | 0.002124 | 0.99707 | 0.03795 |

The error and acceptance rates in the training test data were found to be higher than the test data. The correlation values of both sets are very high and are in compliance with each other. The MSE and MAE values in train and test are 0.014193 and 0.085383, and 0.002124 and 0.03795, respectively. The performance

of the system can be fully accepted. The $R^2$ value in the test sets for this model architecture is 0.9942, which indicates that the performances of the model is significantly high and reliable. Figure 3 and 4 show the effect of Ssa/SiC ratio on the shear modulus of carbon/epoxy and kevlar/epoxy composites.

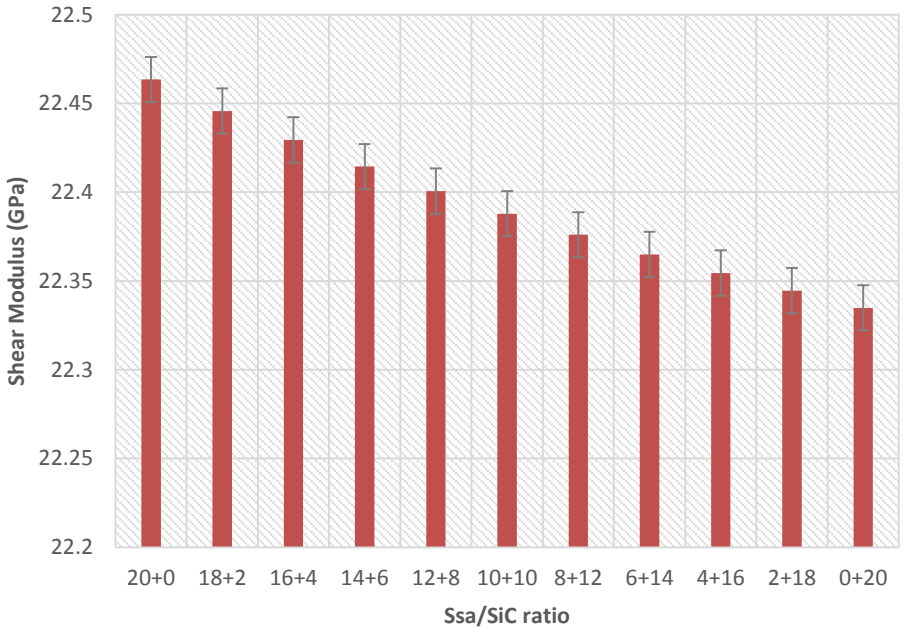


**Figure 3.** Carbon/epoxy composite

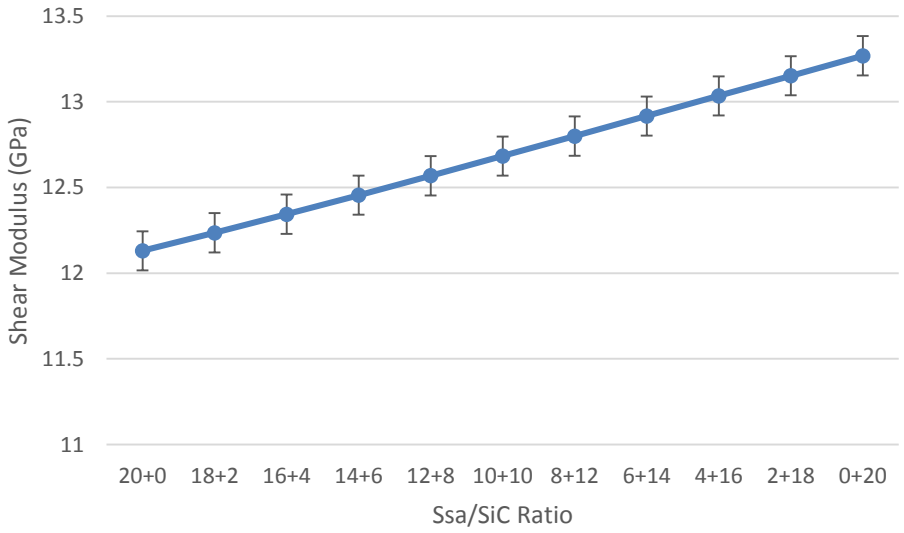


**Figure 4.** Kevlar/epoxy composite

The increase in SiC content causes the decreasing of shear modulus of carbon/epoxy composites but it induces and the shear modulus of kevlar/epoxy composites. The changes can be attributed to interaction of SiC with matrix, interfacial relations and agglomeration of particle [11].

## 4. Conclusions

• In this work, the effect of Ssa/SiC ratio on the shear modulus of carbon/epoxy and Kevlar/epoxy composites was theoretically investigated.
• As a result of the training test, it was seen that the learning capacity ratio of the system was within acceptable limits.
• As a result of the test set, the prediction rate of the system was found to be quite high.
• It was seen that the shear modulus of kevlar/epoxy composites increased due to the increasing SiC content. However, the increasing of SiC content causes the decreasing of shear modulus of carbon/epoxy composites
• It was noted that the artificial neural network approach was a good approach to theoretical analysis of empirical studies, and a good approach to be used in preventing data, such as time, energy and materials.

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