



rates were used to train the ANN model. The model was developed using MATLAB 7.0. The input layer or the independent variables are weight fraction of  $\text{Si}_3\text{N}_4$ , load and sliding velocity. The output layer or the dependent layer is the co-efficient of friction and wear rates of the composites. The input neurons receive the input from the environment with the output neurons sending out outputs out of the system. The performance of the adopted ANN model was improved by training and testing. The sorted experimental data was then divided in 50:50 ratio so that 55 data sets were chosen for the training the network while the remaining 55 data sets were used for testing the generalization of the trained network. The number of hidden layers, the number of neurons in each layer and the transfer function of each layer of the adopted network plays a very important role in determining the functionality and generalization capability of the network. In this regard the present work has adopted a network consisting of two input neurons and five hidden neurons and one output neuron (2:5:1) for prediction of co-efficient of friction and wear rates of the composites.

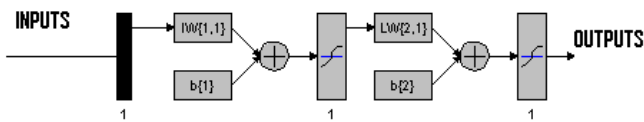


Figure 1: Schematic model of the adopted ANN

### 3. Results and Discussion

Coefficient of friction

Effect of reinforcement

The coefficient of friction decreases with increase content of  $\text{Si}_3\text{N}_4$  in the composites due to its good lubricating property as shown in Fig.2.  $\text{Si}_3\text{N}_4$  reacts with the moisture present in the environment and forms a stable oxide film. The formation of oxide film has been confirmed in our earlier works [5]. The predicted values are in close agreement with the experimentally measured values. The minimum and the maximum errors were observed to be in the range of 2%-5% respectively.

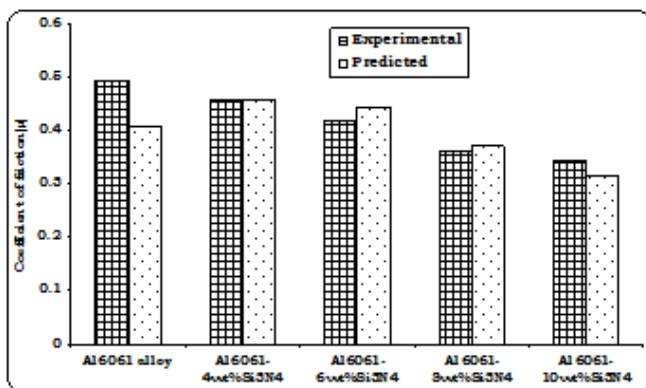


Figure 2: Comparison plot for experimental and predicted values of COF for varying weight fraction of  $\text{Si}_3\text{N}_4$

Effect of load

The performance of neural network in comparison with the experimentally measured values of coefficient of friction with

change in load is shown in Fig.3. It is observed that the increase in load results in the decrease of COF of both composites and alloy. The COF tends to decrease more in case of composites compared to that of alloy.

This can be attributed to higher extent of squeezing out of  $\text{Si}_3\text{N}_4$  from the composite with increased load leading to larger extent of tribofilm formation resulting in lowering of COF at higher loads. The error between the predicted and experimental values of COF with increase in load ranges between 1%-7%.

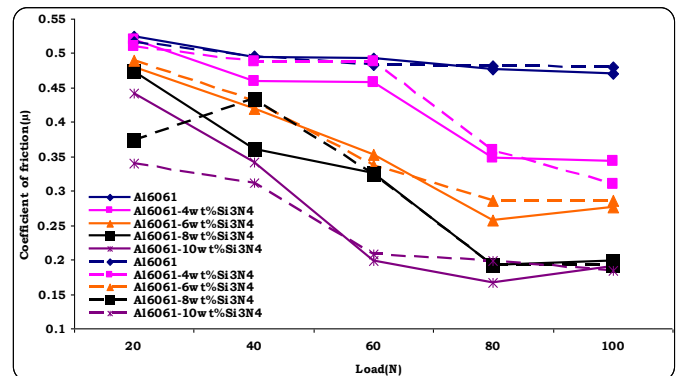


Figure 3: Comparison plot for experimental and predicted values of COF for varying loads

Effect of Sliding Velocity

Fig.4 shows the ANN values and experimental values of COF with increased sliding velocities for both matrix alloy and its composites. The minimum and maximum errors were 1% and 13% respectively. The increase in the sliding velocity results in the increase in the surface temperature and beneficial oxides that are formed gets fragmented at higher sliding velocities. This leads to higher probability of the contact of fresh surfaces during sliding which results in higher coefficient of friction.

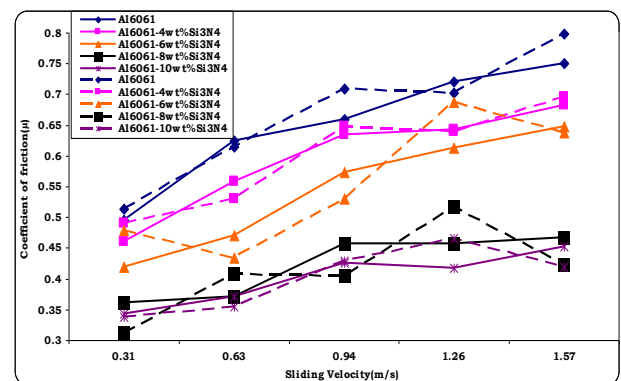


Figure 4: Comparison plot for experimental & predicted values of COF for varying sliding velocity

Wear Rate

Effect of reinforcement

There is a decrease in the wear rates of the composite with increase content of  $\text{Si}_3\text{N}_4$  as shown in Fig.5. This can be attributed to the improved mechanical properties such as

hardness and strength of the composites as discussed in our earlier works [5], improved hardness and strength results in lesser extent of plastic deformation of the composites during the sliding process leading to lesser material removal.

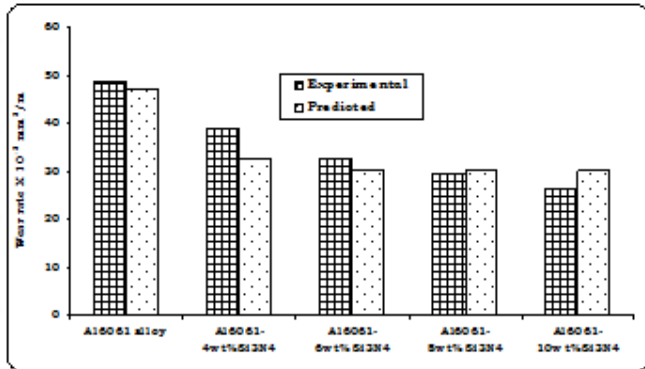


Figure 5: Variation of wear rates of matrix alloy and its composites

Effect of load

The superior wear behavior can also be attributed to the uniform distribution of Si<sub>3</sub>N<sub>4</sub> particles within the matrix alloy as shown in Fig.6. The predicted wear rates from the developed ANN matches closely with the experimental ones. The minimum and maximum error is in the range of 2%-15%. Fig.7 shows the effect of load on wear rates of matrix alloy and its composites. It is observed that the wear rate increases with load linearly up to 40N for both the matrix alloy and the composites. However, at loads higher than 40N the wear rates of matrix alloy is significantly higher compared with the composites. Increased load leads to higher extent of plastic deformation at the sliding surfaces and sub surfaces leading to initiation of cracking and eventually resulting in larger material removal and hence higher wear rate at high loads. The predicted wear rates from the developed ANN matches closely with the experimental ones. The error range is 1%-9%.

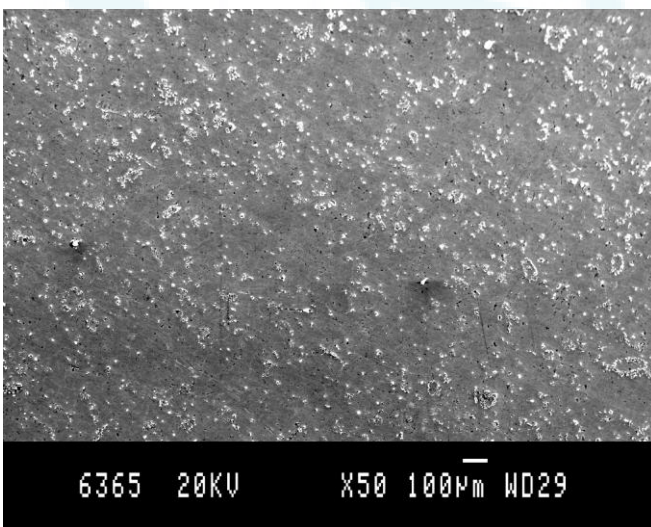


Figure 6: SEM photograph of Al6061- 10wt% Si<sub>3</sub>N<sub>4</sub> composite

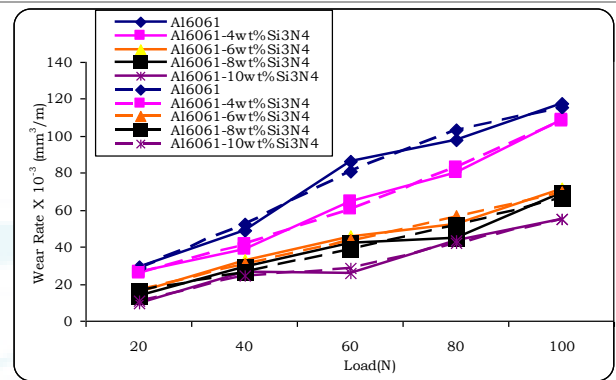


Figure 7: Variation of wear rates of matrix alloy and its composites with load

Effect of Sliding Velocity

The variation of wear rates with sliding velocity is shown in Fig.8. It is observed that for the matrix alloy there is a linear increase in wear rates with increase in sliding velocity up to 0.944 beyond which a steep rise in the wear rates are observed this can be attributed to the fact that higher sliding velocities the surface temperatures during the sliding process increases leading to softening of the sliding surfaces which in turn leads to larger extent of plastic deformation and there is a possibility of gouging of softened surfaces. This phenomenon will result in larger material removal. At all the sliding velocities composites exhibits lower wear rates when compared with the matrix alloy. The predicted wear rates from the developed ANN matches closely with the experimental ones. The error range is 1.5%-8%.

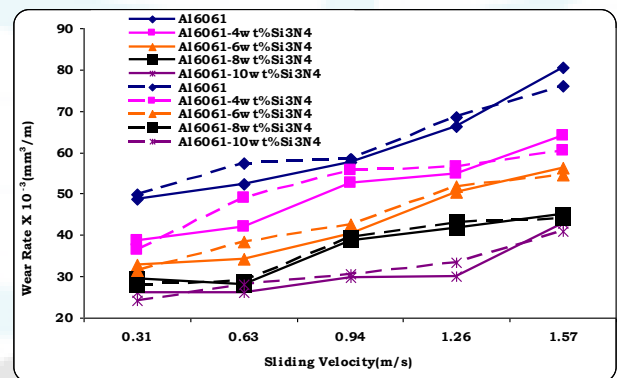


Figure 8: Variation of wear rates of matrix alloy and its composites with sliding velocity

4. Future Scopes

More different percentages of Si<sub>3</sub>N<sub>4</sub> with Al6061 can be used to find their co-efficient of friction, wear rate of matrix alloy and sliding distance at different loads and velocities.

5. Conclusions

ANN predicted values of coefficient of friction and wear rates of Al6061 and Al6061-Si<sub>3</sub>N<sub>4</sub> composites under all the sliding conditions studied agrees very closely with the experimental data.

## References

- [1] K. Genel, S.C. Kurnaz, M. Durman *Modeling of tribological properties of alumina fibre reinforced Zinc–Al composites using ANN*, Material Science and Engineering Vol. A 363 (2003) p. 203
- [2] Necat Altinkok, Rasit Koker *Modeling of the prediction of tensile and density properties in particle reinforced MMCs by using Neural Networks*, Materials Design Vol. 11 (2005) p. 1005
- [3] S.H.M. Anijdan, H.R. Madaah-Hosseini, A. Bahrami *Flow stress optimization for 304 stainless steel under cold and warm compression by ANN by genetic algorithm*, Materials and Design Vol. 28 (2) (2007) p. 609.
- [4] C.S. Ramesh, R. Keshavamurthy, B.H. Channabasappa and Abrar Ahmed *Material Science and Engineering: A, Microstructure and Mechanical Properties of Ni-P Coated Si<sub>3</sub>N<sub>4</sub> reinforced Al6061 composites* Vol. 502 (1-2) (2009) p. 99
- [5] S.K. Jagadeesh, C.S. Ramesh, J.M. Mallikarjuna, R.Keshavamurthy *Prediction of cooling curves during solidification of Al 6061-SiCp based metal matrix composites using finite element analysis*, Journal of Materials Processing Technology Vol. 210 (2010) p. 618

## Author Profile



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