CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

An efficient MLP based NN model for polymeric composites fatigue life prediction under variable amplitude loading has been developed. The NN model was developed by utilizing Bayesian regularization scheme incorporated within the Levenberg-Marquardt algorithm. The NN model predicted the fatigue life of the composites with reasonable and comparable accuracy level. Although only two stress ratios were used in the training set, the NN model developed was able to generalize well and gave reasonably accurate fatigue life prediction under a wide range of stress ratio values. The reliability and accuracy of the NN prediction were quantified by a small MSE value, lower than that achieved by similar work in the past.

Employing ten hidden nodes, for Materials I and II, the best prediction results were achieved by utilizing training sets of 0.1 and -2, and 0.1 and 10, respectively. The corresponding MSE values obtained are 0.11 and 0.19, respectively for Materials I and II. For Material III, by utilizing training set of 0.1 and -0.1, the MSE value for the simulated fatigue data was 0.13. In general, the fatigue lives as predicted by the NN model were consistent with those obtained from the experiments.

Moreover, it is observed that the best prediction results were achieved when using training set with position of the R values far separated in the CLD region, namely training set of 0.1 and -2 for Material I and of 0.1 and 10 for Material II. In addition, the training set of 0.1 and 10 is considered as special, because the stress ratios contained in the training set have symmetrical position in the CLD region. The strategic position of the stress ratios may have provided the best distribution of the fatigue information which in turn resulted in the best prediction results among the other training sets.

Sensitivity analysis carried out in a range of 2 and 30 hidden nodes revealed that the optimum number of hidden nodes for Material I, II and III was 15, 6 and 30, respectively. As the number of hidden nodes used in the current NN model was not the optimum, the reliability and accuracy in the fatigue life prediction may well be improved further. The corresponding optimum MSE values were 0.108, 0.185 and 0.117.

It can be concluded that the NN model developed provides an efficient approach for predicting fatigue life of composite materials for several stress ratio conditions with limited fatigue data for training and offers great benefit in saving time for fatigue life assessment under variable amplitude loading.

6.2 Recommendations

Further confirmation and validation to other composite materials need to be done, such as other polymeric matrix composites, ceramix matrix or carbon-carbon composites. The fatigue behaviour of the composites should be different with the one of polymeric matrix composites studied here. It is interesting for further observation and study.

In addition, for Material II based on the high values of the coefficient r^2 for each testing set, the use of 10 fatigue data as the training examples could be considered as sufficient for the NN model prediction. However, this still needs further confirmation and examination for other types of composites. Moreover, it will be valuable to find the sufficient training data set for various types of composites in relation to the full utilization of fatigue data available.

Care has to be done to control the fatigue testing conditions to be as nearly identical as possible to avoid unnecessary inaccuracies to the fatigue life obtained. The unexpected scatter of fatigue life due to such inaccuracies then could be avoided.

Finally, there are criticisms saying that NN is still a black-box. It should not be an impediment for future work to benefit from the utilization of the NN models. NN models are effective when analyzing complex structures which are commonly found in data, such as non-linearities and interactions.