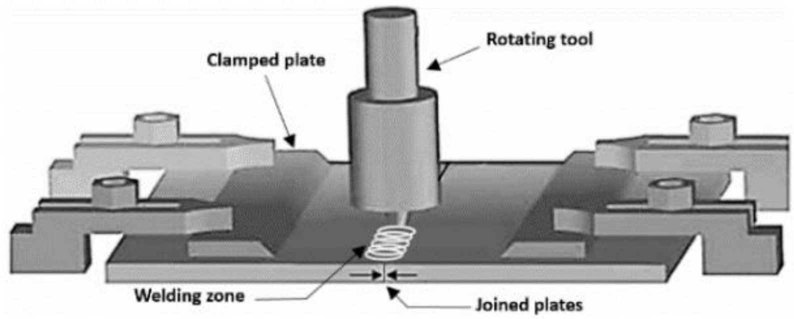

Figure 4. The position of the clamps fixed relative to the surface of the sheet.

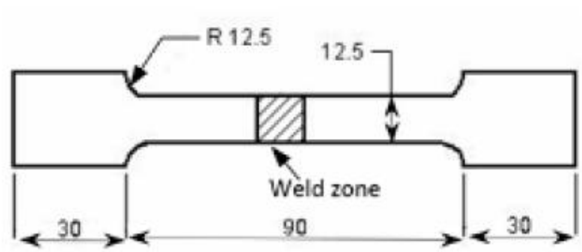

Figure 5. Dimensions of flat tensile specimen.

Table 1. Combination of governing parameter and the of tensile test measurement

Rotation speed (Rpm)	Travel speed (mm/s)	Tensile Strength (MPa)			Mean Tensile Strength (MPa)
		1rst Specimen	2nd Specimen	3rd Specimen	
350	0.80	149.2	149.3	148.2	148.9
350	1.42	169.4	169.3	169.3	170.0
350	2.38	167.1	169.8	169.8	169.0
350	3.33	187.7	189.9	189.9	188.7
350	4.55	190.6	191.0	191.0	188.9
650	0.80	142.7	150.7	152.0	148.5
650	1.42	174.0	175.6	175.7	175.1
650	2.38	194.5	192.5	192.8	193.3
650	3.33	189.8	188.5	188.5	188.9
650	4.55	196.4	196.3	198.7	197.2
950	0.80	135.0	144.1	143.0	140.7
950	1.42	166.2	167.7	161.0	165.0
950	2.38	172.9	191.8	182.5	182.4
950	3.33	187.8	181.1	178.8	182.6
950	4.55	204.5	209.3	207.2	207.0
1400	0.80	168.2	172.6	164.5	168.4
1400	1.42	59.6	70.5	67.3	65.8
1400	2.38	110.3	108.4	100.5	106.4
1400	3.33	143.6	145.4	153.7	147.6
1400	4.55	30.6	27.1	30.3	29.3

4. Model Development and Discussion

The purpose of this research is to propose a prediction model based on artificial neural network technique in predicting mechanical character of FSW welding structure that focuses on tensile strength. Chosen parameter will be considered as an input that will be included in the proposed network model. This network model is packed of several neurons arranged in different layers which are also connected through variable weight. This weight is calculated with iterative method during training process, when network is given a large amount of data for training as bait and when there is input and output matches representing pattern to be modelled.

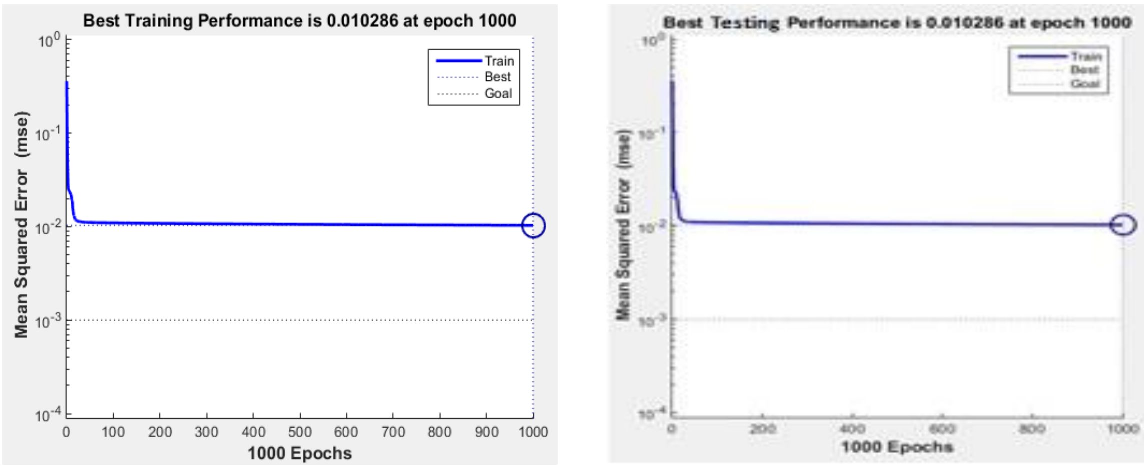

Figure 6. Performance analysis of trained and tested networks.

In this research, BP Algorithm (backpropagation) is used with 2 hidden layers. MATLAB platform is used to train and test proposed ANNs model. In the training, 20 neurons are installed in the first hidden layer and similarly 1 neuron in the second hidden layer which will be used to improve output accuracy. The first ANNs layer is related to the process parameter like rotational speed of FSW tool and travel speed of FSW tool. After training network, testing was conducted by using known testing data. Model of Artificial Neural Network explained in this research is used to predict tensile strength from the welded structure. Statistical method is used to compare results from network and to increase output accuracy. The first layer of ANNs network is aligned with the chosen process parameter which are rotational speed and travel speed of FSW tool. After training network, testing network was conducted using known testing data. ANN's model explained in this research is used to predict FSW tensile strength through training process. Statistical method is used to compare results from network.

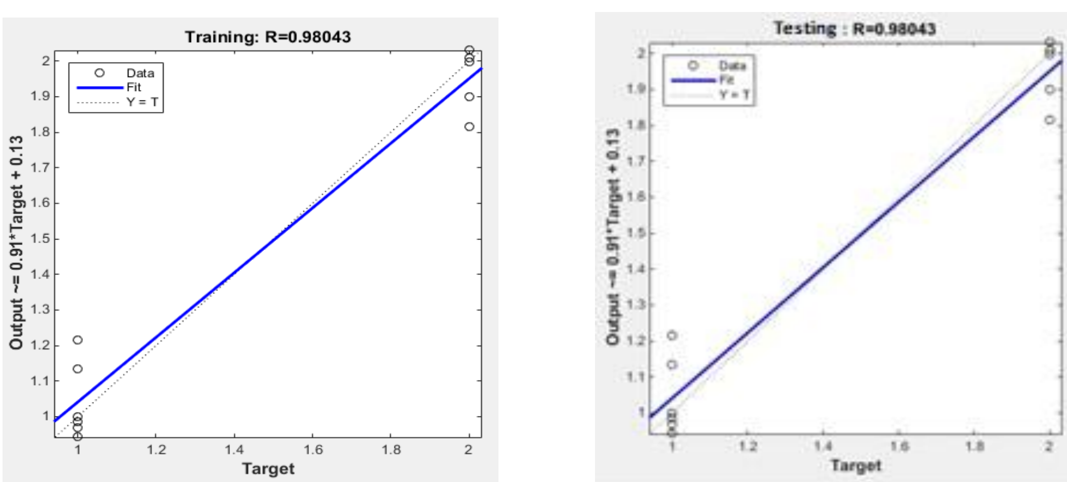

Figure 7. Regression analysis of trained and tested networks.

As shown by figure 6, the final mean-square error is small. Both training and testing network with their linear regression between output network and corresponding target show similar graph. The figure shows that the Mean Square Error (MSE) of ANNs model declines. Well trained ANNs have to have very low MSE at the end of the training which, in this research, equals to 0.010286. This result shows that the MSE is very small (close to zero) where desired ANNs output and resulting ANNs output for the training set are close.

According to the result obtained from the regression graphs of training and testing (Figure 7), the best fit of linear regression line between output and target shows the right linear relationship when compared with the dash line of ideal result. This is based on the R value that is equal to 0.9 or very close to 1 which indicates a good fit.

5. Conclusion

In this research, Artificial Neural Network (ANNs) is used to predict FSW welding parameter in Aluminum 6061-T6 alloy. Rotational speed and travel speed tools are considered to be ANN's model inputs. An effective parameter from the FSW process for tensile strength is modelled. MSE value from training and testing is 0.010286 or very small (close to zero) which means that the desired output and ANN's output for training set and testing become very close to each other. On the other hand, results derived from the regression graphs of training and testing show that the linear regression line between output and target compared to dash line of perfect result (ideal condition) have the right linear relationship where the R value equals to 0.9 or very close to 1. This shows a good fit.

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