ANN Based Modeling for Performance and Exhaust Emission of DI Diesel Engine using Emulsified Diesel Fuel

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Abstract

The aim of this work was to study the artificial neural network (ANN) modeling of a direct diesel engine using emulsified diesel fuel to predict the performance and emission of compression ignition engine. In the model 70% of the experimental data are used for training the network and 30% for prediction and validation. Different percentages of load and diesel-ethanol blend are fed into the input layer of the ANN which contains 2 neurons. It is concluded that R2 values in this model are very nearer to 1 and mean relative error (MRE) are found to be within the acceptable range. This shows good correlation between the experimental and ANN predicted values.

Keywords: Diesel engine, Emulsified fuel, ANN, Emissions

1. Introduction

Diesel engines have higher thermal efficiency, specific power output with high fuel economy and are more efficient than gasoline engine. The major pollutants emitted from compression ignition engine are oxides of nitrogen (NO_x) carbon monoxide (CO), carbon dioxide (CO_2) and particulate matter. (Jamil Ghojel and Damon Honnery, 2006; Mohaminadi et al., 2005; Ajav et al., 1999).

Ethanol is immiscible with diesel fuel because of the prevailing wax content, water content, hydrocarbon composition and high range of temperature of the diesel fuel. (Lincy and Wang, 2003; Letcher, 1983).

Najafi et al (2009) used ANN to predict the engine performance and emission. A standard back-propagation algorithm for the engine was used in this model. It was found that there was a better correlation between the simulations from ANN and the measured values.

Rajasekar et al (2010) used ANN for the prediction of engine performance and emission characteristics of diesel engine. They identified that the performance and emission of diesel engine fuelled with biodiesel have been predicted using the ANN model.

Shanmugam et al (2011) analyzed ANN modeling to predict the performance and exhaust emissions of the diesel engine using hybrid fuel blend They reported that correlation co-efficient was in the range is very low and a least RMS error.

2. Modeling with ANN

An artificial neural network (ANN) based model was developed to predict the performance and emission characteristics of the diesel engine for the best surfactant. The test results are evaluated with respect to performance and emission characteristics of regression co-efficient (R2) and mean relative error (MRE) values for training and testing data. Based on biological neural networks, the ANN technique is a mathematical or computational model. An ANN has been developed for diesel- ethanol blends in diesel engines using the available data in test runs. In the model 70% of the experimental data are used for training the network and 30% for prediction and validation. Different percentages of load and diesel-ethanol blend are fed into the input layer of the ANN which contains 2 neurons. The architecture of the ANN for the diesel engine is schematically shown in Figure 1.

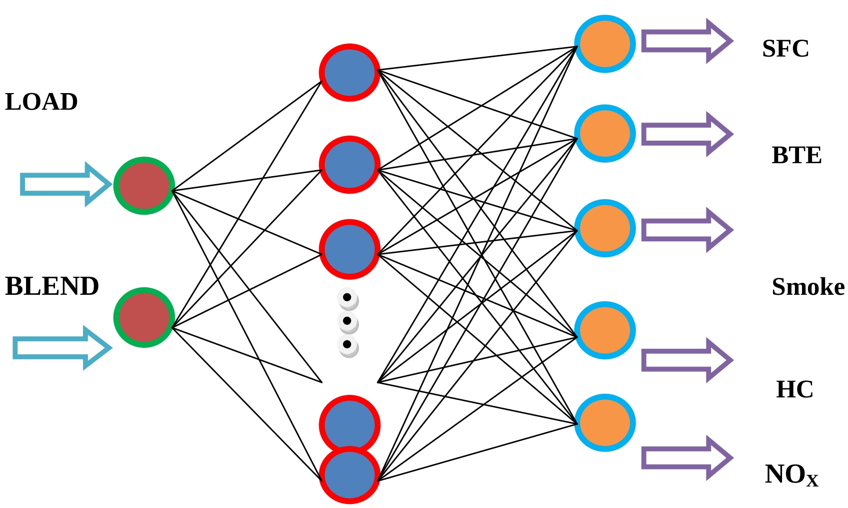


Figure 1. Architecture of the ANN

3. Results and Discussion

3.1 Performance Analysis of ANN

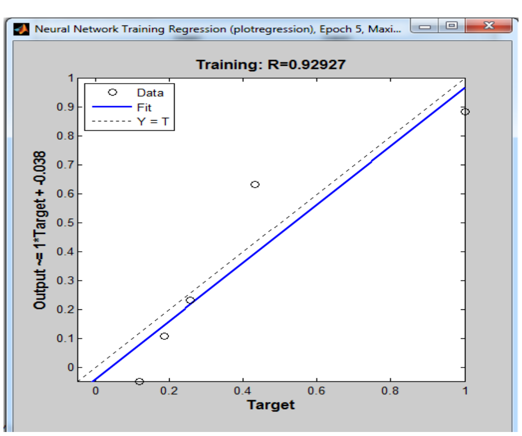
The MRE and the regression coefficient were done by the trained network for the trained and test data. Table 1 shows the statistical values for the training and test data. For the testing data, the R^2 values are 0.999 and 0.740 for brake thermal efficiency (BTE) and specific fuel consumption (SFC) respectively, which are nearer to unity. The MRE values are 2.68 and 2.676% for BTE and SFC. For the training data R^2 values are 0.872 and 0.929 and the MRE values for BTE and SFC are 8.39 and 1.74, respectively. It is within the acceptable limits. This shows good correlation between the experimental and ANN predicted values. The trained outputs and measured values for SFC, BTE, smoke, HC and NO_X were given in Figure 2.

3.2 Emission Analysis of ANN

For the testing data, the R^2 values are 0.984, 0998 and 0.991 for smoke, oxides of nitrogen (NO_X) and hydrocarbon (HC) respectively, which are nearer to unity. The MRE values are 9.8, 6.32 and 5.22% for smoke, oxides of nitrogen (NO_X) and hydrocarbon (HC) respectively. For the training data R^2 values are 0.857, 0.981and 0.948 respectively and the MRE values for smoke, oxides of nitrogen (NO_X) and hydrocarbon (HC) are 7.11, 2.417 and 5.98 respectively. It is within the acceptable limits. This shows good correlation between the experimental and ANN predicted values. The mean squared error plot for SFC, BTE, smoke, HC and NO_X are given in Figure 3. The experimental and ANN predicted values for SFC, BTE, smoke, HC and NO_X are given in Figure 4.

Table 1. Statistical values of ANN predictions

Output	Testing		Training	
	R^2	MRE %	R^2	MRE %
BTE	0.999	2.68	0.872	8.39
SFC	0.740	2.676	0.929	1.74
Smoke	0.984	9.8	0.8578	7.11
NO_X	0.998	6.32	0.981	2.417
HC	0.991	5.22	0.948	5.98



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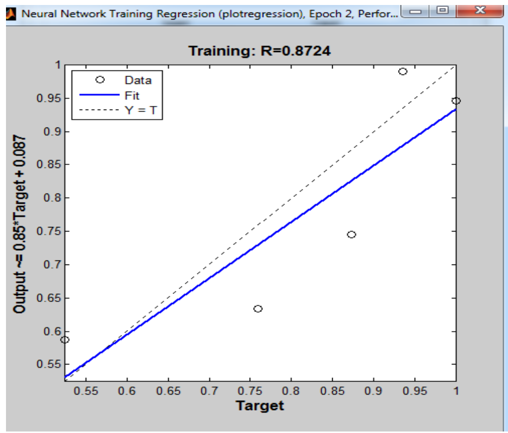

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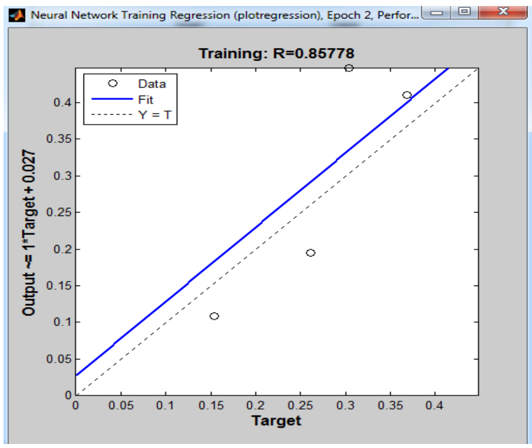

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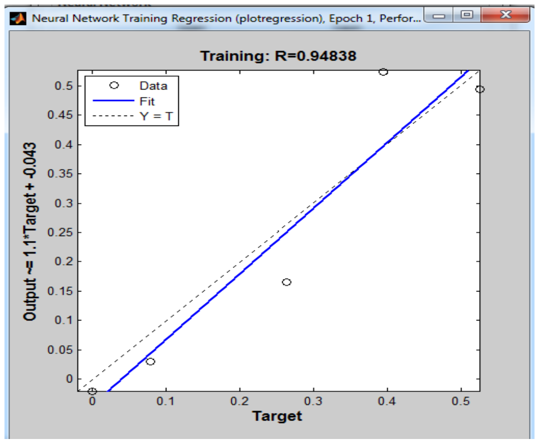

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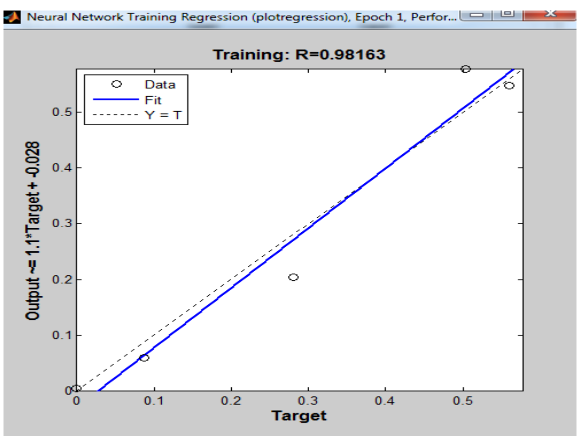

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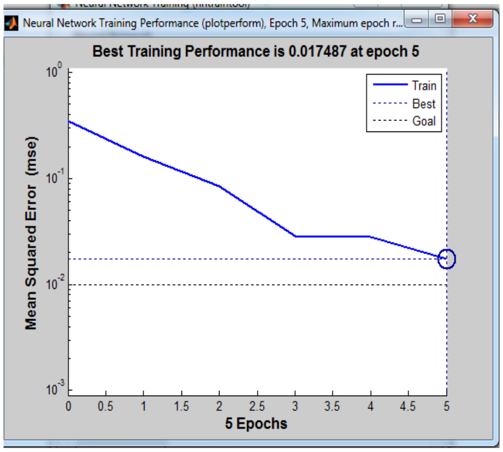
Figure 2.Trained output vs measured values of (a) SFC, (b) BTE, (c) smoke, (d) HC and (e) NO_X



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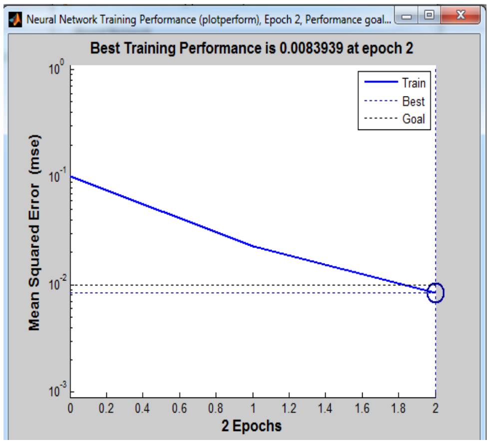

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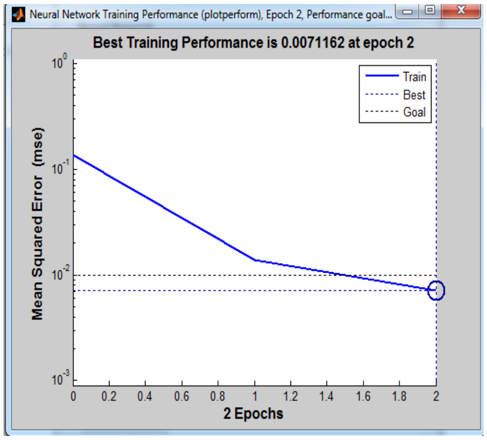

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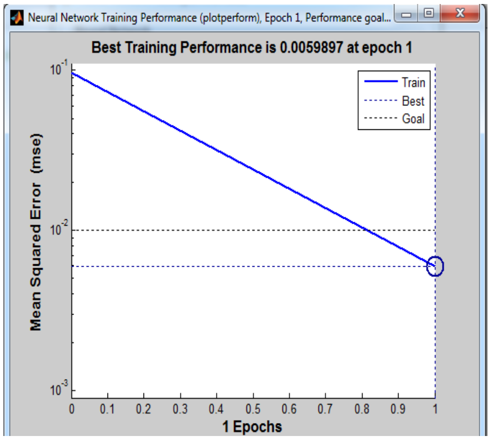
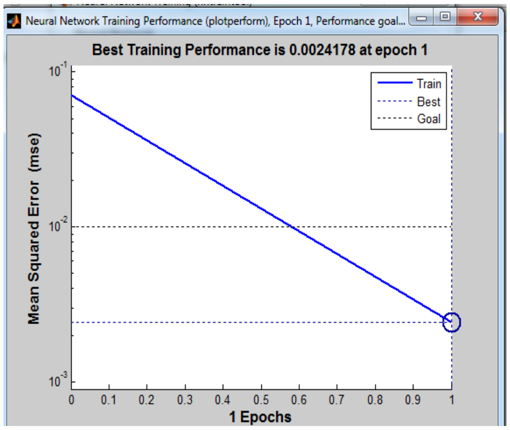


(d)



(e)

Figure 3. Mean squared error plot for (a) SFC, (b) BTE, (c) smoke, (d) HC and (e) NO_X

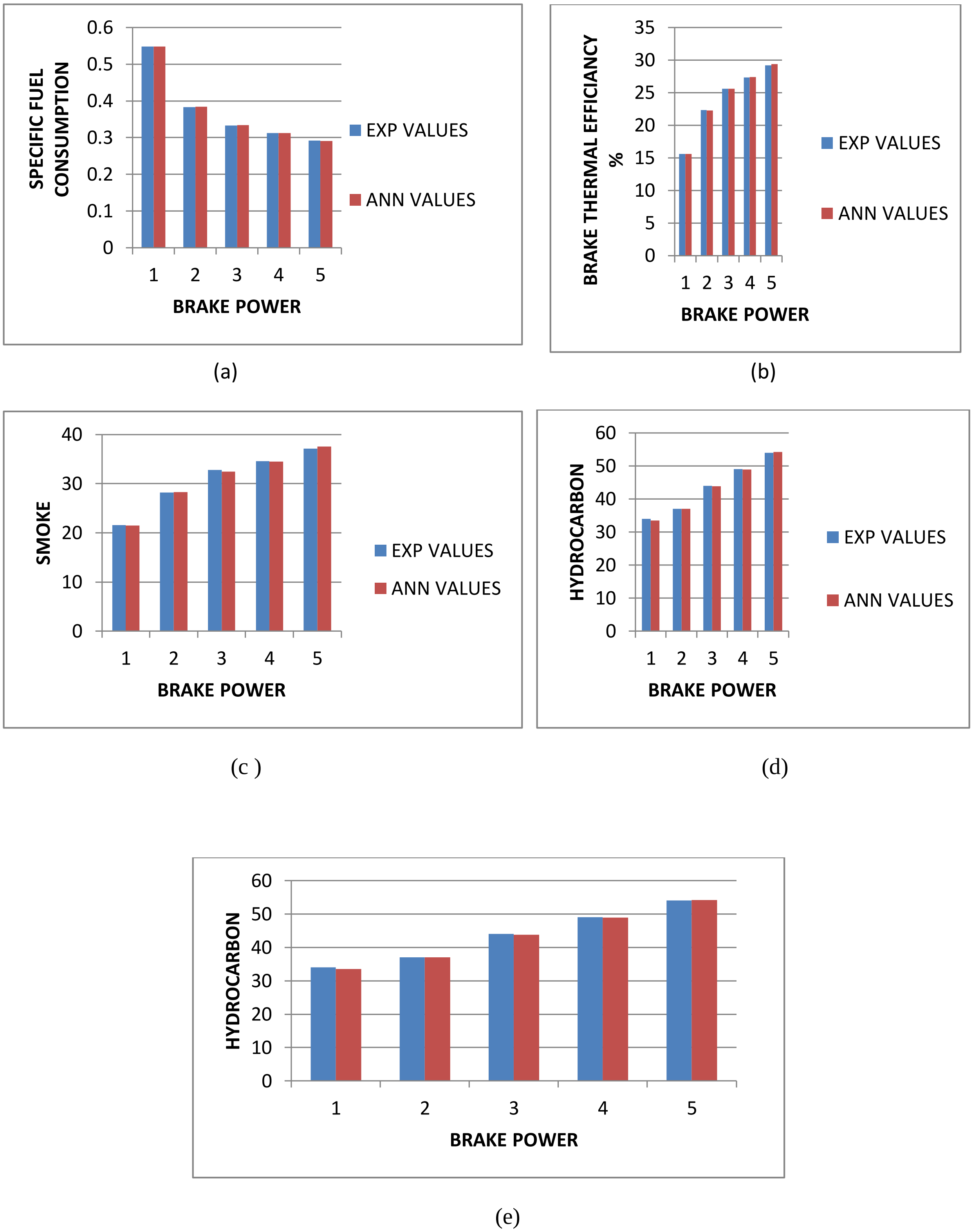


Figure 4. **Experimental and ANN predicted values of (a) SFC, (b) BTE, (c) smoke, (d) HC and (e) NO_X**

4. Conclusion

- In this model, training data correlation co-efficient (R2) and mean relative error (MRE) of performance are in the range of 0.872-0.929 and 1.74-8.39%, respectively.
- In this model, training data correlation co-efficient (R2) and mean relative error (MRE) of emissions are in the range of 0.857-0.981 and 2.41-7.11%, respectively.
- For testing data, the correlation co-efficient (R2) and mean relative error (MRE) of performance are in the range of 0.74-0.999 and 2.67-2.68%, respectively.
- For testing data, the correlation co-efficient (R2) and mean relative error (MRE) of emissions are in the range of 0.984-0.998 and 5.22-9.8%, respectively.
- It is concluded that R2 values in this model are very nearer to unity and mean relative error (MRE) are found to be within the acceptable limits. This shows good correlation between the experimental and ANN predicted values.

References

1. Jamil Ghojel, R., and H. Damon, 2005. Heat role model for the combustion of diesel oil emulsions DI diesel engines. Journal of Applied Thermal Engineering, 25: 2022-2028.
2. Mohammadi Aishiyama, J., T. Kakuta, and S. S. Kee, 2005. Fuel injection strategy for clean diesel engine using ethanol blended diesel fuel. SAE Technical Paper, 2005- 01-1725.
3. Lincy, R., Wang, K. H., 2003. The fuel Properties of three phases emulsion as an alternative fuel for diesel engine. Fuel, 82: 1367-1375.
4. Najafi, G, Ghobadian, B, Tavakoli, T, Butts Worth, DR,Yusaf, TF & Faizollahnejad, M 2009, ‘Performance and exhaust emissions of a gasoline engine with ethanol blended gasoline fuels using artificial neural network’, Applied Energy, vol. 86, pp. 630-639.
5. Rajasekar, E, Baskar, G & Nedunchezhian, N 2010, ‘Prediction of performance and emission characteristics of diesel engine fuelled with biodiesel using ANN’, International Journal of Computational Intelligence Research, vol. 6, no. 4, pp. 515-526.
6. Shanmugam, P, Sivakumar, V, Murugesan, A & Ilangkumaran, M 2011, ‘Performance and exhaust emissions of a diesel engine using hybrid fuel with an artificial neural network’, Energy Sources Part A, vol. 33, pp. 1440-1450.

7. Parthasarathi, R, Gowri, S & Saravanan, CG 2014, 'Effects of ethanol-diesel emulsions on the performance, combustion and emission characteristics of DI diesel engine', American Journal of Applied Sciences, vol. 4, no. 11, pp. 592-600.
8. Parthasarathi, R, Gowri, S & Saravanan, CG 2014, 'Experimental investigation on DI diesel engine fueled with diesel-ethanol emulsions', Research Journal of Applied Sciences, Engineering and Technology, vol. 11, no. 7, pp. 2394-2399.
9. Parthasarathi, R, Gowri, S & Saravanan, CG 2012, 'Experimental investigation of performance, emission and combustion characteristics of kirloskar TV-I di diesel engine using diesel-ethanol-surfactant as fuel', ARPN Journal of Engineering and Applied Sciences, vol.7, no. 11, pp. 1468-1472.
10. Parthasarathi, R, Gowri, S & Saravanan, CG 2012, 'Experimental study of performance, emission and combustion characteristics of a constant speed TV-I kirloskar direct injection diesel engine using emulsified diesel fuel', European Journal of Scientific Research, vol. 93, no. 3, pp.414-421.
11. Parthasarathi, R & Saravanan, CG 2016, 'Experimental investigation of performance, emission and combustion characteristics of a constant speed TVI kirloskar DI diesel engine using emulsified diesel fuel', IJAET, vol.VII/issue III, pp. 83-87.
12. Parthasarathi, R, V. Nirmal Kannan, Gopikrishnan.T, 2017, FEA models and experimental results of 3D printing process for fabricating a mini robot, Indian journal of science and research,vol 17(2), pp. 135-140 (UGC Approved).