PREDICTION OF PERFORMANCE PARAMETERS IN C. I. ENGINE FOR BLENDING OF JATROPHA BIODIESEL AND DIESEL FUEL

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Abstract: The world is getting modernized and industrialized day by day, as result vehicles and engines are increasing. But energy resources used in these engines are limited and decreasing gradually. Jatropha biodiesel (JBD) has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. Jatropha biodiesel engine is important as they significantly affect it performance and emissions. This paper investigates the performance parameters of CI engine with varying load condition (0%,20%, 40%, 60%, 80% and 100% load) for diesel and jatropha biodiesel blending fuel. Blending selected as JBD0, JBD20, JBD40, JBD60, JBD80, and JBD100. Also this study deals with artificial neural network (ANN) modeling to predict the brake power, brake specific fuel consumption, brake thermal efficiency and smoke intensity of the engine. To obtain training and testing data, a number of experiments were performed with a single -cylinder, four-stroke CI engine operated at different engine load conditions. Using some of the experimental data training the ANN model which based on standard back propagation algorithm. Then, the predictions performance of the ANN was measured by comparing with the experimental results. Load, % of blending and fuel consumption have been used as input parameters, while brake power, brake specific fuel consumption, brake thermal efficiency and smoke intensity are output parameters. After training and testing the ANN, it was found that the RMS values are smaller for the tested data, so it was found that the developed ANN model is a powerful technique for predicting the selected output performance parameters of compression ignition engine.

Key Words: **C.I. engine, Jatropha biodiesel performance, ANN , Back propagation algorithm.**

1 INTRODUCTION

The requirement of energy increases due to industrialization and continuously growing population in the world. Therefore, developing and newly developing countries tend to the new energy sources to compensate their energy necessity. Currently, the main energy source of the motor vehicles is petroleum products. It is expected that the petroleum reserves will be consumed away in the near future. In addition, one of the main causes of air pollution in the cities is harmful emissions of the motor vehicles which are operated with petroleum products. As a result, a lot of researchers have started to search for cheap, renewable and environmentally friendly alternative fuels such as different type of biodiesel [1]. But number of researcher had found that the less emission produced when using the biodiesel as alternative fuel for compression ignition engine as comparative to petrol diesel fuel.

Biodiesels such as Jatropha, Karanja, Sunflower and Rapeseed are some of the popular biodiesels currently considered as substitute for diesel. When biodiesel is used as a substitute for diesel, it is highly essential to understand the parameters that affect the combustion phenomenon which will in turn have direct impact on thermal efficiency and emission. In the present energy scenario lot of efforts is being focused on improving the thermal efficiency of IC engines with reduction in emissions. [1-3]. Direct injection diesel engines occupy an important place in the developing countries since they power agricultural pumps, small power tillers, light surface transport vehicles and other machineries. The problem of increasing demand for high brake power and the fast depletion of the fuels demand severe controls on power and a high level of fuel economy. Many innovative technologies are developed to tackle these problems. Modification is required in the existing engine designs. Some optimization approach has to be followed so that the efficiency of the engine is not comprised. As far as the internal combustion engines are concerned the thermal efficiency and emission is the important parameters of the engine. For this purpose the operating performance parameters have to be optimized when using the biodiesel as fuel for compression ignition engine, because of the estimation of biodiesel performance of engine is non linear complex problem due to variations in chemical and thermodynamic properties of biodiesel fuels that affects the combustion process. Many researchers have carried out experiments to evaluate diesel engine for various biodiesel blends. But the experimental investigation is time consuming, tedious and costly that's why there is need of optimization technique. The most common optimization techniques used for engine analysis are response surface method, grey relational analysis [4], non linear regression [5], genetic algorithm [6], Taguchi method and artificial neural network. ANN technique has been popular for performance parameter optimization in design of experiments engine. In this study, the changes in engine performance have been observed by using jatropha biodiesel blending as fuel for C.I. engine without any modifications and the impact of the fuel on engine performance has been examined, and optimized selected input and output parameters of theengine. An ANN model was developed by considering the input parameter such as load, percentage blending of fuel, and fuel consumption, By this way, prediction of some output parameters such as brake power, B.S.F.C., thermal efficiency and smoke intensity. This research work analyses and models the experimental data of different 10 JBD biodiesels and their blends (up to JBD100) operated at varying operating load conditions. In this work, an artificial neural network based computing model is developed to estimate diesel engine performance parameters by training the ANN with available experimental data.

2. JATROPHA BIODIESEL

Jatropha curcas is unusual among tree crops is a renewable non-edible plant. From jatropha seeds jatropha oil can be extracted which have similar properties as diesel fuel. Jatropha biodiesel is derived from Jatropha curcas seeds and oils which is produced from transesterification process. Blending refers to the mixing of jatropha biodiesel with diesel fuel. It results in reducing the viscosity of the blends and increasing the cetane number. The blends can be directly used in diesel engines for better results. The use of 100% JBD oil was found to be possible with some minor modifications in the fuel system.
JBD10: A blend of 10% Jatropha biodiesel and 90 % of diesel fuel by volume.

3. EXPERIMENTAL TEST SET-UP

The Jatropha biodiesel blending (JBD) with diesel fuel is used as an alternative fuel to operate diesel engine in the Automotive Power Plant Laboratory of Department of Automobile Engineering, in Rajarambapu Institute of Technology Sakhrale.
The Performance test are conducted on a computerized single cylinder, four stroke, direct injection, water cooled diesel engine test rig. The engine directly connected to eddy current dynamometer for variable loading. First of all make all the electric supply switches 'ON' and check water supply connections to engine and dynamometer through rotameter. Make fuel supply 'ON', if separate arrangement is done for storage and supply of biodiesel. After conditioning the equipment, the engine is started and warm up for 10minutes. Start the computer and select the mode 'configure' to enter the data like fuel density and calorific value etc. Then select the RUN option, which continuously displays the process screen. Each test is conducted and data is stored at seven different loads. The load conditions varied from 0%, 20%, 40%, 60%, 80%, 100% and overload conditions. Engine is run for 15-20 Minutes for one test and data available is stored by log key at the end of time interval.
The schematic photograph of experimental setup is as shown in fig 3.1 and the tested engine specification is shown in Table-3.1. The engine has been run using different jatropha biodiesel blending (JBD20%, JBD40%, JBD60%, JBD80% and JBD100%) and required data are collected to prediction of the engine performance parameters.

Photograph 3.1: Computerized Single Cylinder Diesel Engine Test Set Up

Table 3.1: Computerized Single Cylinder Diesel Engine Test Rig

Parameter	Description
Manufacturer	Kirlosker Oil Engins Ltd .,Pune
Engine Type	Single Cylinder, 4 Stroke, Water Cooled, Diesel Engine.
Cylinder	Single
Stroke	110mm
Cubic capacity	661 cc (0.661 ltr.)
Bore	87.5 mm
Net Power	7 HP @ 1500 rpm
Compression Ratio	17.5 :1

The performance of Jatropha Biodiesel - diesel blends at different loading conditions namely o% , 20% , 40%, 60%, 80% and 100% load conditions were evaluated. The test result obtained in the experimental was used to train and test the ANN. Table3.2 below shows the performance parameters of diesel and jatropha biodiesel blend at 0% to 100% blending condition respectively.

4. CONSTRUCTION OF ANN MODEL

4.1 Network Structure

An artificial neural network (ANN), usually called neural network (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. ANN has three main layers, namely, input, hidden and output layers. Neurons (processing elements) at input layer transfer data from external world to hidden layer. The data in input layer do not process as the data in the other layers. In the hidden layer, outputs are produced using data from neurons in input layer and bias, and summation and activation functions. There can be more than one hidden layer. In this case, each hidden layer sends outputs to the following layer. In the output layer, the output of network is produced by processing data from hidden layer and sent to external world. The summation function calculates net input coming to a cell. For this reason, different functions are used.

Table 3.2 : Testing Result of JBD Blending fuel on CI engine

Sr. No.	Load (%)	Jatropha Blending (%)	F. C. (kg/hr)	B.P. (kW)	η_{th}	B.S.F.C. (kg/kWhr)	BSU
2	0	20	0.37	0.46	11.7	0.74	2
3	0	40	0.41	0.47	10.23	0.85	3
4	0	60	0.45	0.46	9.18	0.98	3
5	0	80	0.45	0.48	10.69	0.84	2
6	0	100	0.49	0.44	8.42	1.11	3
7	20	20	0.48	1.04	18.7	0.46	2
8	20	40	0.54	1.05	21.65	0.41	2
9	20	60	0.61	1.06	15.69	0.57	2
10	20	80	0.52	1.05	18.07	0.5	2
11	20	100	0.7	1.15	15.09	60	3
12	40	20	0.62	2.1	29.34	0.3	3
13	40	40	0.68	2.03	26.34	0.33	2
14	40	60	0.69	2.08	27.27	0.32	3
15	40	80	0.7	2.12	27.32	0.33	3
16	40	100	0.9	2.17	22.15	0.41	4
17	60	20	0.83	3.14	32.89	0.26	3
18	60	40	0.87	3.01	30.29	0.29	3
19	60	60	0.96	3.02	28.25	0.32	2
20	60	80	0.98	3.11	28.26	0.31	4
21	60	100	1.14	3.14	25.76	0.35	5
22	80	20	1.11	3.89	30.55	0.28	4
23	80	40	1.05	3.86	30.22	0.27	3
24	80	60	1.27	4.03	28.61	0.31	4
25	80	80	1.23	4	29.24	0.31	4
26	80	100	1.52	3.94	23.82	0.38	5
27	100	20	1.41	4.89	30.01	0.29	3
28	100	40	1.46	4.98	30.06	0.29	4
29	100	60	1.54	4.88	26.75	0.31	4
30	100	80	1.45	4.92	30.6	0.29	5
31	100	100	1.86	4.89	24.88	0.37	6

The most common one is to calculate the weighted sum. Inputs (load, %blending and fuel consumption) are the knowledge from other cells or external world to the input cells. These are determined by examples that network wants to learn. Weights (w1, w2.wn) are the values which determine the effect of input set or another processing element in previous layer on the processing element. Each input value is multiplied by weight value which connects it to the processing element and then, it is combined by summation function. Thus, net input of the network can be found. Summation function is given in Eq. (1).

$$NETi = \sum_{j=1}^{n} w_{ij}x_j + wb_i \qquad (1)$$

Activation function provides a curvilinear match between input and output layers. In addition, it determines the output of the cell by processing net input to the cell. Selection of appropriate activation function significantly affects network performance.

Recently, logistic sigmoid transfer function has been commonly used as an activation function in multilayer perception model, because it is a differentiable, continuous and non-linear function. For this reason, the logistic sigmoid transfer function was used as the activation function in this study. This function produces a value between 0 and 1 for each value of net input. The formula of the logistic sigmoid function is as follows:

$$f(NET_i) = \frac{1}{1+e^{-NETi}} \qquad (2)$$

The relationship between the various inputs and output parameters can be easily brought about by optimization. The uses of neural network for engine predictions make it possible to perform optimization studies over the entire operating conditions. The optimized output is obtained by using Backward Feed Propagation method in Artificial Neural Network. Because of Backward Feed Propagation algorithm is more accurate than other algorithm. The optimized output is obtained by using Artificial Neural Network with MATLAB software.

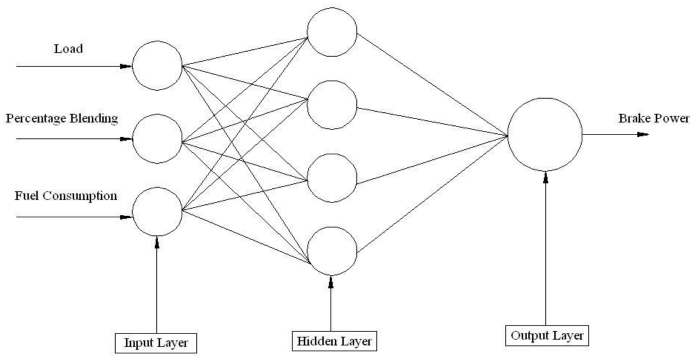


Fig. 4.2: ANN architecture with multiple hidden layer

4.2 Training and Testing Data

Determination of percentages of training and testing data has an important role for building of ANN architecture. When the studies in literature are analyzed, it is revealed that different ratios for training and testing data are used. In this study, 36 experimental results were prepared for training and testing data of ANN. The ratio for training and testing data was selected as 85%:15%. In this context, 6 data for testing and 30 data for training were randomly selected.

4.3. Normalization of input and output data

In back propagation model, scaling of inputs and outputs dramatically affects performance of ANN. For implementing back propagation logistic sigmoid transfer function was used in this study. One of the characteristics of this function is that only a value between 0 and 1 can be produced. Input and output data sets are normalized before training and testing process. In ANN normalization can be performed using following equation.

$$T = \frac{T_v - T_{min}}{T_{max} - T_{min}} \qquad (3)$$

In this study, the input and output values are normalized between 1.00e – 30 Gradient and performed between 0.1 and 0.9 using above formula.

5. RESULTS AND DISCUSSION

5.1 Experimental Values

The experimental results are shown in following figures. Figure 4.1 shows the brake power of Jatropha biodiesel - diesel blends at different loading conditions namely 0%, 20%, 40%, 60%, 80%, 100% load for different blending. At the different varying load brake power increases as increase in load percentage because of the higher density of blends containing a higher percentage of jatropha biodiesel has led to more discharge of fuel for the same displacement of the plunger in the fuel injection pump, thereby increasing the brake power.

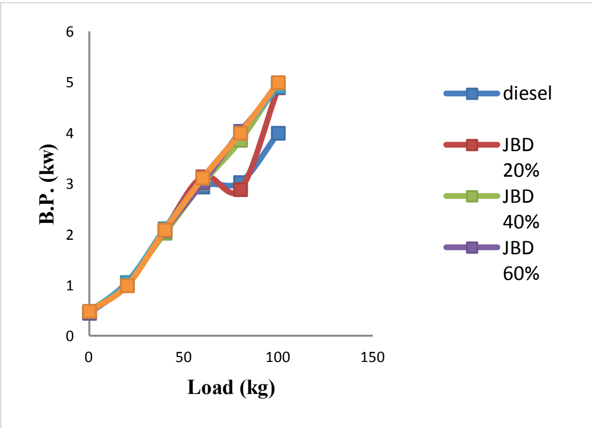


Fig. 5.1 Variation Load vs Brake Power

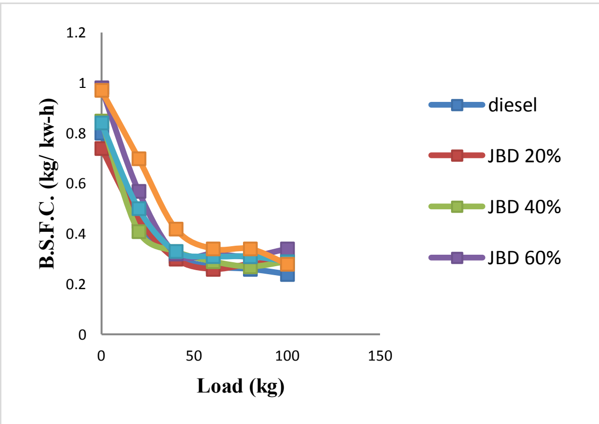


Fig. 5.2:Variation Load vs B.S.F.C

Fig. 5.2 shows the variation of brake specific fuel consumption (bsfc) of the engine for various blending of fuels. The best bsfc obtained for full load at JBD60 blending as near about to diesel fuel. This bled shows that about 2% less bsfc in average than diesel fuel. The brake specific fuel consumption of diesel and various blends of jatropha biodiesel at varying loads in the range 0% - 100% load. It was observed that the specific fuel consumptions of the diesel as well as the Jatropha blends were decreased with increasing load. The fuel consumptions were also found to increase with a higher proportion of jatropha biodiesel in the blends. This is mainly due to the combined effects of the relative fuel density, viscosity and heating value of the blends. The variation of brake thermal efficiency of the engine with various JBD blends is shown in Fig. 5.3. From the test results it was observed that initially with increasing load the brake thermal efficiencies of the jatropha biodiesel blends and the diesel were increased and the maximum thermal efficiencies were obtained and then tended to decrease with further increase in load. but the brake thermal efficiencies of the blends and the jatropha biodiesel were lower than that with diesel fuel throughout the entire range. The drop in thermal efficiency with increase in proportion of jatropha biodiesel must be attributed to the poor combustion characteristics due to their high viscosity and poor volatility, that's why higher jatropha blends suffer from worse atomization and vaporization.

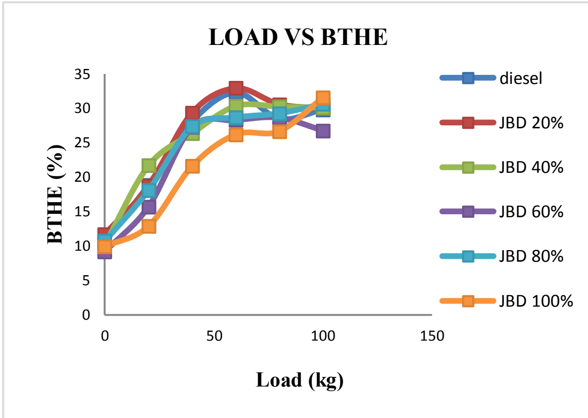


Fig 5.3 Variation Load vs BThE intensity

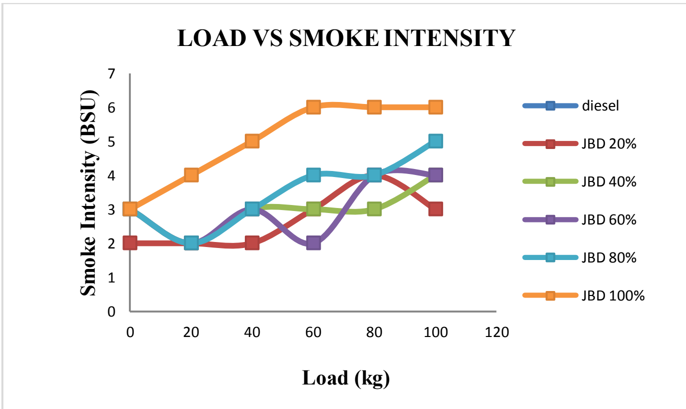


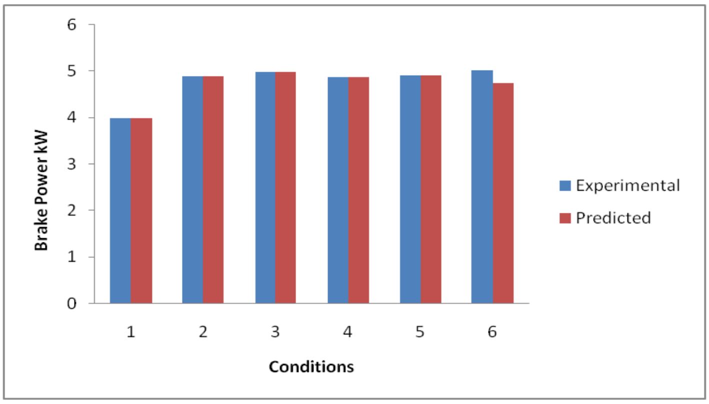
Fig. 5.4: Variation Load vs Smoke

The variation of the smoke intensity as shown in fig. 5.4 with various load it was found that as load and percentage of blending increases then smoke intensity also increases. 100JBD fond that smoke intensity will more as compared to another blending and diesel fuel. Due to increase in density and viscosity with increase in blending percentage in fuel, incomplete combustion occurs.

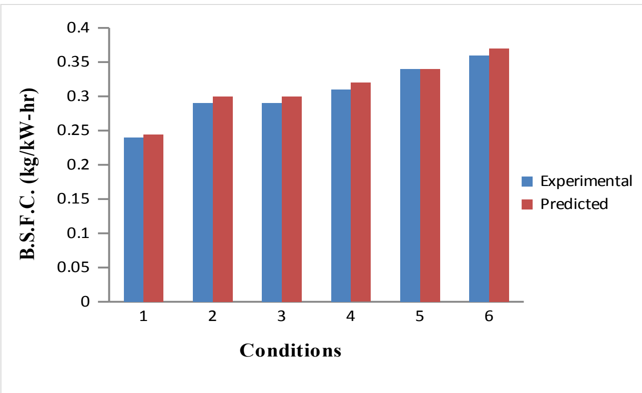
5.2 Prediction of Engine Performance Using ANN

The aim of using the ANN model, considered as a practical approach, is to test the ability to predict the output parameters brake power, B.S.F.C., Thermal Efficiency, and Smoke intensity for a jatropha biodiesel – diesel blending fuel for CI engine. The network has three input parameters such as load, percentage blending and fuel consumption.
Statistical values obtained for each output parameters it was shown that RMS and are close to the 1 for training and

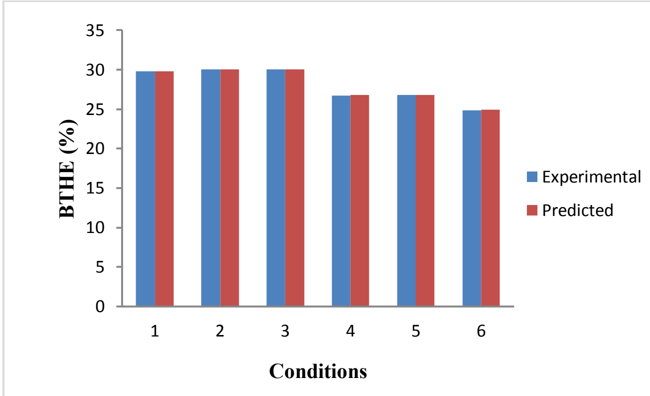
testing data. All results obtained for training and testing data are within acceptable error limits. Predictive ability of the network for the brake specific fuel consumption, Brake power, Brake thermal efficiency and smoke intensity was found to be fairly satisfactory. For 100% load condition shows the trained values for different output of experiment in fig 5.5). The predicted value for output parameters was found to be much more accurately using ANN Back Propagation algorithm, their different comparison in predicted values and experimental values are shown in fig below. In fig. 5.5 (a) shows the brake power of experimental values and predicted values, it has shows that the condition six there is minimum value of error for brake power is 0.28. Fig. 5.5 (b)shows the maximum value of error for BTHE in load condition six is for 0.4432. The minimum value of error is for B.S.F.C. for condition 5as shown in fig. 5.5 (c) is 0.00028. The minimum value of error for smoke intensity is trail 2 for 0.99. the remaining output parameters will have error range in satisfactory means its range in between the above values.



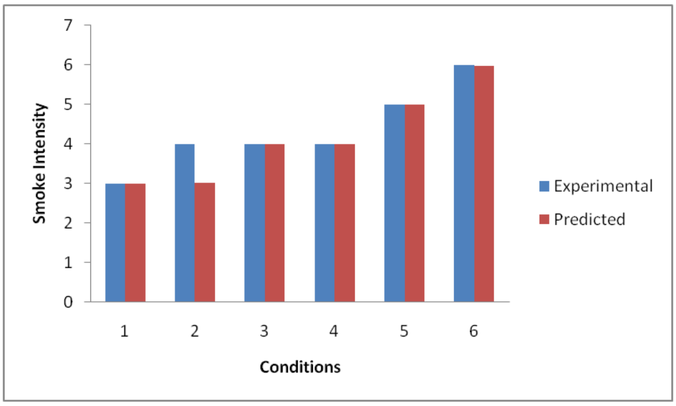
(a)



(b)



(c)



(d)

Fig. 5.5 Comparison of experimental and ANN predicted results of output parameters.

6. CONCULSION

A Single Cylinder Four Stroke Compressed Ignition Engine was operated successfully using the jatropha biodiesel and diesel fuel blends as fuel. The following conclusions are made based on the experimental and trained results.

From the experimental results obtained jatropha biodiesel blending fuel as the brake power is same about for diesel and biodiesel blending upto 60% load then it increases as increase the blending of jatropha fuel. As blending increases with respect to load B.S.F.C. decreases and its same about for diesel fuel. but JBD100% blending B.S.F.C. was found slightly more as comparative to another blending of fuel. The brake thermal efficiency values for JBD20 is more than diesel fuel and other blends over the entire load range. Smoke intensity is more as compare to diesel fuel, it increase the increases the increase the blending of jatropha biodiesel fuel.

This study deals with ANN modeling of jatropha biodiesel and diesel fuel blending for CI engine to predict the brake power, brake specific fuel consumption, brake thermal efficiency and smoke intensity of the engine. Using some of the experimental data for training, an ANN model based on standard back propagation algorithm for the engine was developed. Then, the performance of the ANN predictions were measured and by comparing the predictions with the experimental results. The predicted results of performance parameters have been in close agreement with experimental results. The developed back propagation algorithm is to be a useful tool in ANN for predicting and optimizing the performance parameters of CI engine. Thus the developed BP model in ANN can be considered as an efficient tool to calculate the effect of operating and performance parameters on CI engine. Therefore ANN will be a very good tool to optimize engines in the future.

NOMENCLATURES

ANN	Artificial Neural Network
B.P.	Brake Power
Bp	Back propagation algorithm
B.S.F.C.	Brake Specific Fuel Consumption
f	Operation Function
ij	Processing Element
JBD	Jatropha Biodiesel
RMS	Root Mean Square Error
T	Target

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