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ANN BASED MODELING OF PERFORMANCE CHARACTERISTICS OF SINGLE CYLINDER DIESEL ENGINE FUELED WITH CONVENTIONALDEISEL AND PALMSTYRINE BIODIESEL

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ABSTRACT

The intention of this work is to predict the performance characteristics of a single cylinder four-stroke diesel engine fueled with vegetable oil (palmstyrine) and its blends with diesel using the aid of artificial neural network (ANN). The tests were performed with fuel blends of B10%, B15% and B20 biodiesel with standard diesel under different loading conditions. The performance parameters viz. Brake Power, Brake Thermal Efficiency, Mass of Fuel Consumed, Brake Specific Fuel Consumption and Volumetric Efficiency was evaluated against various loads.

The test results were trained in ANN network and predicted the efficiencies which are identical as the numerically calculated values and it is observed that the brake thermal efficiency and volumetric efficiency of engine was slightly higher using biodiesel blends than diesel fuel and the Specific Fuel Consumption is also less using biodiesel

INTRODUCTION

Rapidly increasing energy demand due to industrialization has led to a large number of developing countries importing crude oil. Thus, a major part of their export earnings is spent on purchase of petroleumproducts. The other problem of concern is the degradation of environment due to fossil fuel combustion besides the fuel crisis. Thus, it is essential that low emission alternate fuels must be developed for use in diesel engines.

Artificial neural networks (ANN) are particularly used to solve problems which cannot be solved by the conventional modelling methods. A well-trained ANN model predicts much faster than the conventional modelling techniques. The cost and time can be tremendously reduced by using artificial neural networks(ANN).

The use of ANN for modelling the operation of internal combustion engines is more recent progress. Thishas been used for the prediction of performance of diesel engine under varying conditions. Engine performance can be modelled by using Artificial Neural Networks (ANNs). This new modelling techniquecan be applied to estimate the desired output parameters when enough experimental data is provided.

The present paper work is carried on blending of alternative fuel to the diesel with the different proportions for vegetable oil B10 (10% of vegetable oil & 90% diesel), B15 (15% of vegetable oil & 85% of diesel), B20 (20% of vegetable oil & 80% of diesel).

LITERATURE REVIEW

Abhishek Sharma.et.al. (1); International Energy Journal: ANN Based Modeling of Performance Characteristics of Diesel Engine Fueled with Polanga Biodiesel at Different Injection Pressures. The different polanga biodiesel blends in the present work can be conveniently used in 4 stroke single cylinder diesel engines as blends with diesel without any engine alterations. Multilayer feed forward network with back propagation training algorithm was used to predict the performance characteristics of diesel engine at various loads. Analysis of the experimental data by the ANN revealed that there was good correlation between the predicted data resulted from the ANN and measured ones.

- Farzad Jaliliantabar.et.al. (2); ResearchGate: Artificial Neural Network Modeling and Sensitivity Analysis of Performance characteristics in a Compression Ignition Engine Using Biodiesel Fuel. The performance and emissions of an air-cooled single cylinder diesel engine have been investigated in this study. The engine was run under different operating conditions and fueled with different biodiesel

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diesel blends. It was evident that the ANN predicted data matched the experimental data with high overall accuracy with coefficient (R 2) values very close to 1.

- Rajayokkiam Manimaran.et.al. (3); PubMed: ANN Modeling for Forecasting of VCR Engine Performance and Emission Parameters Fueled with Green Diesel Extracted from Waste Biomass Resources. In this study performance parameters are tested and predicted. The multiple regression ANN model was developed to forecast the engine performance (BTE, BSFC) parameters. The R 2 values of training, validation, test and overall are obtained as 0.99798, 0.99619, 0.99092 and 0.99673. These R 2 values are about 1, which provides exact output responses of the ANN model. It can reduce the experimental efforts and act as an effective tool for forecasting the engine process parameters under different operating conditions.

EXPERIMENTATION

A single cylinder 4-stroke water-cooled diesel engine having 5 HP as rated power at 1500 rpm was used for the research work. The engine is coupled to a rope pulley brake arrangement to absorb the power produced.

The fuel flow rate is measured on volumetric basis using burette and a stopwatch. Themo couples in conjunction with a digital temperature indicator were used for measuring the engine and exhaust gas temperatures. Air consumption is measured by using a M.S. tank, which is filled with a standard orifice and a U-tube manometer that measure the pressure inside the tank.

Fig No 3.1 Experimental setup of 5Hp Diesel Engine

Engine Type	Kirloskar
BHP	5HP
Speed	1500
Compression ratio	12:1 to 20:1
Number of cylinders	Single
Bore	80 mm
Stroke	110 mm
Orifice Diameter	20 mm
Type of ignition	Compression ignition
Method of Loading	Eddy current dynamometer
Method of starting	Manual cranking
Method of cooling	Water cooled

Table No 3.1 Engine Specifications

3.1 EXPERIMENTAL PROCEDURE

Initially the experiments were conducted on the engine with diesel to find optimum cooling rate and further all the experiments are conducted on the engine by maintaining this optimum rate of engine cooling. Initially performance test is conducted using Diesel as fuel and the using various blends. The following step by step procedure is adopted for the test:

1. Give the necessary electrical connections to the panel.

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2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate.
5. Release the load if any on the dynamometer.
6. Open the fuel flow cock so that fuel flows to the engine.
7. Start the engine by hand cranking.
8. Allow the engine to run under idling condition (no load) for 2 to5 minutes to ensure warmand steady operating conditions.
9. Record all the thermal performance parameters for no load condition through a data acquisition system.
10. Repeat the experiment for different loads and note down the readings.
12. After the completion release the load and then switch of the engine.
13. Try with different blends and note down the readings.
14. Allow the water to flow for few minutes and then turn it off. The performance tests on the engine were conducted one by one with diesel and biodiesel blends (B10, B15, and B20) and compared. Each and every time, when the biodiesel or blend proportion is changed the engine was run with diesel fuel for few minutes to wash the fuel lines. The performance of the engine is evaluated in terms of Brake thermal potency, Brake specific fuel consumption, Exhaust gastemperature.

PROPERTIES OF FUELS

BLEND	**VISCOSITY Cst**	**DENSITY Kg/m3**	**CALORIFIC VALUE**
B10	3.97	843.58	42700
B15	3.97	843.8	42550
B20	3.98	844.03	42400
DIESEL	3.90	840	43000

Table.No.3.2 Properties of Fuels Used

3.2 CALCULATION RESULTS OF DIFFERENT BLENDS:

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	SFC (Kg/KW hr)	Va	ɳve (%)	ɳbth (%)
1	2	0.45	0.40	0.88	17.98	72.28	9.56
2	4	0.91	0.46	0.50	17.75	71.37	16.59

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3	6	1.34	0.53	0.39	17.75	71.37	21.38
4	8	1.75	0.54	0.31	17.29	69.51	27.04
5	10	2.18	0.59	0.27	17.29	69.51	30.71
6	12	2.64	0.60	0.23	17.29	69.51	36.55
7	14	3.10	0.64	0.20	17.09	68.57	40.47
8	16	3.37	1.00	0.29	16.82	67.61	28.30
9	18	3.77	0.99	0.26	16.58	66.64	31.86
10	20	4.17	1.03	0.24	16.33	65.65	34.12

Table.No.3.21. Calculation Results of B10

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	SFC (Kg/KW hr)	Va	ɳve (%)	ɳbth (%)
1	2	0.4	0.55	1.29	17	69	6.54

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		2			.17	.02	
2	4	0.85	0.63	0.74	17.17	69.02	11.38
3	6	1.28	0.74	0.57	17.59	70.72	14.72
4	8	1.67	0.82	0.49	17.59	70.72	17.10
5	10	2.10	0.97	0.46	17.38	69.88	18.14
6	12	2.53	1.07	0.42	17.38	69.88	19.92
7	14	2.96	1.24	0.42	17.80	71.56	20.09
8	16	3.39	1.32	0.39	17.80	71.56	21.67
9	18	3.82	1.55	0.40	17.89	70.72	20.81
10	20	4.06	1.57	0.38	17.80	71.56	21.80

Table.No.3.22. Calculations And Results of B15

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	SFC (Kg/KW hr)	Va	ηve (%)	ηbth (%)
1	2	0.48	0.48	1.01	18.63	74.87	8.79
2	4	0.97	0.59	0.61	18.41	73.99	13.71
3	6	1.45	0.69	0.47	18.63	74.87	17.54
4	8	1.94	0.79	0.40	18.41	73.99	20.48
5	10	2.37	0.87	0.36	18.41	73.99	22.67
6	12	2.80	0.97	0.34	18.41	73.99	24.09
7	14	3.23	1.12	0.34	18.41	73.99	24.14
8	16	3.64	1.23	0.33	18.41	73.99	24.63
9	18	4.09	1.42	0.34	18.41	73.99	23.99
10	20	4.58	1.52	0.33	18.63	74.87	25.20

Table.No.3.23. Calculations And Results of B20

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	SFC (Kg/KW hr)	Va	ηve (%)	ηbth (%)
1	2	0.48	0.48	1.01	18.63	74.87	8.79
2	4	0.97	0.59	0.61	18.41	73.99	13.71
3	6	1.45	0.69	0.47	18.63	74.87	17.54
4	8	1.9	0.7	0.40	18.	73.	20.

		4	9		41	99	48
5	10	2.37	0.87	0.36	18.41	73.99	22.67
6	12	2.80	0.97	0.34	18.41	73.99	24.09
7	14	3.23	1.12	0.34	18.41	73.99	24.14
8	16	3.64	1.23	0.33	18.41	73.99	24.63
9	18	4.09	1.42	0.34	18.41	73.99	23.99
10	20	4.58	1.52	0.33	18.63	74.87	25.20

Table.No.3.24. Calculations And Results of Diesel

ARTIFICIAL NEURAL NETWORK

4.1 INTRODUCTION

Neural network models are structured as a series of layers that reflect the way the brain processes information. The neural network classifiers available in Statistics and Machine Learning Toolbox™ are fully connected, feedforward neural networks for which you can adjust the size of the fully connected layers and change the activation functions of the layers. To train a neural network classification model, use the Classification Learner app. For greater flexibility, train a neural network classifier using fitcnet in the command-line interface. After training, you can classify new data by passing the model and the new predictor data to predict. If you want to create more complex deep learning networks and have a Deep Learning Toolbox™, you can try the Deep Network Designer (Deep Learning Toolbox) app.

What is a neural network?

A neural network (also called an artificial neural network) is an adaptive system that learns by using interconnected nodes or neurons in a layered structure that resembles a human brain. A neural network can learn from data-so it can be trained to recognize patterns, classify data, and forecast future events.

A neural network breaks down the input into layers of abstraction. It can be trained using many examples to recognize patterns in speech or images, for example, just as the human brain does. Its behaviour is defined by its individual elements being connected and by the strength, or weights, of those connections. These weights are automatically adjusted during training according to a specified learning rule until the artificial neural network performs the desired task correctly.

How Do Neural Networks Work?

Inspired by biological nervous systems, a neural network combines several processing layers, using simple elements operating in parallel. The network consists of an input layer, one or more hidden layers, and an output layer. In each layer there are several nodes, or neurons, and the nodes in each layer use the outputs of all nodes in the previous layer as inputs, such that all neurons interconnect with each other through the different layers. Each neuron typically is assigned a weight that is adjusted during the learning process and decreases or increases in the weight change the strength of that neuron's signal.

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4.2 NEURAL NETWORK DESIGN

Artificial neural networks

ANNs are logic programming technique developed by imitating the operation of the human brain to perform functions such as learning, remembering, deciding, and inference, without receiving any aid. ANNs have various important features, such as learning from data, generalization, working with an infinite number of variables, etc. Artificial neural cells are the smallest units that form the basis of the operation of ANNs just like a biological neuron which receives inputs from other sources, combines them in some way, performs generally a non-linear operation on the result, and then outputs the final result.

ANN has three main layers namely; input, hidden and output layers. The inputs are data from the external source. The processing elements, called neurons, in the input layer transfers data from the external source to the hidden layer. The weights are the values of connections between cells. The outputs are produced using data from neurons in the input and hidden layers, and the bias, summation and activation functions. In the output layer, the output of network is produced by processing data from hidden layer and sent to external source.

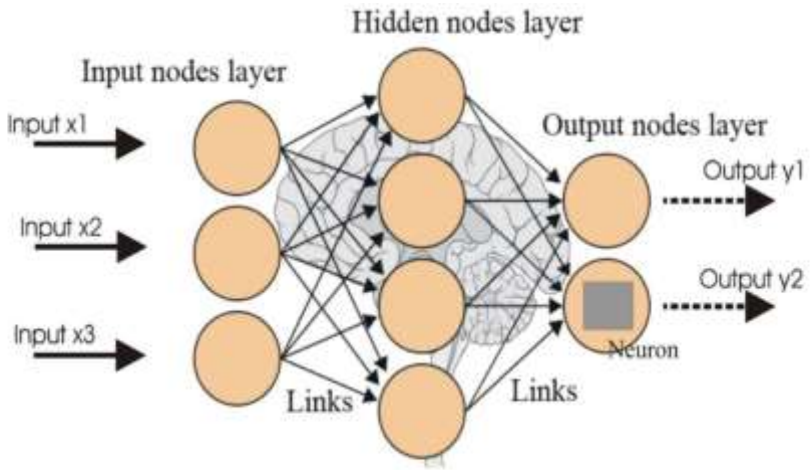

Fig 4.2 Typical neural network architecture

The significant advantages of artificial neural networks are learning ability and the use of different learning algorithms. The most important factor which determines its success in practice, after the selection of ANN architecture, is the learning algorithm. In order to obtain the output values closest to the numerical values, the best learning algorithm and the number of optimum neurons in the hidden layer must be determined.

A most sought-after algorithm is the backpropagation algorithm, which has different variants. Back-propagation training algorithms such as conjugate gradient, quasi-Newton, and Levenberg– Marquardt (LM) use standard numerical optimization techniques. ANN with back-propagation algorithm learns by changing the weights which are stored as knowledge. The algorithm uses the second-order derivatives of the cost function so that a better convergence behavior can be obtained. To get the best prediction by the network, several architectures were evaluated and trained using the experimental data. The back-propagation algorithm was utilized in training of all ANN models. In the training stage, to obtain the output precisely, the number of neurons in the hidden layer was increased step by step (i.e., 1 to 20). As a result of conducted trials, best learning algorithms for most of the parameters was found to be the Levenberg Marquardt learning algorithm.

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RESULTS AND DISCUSSIONS:

ACTUAL VS ANN VALUE OF DIFFERENT BLENDS

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	ɳve (%)	ANN ɳve	ɳbth (%)	ANN ɳbth
1	2	0.45	0.40	72.28	73	9.56	10
2	4	0.91	0.46	71.37	72	16.59	17
3	6	1.34	0.53	71.37	72	21.38	21
4	8	1.75	0.54	69.51	70	27.04	27
5	10	2.18	0.59	69.51	70	30.71	31
6	12	2.64	0.60	69.51	70	36.55	37
7	14	3.10	0.64	68.57	69	40.47	41
8	16	3.37	1.00	67.61	68	28.30	28
9	18	3.77	0.99	66.64	67	31.86	32
10	20	4.17	1.03	65.65	66	34.12	34

Table.5.1 ACTUAL VS ANN VALUE OF B10

SL. NO	Loads (K	BP (KW	MFC (Kg/	ɳve (%)	ANN ɳve	ɳbth (%	ANN ɳbth

	g)	)	hr)			)	
1	2	0.42	0.55	69.02	69	6.54	7
2	4	0.85	0.63	69.02	69	11.38	11.5
3	6	1.28	0.74	70.72	71	14.72	15
4	8	1.67	0.82	70.72	71	17.10	18
5	10	2.10	0.97	69.88	70	18.14	18.5
6	12	2.53	1.07	69.88	70	19.92	20
7	14	2.96	1.24	71.56	72	20.09	20
8	16	3.39	1.32	71.56	72	21.67	22
9	18	3.82	1.55	70.72	71	20.81	21
10	20	4.06	1.57	71.56	72	21.80	22

Table.5.2 ACTUAL VS ANN VALUE OF B15

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	ɳve (%)	ANN ɳve	ɳbth (%)	ANN ɳbth
1	2	0.48	0.47	69.45	70	8.51	9
2	4	0.99	0.57	69.45	70	14.69	15
3	6	1.45	0.76	70.37	71	16.13	17

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4	8	1.94	0.79	69.45	70	20.79	21
5	10	2.42	0.96	67.56	68	21.40	22
6	12	2.83	1.13	65.59	66	21.15	22
7	14	3.28	1.30	64.59	65	21.32	22
8	16	3.77	1.50	63.58	64	21.32	22
9	18	4.17	1.64	63.58	64	21.56	22
10	20	4.58	1.66	62.54	63	23.35	24

Table.5.3 ACTUAL VS ANN VALUE OF B20

SL. NO	Loads (Kg)	BP (KW)	MFC (Kg/hr)	η_{ve} (%)	ANN η_{ve}	η_{bth} (%)	ANN η_{bth}
1	2	0.48	0.48	74.87	75	8.79	9
2	4	0.97	0.59	73.99	74	13.71	14
3	6	1.45	0.69	74.87	74	17.54	18
4	8	1.94	0.79	73.99	74	20.48	21
5	10	2.37	0.87	73.99	74	22.67	23
6	12	2.80	0.97	73.99	74	24.09	24
7	14	3.23	1.12	73.99	74	24.14	24
8	16	3.64	1.23	73.99	74	24.63	25
9	18	4.09	1.42	73.99	74	23.99	24
10	20	4.58	1.52	74.87	75	25.20	26

Table.5.4 ACTUAL VS ANN VALUE OF DIESEL

Prediction of engine performance and exhaust emissions using ANN

ANN model is considered as a sensible and reliable approach for non-linear problems. The input parameters of the network are blends of Palmstyrine with diesel at different loads and performance parameters Brake Power (BP), Brake Thermal Efficiency (BTE), Mass of Fuel Consumed, Brake Specific Fuel Consumption and Volumetric Efficiency was evaluated against various loads. In this

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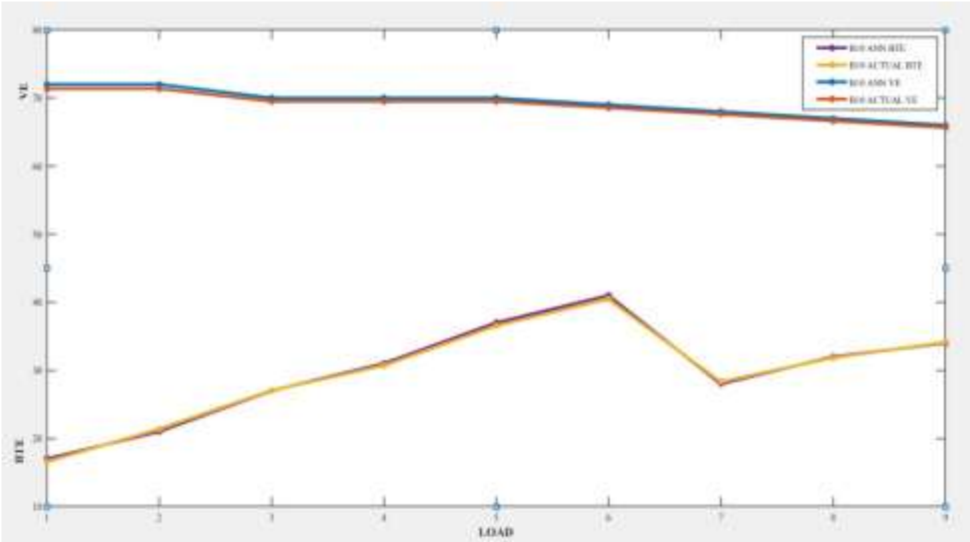
work, a computer program has been developed in MATLAB platform to predict Brake Thermal Efficiency (BTE), Volumetric Efficiency of the engine. The most favorable network structures and statistical parameters of ANN models for diverse learning algorithms are represented in grapes below.

The prediction performances for both training and testing sets of performance showed that all the approaches provided a fairly acceptable accuracy. Comparisons of the ANN predictions and actual results for testing sets of output performance The most outstanding point here is that the prediction results are extremely close to actual results.

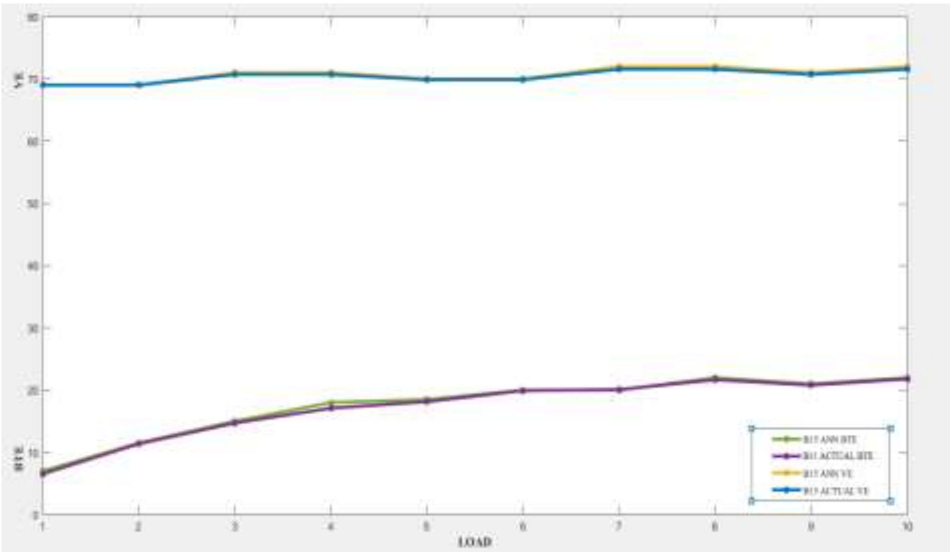
EXPERIMENTAL VALUE Vs ANN PREDICTED VALUE OF B10



Graph. No 5.1
Load Vs Volumetric Efficiency & Brake thermal Efficiency

The test results were trained in ANN network and predicted The Volumetric Efficiencies and Brake Thermal Efficiencies OF B10 which are Identical as the numerically calculated values of B10.

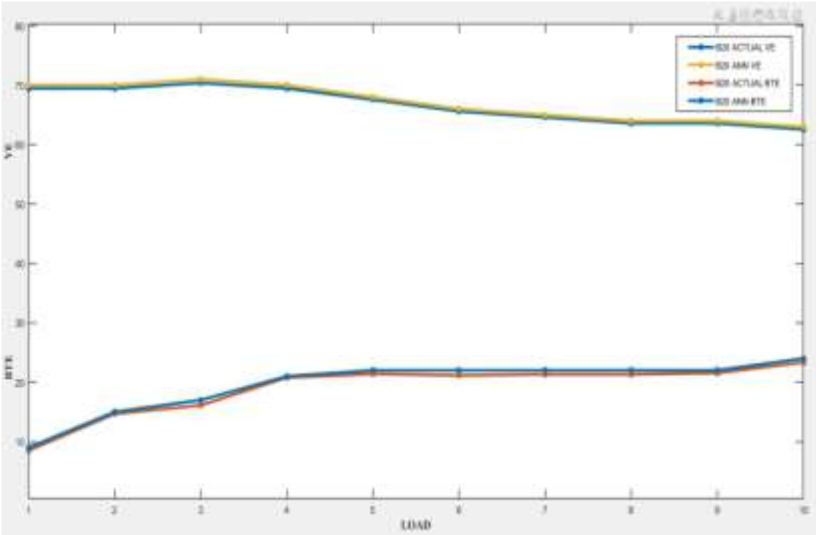
EXPERIMENTAL VALUE Vs ANN PREDICTED VALUE OF B15



Graph.No5.2
Load Vs Volumetric Efficiency & Brake thermal Efficiency

The test results were trained in ANN network and predicted The Volumetric Efficiencies and Brake Thermal Efficiencies OF B15 which are Identical as the numerically calculated values of B15.

EXPERIMENTAL VALUE Vs ANN PREDICTED VALUE OF B20

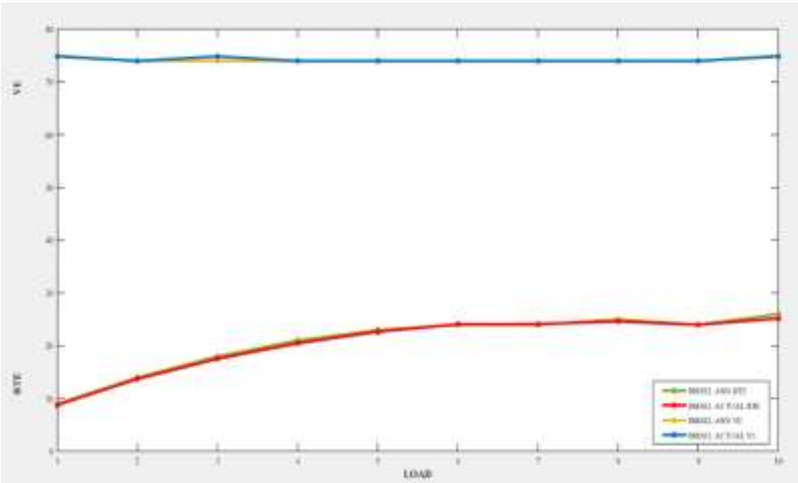


Graph.No5.3

Load Vs Volumetric Efficiency & Brake thermal Efficiency

The test results were trained in ANN network and predicted The Volumetric Efficiencies and Brake Thermal Efficiencies of B20 which are Identical as the numerically calculated values of B20.

EXPERIMENTAL VALUE Vs ANN PREDICTED VALUE OF DIESEL



Graph.No5.2.4

Load Vs Volumetric Efficiency & Brake thermal Efficiency

The test results were trained in ANN network and predicted The Volumetric Efficiencies and Brake Thermal Efficiencies of Diesel which are Identical as the numerically calculated values of B20.

5. EVALUATION OF RESULTS

The network was trained successfully and then the test data was used to evaluate the selected network. Using results obtained from the network, a comparison was carried out using statistical methods. The performance of the network was evaluated using MATLAB. Comparisons of the ANN predictions and actual results for testing sets of output performance The most outstanding point here is that the prediction results are extremely close to actual results.

The comparison is expressed in graphs. Hence, the results obtained from optimum ANN model may easily be considered to be within the acceptable limits. shows that there is a better correlation between the actual values and prediction values.

CONCLUSION

- The different Palmstyrine biodiesel blends in the present work can be conveniently used in 4 stroke single cylinder diesel engines as blends with diesel without any engine alterations.
- Experimental examination showed that the brake thermal efficiency was slightly higher in biodiesel blends when compared with diesel fuel. Because, decrease in fuel consumption and calorific value led to increasing in Brake Thermal Efficiency of Biodiesel blends.
- The brake power generated by the engine under different load, As the load increases, the brake power produced by the engine also increases for B10, B15, B20 and DIESEL.
- . Mass of fuel consumption is more while using diesel than Biodiesel blends. B10 has the least fuel consumption compared to the remaining fuels. Because the calorific value of biodiesel is higher compared with Diesel fuels.
- The volumetric efficiency is higher for diesel compared to the biodiesel blends due to low viscosity and density of diesel.
- However, the mass of fuel consumed is more in using diesel than remaining bio diesel blends. Comparisons of the ANN predictions and actual results for testing sets of output performance.
- The developed model thus reduces the experimental efforts and hence can serve as an effective tool for predicting the performance of the engine characteristics under various operating conditions with different biodiesel blends.

REFERENCES

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