ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Prediction Performance of Emission Characteristics of Mauha Methyl Ester with Diesel Using ANN

S. H. Jamshak*, M. Dev Anand
Department of Mechanical Engineering, Noorul Islam Centre for Higher Education, Kumaracoil – 629180
***Corresponding author: E-Mail: jamshak.sh@gmail.com**

ABSTRACT

Petroleum dependent fuels contribute a trivial role in progressive conventional energy sources depletion together with rising demand and also chief supplier of air pollutants. Chief segment of today's energy requirement in India is satisfied using fuels of fossils. For this reason, in this peak time that choice of fuels for engines must be derived from original resource. Since India is known to be an agricultural country, extensive scope for the vegetable oils production (both edible and non-edible) from numerous seeds of oil exist. Current work pays attention only on oils that are non-edible which are engines fuels, since there exist great range of demand for the oils that are edible and are highly costly. In this area current research have been projected after a meticulous literature review. Experiments have been performed in a highly familiar four stroke single cylinder, Air cooled diesel engine. Chief issues relating the oils or vegetables are viscosities of higher range, reducing values of heating, elevation in stoichiometric fuel air ratio and thermal cracking. The test engine performance parameters Viz. Brake thermal efficiency, Exhaust gas temperature, Brake specific fuel consumption have raised for all neat oils assessed against diesel. Parameters for emission of engine namely Carbon dioxide, Smoke, Carbon monoxide, Nitrogen oxides gets raised, but hydrocarbons declines for all neat oils and their blends assessed with diesel. All neat oils are transformed into their corresponding Methyl Esters via the process of trans-Esterification. This tendency has been noticed because of the wholesome Bio-diesels combustion, due to the decline in viscosity. From the experimentation, it is noticed that 30% of neat oil assorted with 70% of diesel is the most excellent appropriate blend, devoid of heating and any alteration of the engine.

KEY WORDS: Emission Characteristics, Esterification, Mahua Methyl Ester, Artificial Neural Network, Research Highlights.

1. INTRODUCTION

India grows up faster and in one among the top emerging countries exhibiting a steady progress economically that multiplies the claim for transportation in numerous folds. Consumption of fuel is directly proportionate to current requirement. India tend to rely much on fuels which gets imported because of fossil fuel reserves demand which impacts much on country's economy. India tries to find an option for maintaining the rate of growth.

Latest research depicts renewed attention on Biodiesel as fuel in diesel engines, although concept of using vegetable oil as engine fuel is as old as the engine itself. The lower cost of the petroleum diesel has so far attracted the world for utilizing it as diesel engines fuel until now. But nowadays due to global political turmoil and other reasons, the cost of petroleum diesel has been increasing exponentially. Moreover, the emission norms are more stringent as ever before. In this context, many Biodiesels have been used by different countries, but only a very few and nonedible type such as Jatropha, Pongamia, and Mahua can be considered to be economically affordable to some developing nations like India in particular.

Mahua Biodiesel is one of the most promising Biodiesel options among these. Mahua oil's scientific name is "Madhuka Indica", "Madura Long Folia" is botanical name which is derived from a tropical tree corresponding to Sapotaceae family. As a plantation tree, the significant plant named Mahua possess imperative socioeconomic value whose species could be planted on roadside, canal banks etc on commercial scale and in social forestry programs, specifically in areas of tribes.

Literature survey: Biodiesel is novel, substitution and green fuel that holds the potential for replacing petroleum diesel in upcoming days. It can help for reducing our trust on conventional/non-renewable fossils fuel together with get better quality of environment in metro cites, rural and urban sectors by dropping emissions of automotive/vehicles.

Experiments on a direct injection, diesel engine which is turbocharged using Methyl Esters of rapeseed oil has been by Salvatore which was reported to be similar injection timing, Methyl Ester encouraged an increase in emissions of NO_x and dropped HC and co along with greater smoke diminution. CO, NO_x and HC Bio-diesel emissions were dropped by a drain oxidizing agent.

Comprehensive analysis of combustion were conducted by Hadi rahmi, Talal Fyusaf on Biodiesel fuel which is from waste cooking with an ANN aid and found the emissions CO and HC concentration were predominantly dropped. By adding 20% of Bio-diesel, maximum power and torque gets raised by 2.7% and 2.9% correspondingly have been noticed.

Mustafa Canakci, Amet Erdil, Erol Arcakliogu the applicability of the ANNs were investigated for the functionality and values of exhaust emission corresponding to a diesel engine fuelled with Biodiesels from dissimilar feed stocks and petroleum with Biodiesels feed stocks and petroleum diesel fuels. Characteristics of performance and emissions of two dissimilar petroleum diesel fuels, Biodiesels and their blends with fuel as diesel have been utilized as outcomes of experiments. For training the network, net heat of combustion, average molecular weight, kinematic viscosity, C/H ratio, specific gravity and cetane number corresponding to every fuel to be used as the input layer, whilst exhaust temperature, exhaust emissions and brake specific fuel consumption are the output. Back – propagation learning algorithm with three dissimilar variants, logistic sigmoid transfer and single layer have been utilized in the network. On utilizing network weights, formulations were provided for every output. Yield by network are the values of R^2 which are about 0.99 and for the test data, mean %errors are lesser than 5.5. Diesel engine's performance and exhaust emissions utilizing blends of Biodiesel with diesel fuel upto 30% blend were predicted involving ANN model.

Das, Gajendra Babu and Sudhir Ghai used sunflower Methyl Ester in diesel engine and found the characteristics of performance of sunflower Methyl Ester blended with diesel as similar with diesel fuels. The emissions namely CO, HC were less but NO_x emissions are higher.

Extraction of biodiesel from mahua oil and characteristics of mahua oil ester: Experimental set up is depicted in Figure 1. Reactor utilized for experiments was a 1000ml three necked flask with round bottom. One among three necks has been equipped with a condenser and the other two have been utilized for thermo well and for collection of sample correspondingly. A thermometer has been put up in the thermo well to measure temperature within the reactor. Neck at centre has been adapted for paddling blade impeller with a stirrer made of glass. Stirrer rod has been passing via the neck utilizing Teflon cap. Motor has been connected with a speed regulator to adjust and control the speed of stirrer.

Figure.1. Photographic View of Biodiesel Plant

500 ml. of Mahua Oil free from contaminants and water has been taken in the three necked flask with round bottom. Heat has been supplied to the setup. Measured quantity of Methanol and sulphuric acid have been supplemented to the oil. Heat has been supplied and stirred incessantly preserving a temperature which is steady. Reaction time has been conducted for 1.5 hours. Intermittently samples have been composed at usual intervals and acid value has been determined. Later on the authentication of entire lessening of acid value to 0.1-0.5, the heating has been stopped and the products have been cooled. Left out product has been analyzed for acid value and the acid value varied from 0.1 to 0.5 has been found out. This sample of oil has been further treated for transesterification step for obtaining Methyl Esters.

A recognized quantity of oil has been charged to a three necked flask which is round bottomed. Identified quantity solution of catalyst sodium methoxide has been brought up in methanol. Solution and the left out demands certain quantity of methanol which has been supplemented to the sample of oil. Later on closing flask properly, mantle heater was put on. Maintenance of the system has happened airtight for preventing the alcohol loss. Mix of reaction mix has been preserved at temperature just little more than the alcohol boiling point i.e. approximately 70°C to fast up the reaction. Suggested times of reaction keeps changing from 1 to 2 hours. Surplus alcohol has usually been utilized for ensuring oil's total conversion to its Esters. Formation of Methyl Ester has been checked by means of Thin Layer Chromatography (TLC) technique. Coated silica gel glass plates have been marked using Mahua oil and the sample of product. Samples that are spotted have been brought up in system of solvent in chamber of glass by means of solvent. Achievement of Transesterification is identified by spraying the brought up plate by means of iodine. Current procedure has been followed for every samples composed at usual gap of time for checking the Methyl Ester formation. Later on the authentication of achievement of formation of Methyl Ester, the heating has been closed and cooling of products has been done along with transfer to a funnel that separates. Ester layer composing primarily Methyl Ester and methanol and layer of glycerol possessing principally glycerol and methanol have been separated. Methyl Ester has been washed and in presence of vacuum it is dried for removing moisture traces.

These values in standard of raw Mahua oil Methyl Ester (Bio-diesel) and Mahua oil has been estimated and assessed. Fire point, Flash point, Cetane number, Iodine value, Viscosity, Saponification Number (SN), Acid value, Calorific value etc of Mahua oil Methyl Ester and Mahua oil have been determined is as shown in Table 1.

Table.1. Properties of mahua oil before and after trasesterification compared with diesel

Fuel Properties	Before		After	
	Diesel	Mahua Oil	Diesel	Mahua Oil
Density at 15^0C, kg/m^3	840	917	840	860
Cetane Number	50	45	50	53
Kinematic Viscosity at 40^0C, mm^2/s	2.6	34	2.6	3.1
Surface Tension at 20^0C, N/m	0.023	0.037	0.023	0.025
Calorific Value, MJ/kg	44.5	38	44.5	44
Specific Heat Capacity J/kg^{0}C	1850	2040	1850	1936
10% Distillation Point, ^{0}C	220	380	220	241
90% Distillation Point, ^{0}C	300	420	300	320
Oxygen, % Weight	0	10	0	10
Latent heat of Evaporation, kJ/kg	250	200	250	240
Bulk Modulus of Elasticity, bar	16,000	19150	16,000	16840
Stoichiometric Air to Fuel Ratio	15.0	13.5	15.0	13.5
Molecular Weight	170	810	170	200

Experimental work: Engine preferred for executing experimentation is a single cylinder, vertical, four stroke, direct injection computerized Kirloskar make CI engine which is water cooled which could sustain greater range of pressures encountered and has been utilized comprehensively in industrial and agriculture sectors. Hence this engine has been chosen for performing experiments. Engine specifications is mentioned below.

Table.2. Engine specification

Engine Parameters	Specifications	Engine Parameters	Specifications
Engine Type	Kirloskar, Four Stroke	Rated Speed	1500rpm
No. of Cylinder	Single	Orifice Meter	13.6mm
Bore	87.5mm	Dynamometer	Eddy Current, Air Cooling
Stroke	110mm	Propeller Shaft	With Universal Joints
Cubic Capacity	661cc	Fuel Injection Pressure	200bar
Compression Ratio	17.5	Fuel Injection Timing	300 ± 10 before TDC
Rated Output	4.4kW		

Engine possesses a DC electrical Dynamometer for measuring its output. Statistically calibration of Dynamometer is done prior to use. Emission measurement in smoke meter depends on light absorption principle by particle. Photo electronic smoke detection depends on the optical detection principle. Every emissions similar to Carbon Dioxide, Un-Burnt Hydrocarbons, Carbon Monoxide, Unused Oxygen and Nitrogen Oxide are identified in 5 gas emission analyzer of model "5G -10, Planet Equipment" has been used. One end connects analyzer inlet and the other end connects exhaust gas outlet end in the cable. Analyzer charging has to be necessarily continuous for working in an effectual way. Technique to measure depends on light absorption principle in the region of infrared, referred to be "non-dispersive infrared absorption".

Experiments have been performed for variable loads like 0, at speed that has been rated, with pressure of 210 bar for injecting and at 650C, cooling water at exit. Three blends of every vegetable oils types namely 10%, 20%, 30%, 40% and 100% (neat oils) have been utilized in current experimentation. Vegetable oils and their blends with diesel have been externally heated to essential temperature as stated prior earlier to injecting into the test cylinder. Engine has been adequately warmed up and stabilized earlier to take every reading. Every observations recorded have been replicated thrice for getting a value that is reasonable. Parameters of performance namely Brake Specific Fuel Consumption (BSFC), Indicated Thermal Efficiency (η_{ith}), Exhaust Gas Temperature (EGT), Brake Thermal Efficiency (η_{bth}), Emission parameters namely Carbon Dioxide (CO_2), Nitrogen Oxides (NO_x), Un-burnt Hydro carbon (UHC), Carbon Monoxide (CO) and Smoke have been estimated. Corresponding parameter of emission and performance of oils have been assessed with pure diesel.

Maximum Torque Calculation: Maximum Torque (T) = (BP x 60 x 1000) / (2πN) = 28.01Nm

Where, BP = Brake Power in kW, N = Rated speed = 1500rpm

Total Fuel Consumption (TFC) = (q / t_f) x Density of fuel = (10×10^{-6} / 23) x 830 = 3.608×10^{-4} Kg/s

Where, q = Volume of fuel consumed = 10×10^{-6} m^3, t_f = Time taken for 10 cc of fuel consumption in s

Brake Power (BP) = (2π N T) / (60 x1000) = 4.166kW

Where, T = Load Torque in Nm, N = Engine speed in rpm.

Indicated Power (IP) = (IMEP x LAN / 2) / (60 x 1000) = 5.193 kW.

Where, IMEP = Indicated Mean Effective Pressure in Pa, L = Stroke length in m.

A = Cylinder area in m^2 = ($\pi D^2 / 4$) = ($\pi \times 0.0875^2 / 4$) = 6.013×10^{-3} m^2

Specific Fuel Consumption (SFC) = (TFC / BP) = 0.311Kg/KWh

Where, TFC = Total Fuel Consumption in kg/h, BP = Brake Power in kW

Mechanical Efficiency (η_m) = (BP / IP) x 100 % = 80.22 %

Brake Thermal Efficiency (η_{bth}) = (BP / (TFC x CV)) x 100% = 25.95 %

Where, TFC = Total Fuel Consumption in kg/h, BP = Brake Power in kW

Indicated Thermal Efficiency (η_{ith}) = (IP / (TFC x CV)) x 100% = 32.34 %

Where, TFC = Total Fuel Consumption in kg/h, IP = Indicated Power in kW

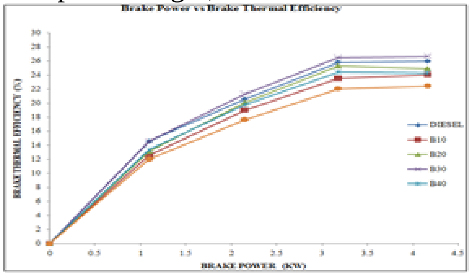

Figure.2. Brake Power Vs Brake Thermal Efficiency

a) BTE goes up with rise in load for every case.

b) MTE is for B30 is 12.32% greater than that of pure diesel. BTE for B10, B20, B40 and pure Mahua Ester are less than that of BTE of pure diesel in Figure 2.

c) Blend B30 was selected as optimum blend for further investigation. Thus we concluded that BTE of diesel engine is not influenced on substituting diesel with Bio-diesel blends.

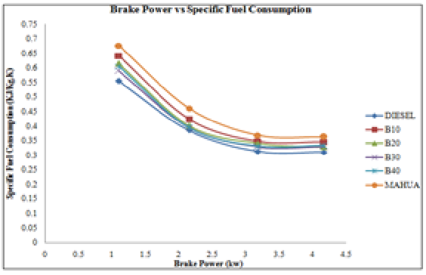

Figure.3. Brake Power vs Specific Fuel Consumption

a) Ratio between MFC to the Brake Power is BSFC.

b) SFC when using Bio-diesel fuel is expected fuel to be increased by 20% as compared to pure diesel.

c) BSFC decreases piercingly with rise in load for every fuels. Primary reason could be that the percent fuel rise necessary for operating the engine is much comparatively losing least heat portion at elevated temperatures.

d) On each 10% of supplemented blending of Bio-diesel in diesel increases mean specific fuel consumption respectively in Figure 3.

e) On calculating BSFC on weight basis, greater densities outcome in greater BSFC values.

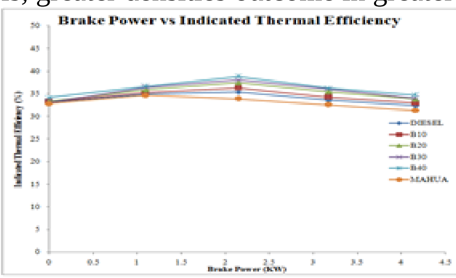

Figure.4. Brake Power vs Indicated Thermal Efficiency

a) ITE slightly rise up with rise in load for every case.

b) Maximum indicated TE is for B30. The ITE for other blends and diesel are slightly less than that of B30 in Fig.4.

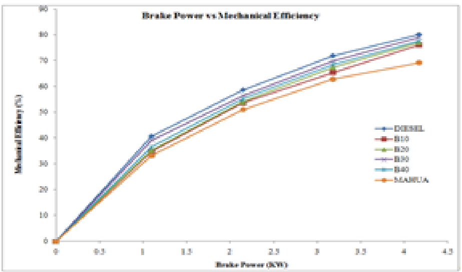

Figure.5. Brake Power Vs Mechanical Efficiency

a) ME goes up with rise in load for every Biodiesel blends.
b) ME for B30 is similar as compared to the diesel.
c) While for other blends B10, B20, B40 and pure Biodiesel are not as much of Biodiesel in Figure 5.

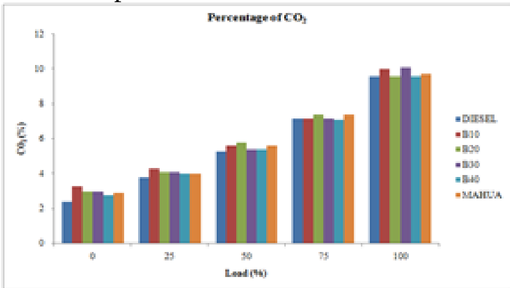

Figure.6. Load Vs Percentage of CO_2

a) The emission of CO_2 rise up with increase in load for diesel and all blends of Biodiesel.
b) The increase in emission of CO_2 indicates that entire fuel combustion take place in the chamber of combustion in Figure 6.
c) On rising of load, the Air-Fuel ratio of fuel supplied shoots up which result in rise in temperature and emission of CO_2.

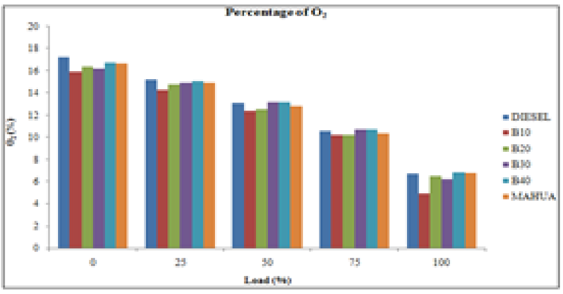

Figure.7. Load Vs Percentage of O_2

a) As the load increases by the emission of O_2 present in exhaust gas decreases linearly.
b) This is due to the utilization of conversion of CO into CO_2 in the combustion chamber.
c) It's evident that the as O_2 composition decreases, the CO_2 (%) Composition increases as shown in above Fig. 7.

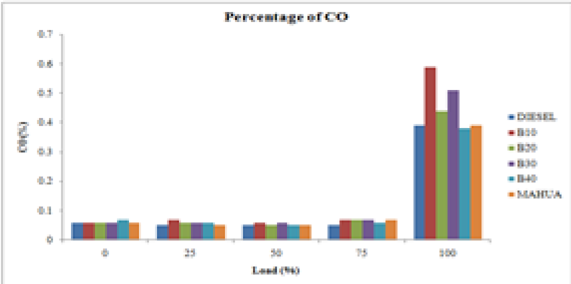

Figure.8. Load Vs Percentage of CO

a) CO primarily declines on increasing load and increased afterward sharply at filled load.
b) This takes place because of unfinished combustion of charge in chamber for combustion.
c) CO emission for the pure Biodiesel is less compared to the diesel.
d) The lower emission of CO generated throughout Biodiesel combustion would get converted as CO_2 by enchanting additional molecules of oxygen available in chain of Biodiesel in Figure 8.

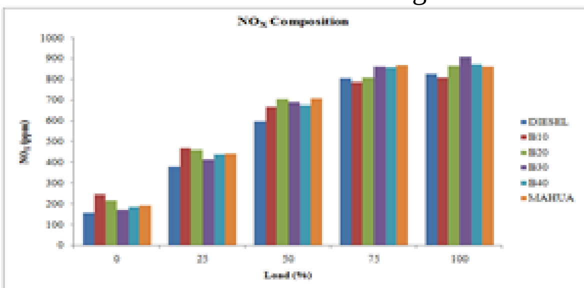

Figure.9. Load Vs Percentage of NO_X

a) The NO_X emission is highly depend on temperature of combustion, together with oxygen concentration available in combustion outcomes.
b) It is observed that rise in Biodiesel proportion in blends gets to rise in NO_X linearly on comparing with diesel.

c) As load gets rise the overall Air-Fuel ratio goes up, ending up in rise in Exhaust Gas Temperature and temperature of chamber for combustion and for this reason formation of NO_X seems to be sensitive compared to temperature increases in Figure 9.

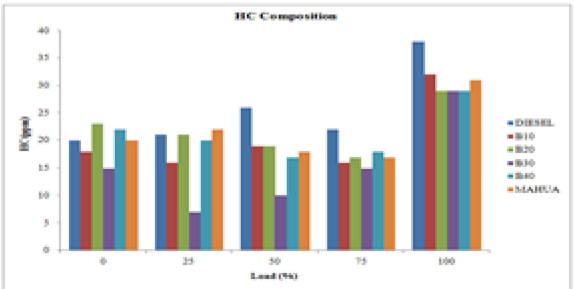

Figure.10. Load Vs Percentage of HC

a) Decline in HC seems to be linear in supplement to blends of Biodiesel.
b) This indicates a more complete combustion of the fuel
c) There is a reduction of 32% of mean HC composition as compared to diesel for maximum power output i.e., B30 in Figure 10.

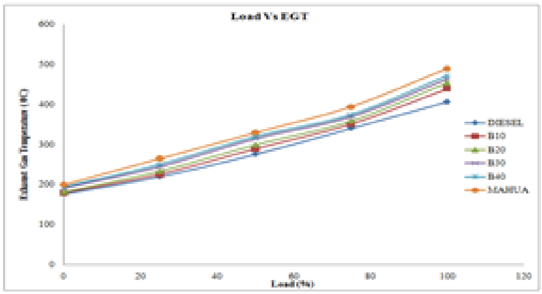

Figure.11. Load Vs Exhausts Gas Temperature

a) EGT goes up with rise in loading of engine. Mean temperature goes up linearly from 185^{0}C at a condition without load to 498^{0}C till entire load in Figure 11.
b) Rise in EGT with load is noticeable from the basic fact that great amount of fuel is necessary for generating additional power required for taking up the supplementary loading.
c) EGT has been identified to maximum for the B30 blend as compared to the diesel and other blends.

ANN for determining performance and emission: On preferring the usages of artificial neural networks, considering those in the conventional computing context seems to be useful. Traditionally computers perform as a “von-Neumann machine”: Instructions have been obtained from memory, later data is processed in CPU as per its instructions, and repetition of this process occurs until every instruction gets finished. This process is predominantly apt to solve issues utilizing a sequence of clearly briefed steps (an algorithm) similarly when an item gets searched in a database. On the other hand there are numerous restrictions for computing conventionally. Primarily, the computer has to be informed in advance the algorithm details, frequently to enormous detail. Nevertheless, still comparatively basic responsibilities for people known as distinguishing faces are highly tough in expressing in a rigid algorithm. Subsequently even when an algorithm is recognized the data utilized has to be as precise as promising. Conventional computers frequently incapable of managing the data variability acquired in the real world. These both troubles find its place in numerous areas where computers have conventionally been weak similar to prediction of data and its classification. In disparity to von-Neumann a circumstance that does not possess any clear algorithmic solutions and are capable of managing noisy imprecise data which permits them for excelling in those areas that conventional computers frequently identify to be difficult.

ANN using back propagation network (BPN) algorithm prediction of % and emission performance of CI engine taking up diesel and Bio-diesel blend parameters used.

```
% Input (Percentage of Blends)
% Output (Mechanical Efficiency, Brake Thermal Efficiency, Torque and Carbon Di Oxide)
%----------------------------------------------------------------------% the ANN model have been created using MATLAB
% the data used to train the model have obtained from experiments conducted on engine
% MATLAB program starts
%=========================================
% Input parameter values are initialized for the training model
% the 2 input parameters for 0 Kg are:
% d - percentage of diesel in blend
% b - percentage of Bio-diesel in blend
```

```
d_b=[100,90,80,70,60;0,10,20,30,40];
% Output parameter values are initialized as target values
% the 4 output parameters for 0 Kg are:
% mef - Mechanical Efficiency
% bef - Brake Thermal Efficiency
% t - Torque
% co2 - Carbon Di Oxide
mef=[0,0,0,0,0];
bef=[0,0,0,0,0];
t= [0, 0, 0, 0, 0];
co2 = [2.40, 3.30, 3, 3, 2.80];
%========================================
% ARTIFICIAL NEURAL NETWORK (ANN) MODEL
%========================================
% neural network for the 1st output parameter
% A new neural network is created
net1_c=newff(minmax(d_b),[12,1],{'tansig','purelin'},'trainlm');
% maximum quantity of epochs to train is defined
net1_c.trainParam.epochs=1000;
% performance goal id defined
net1_c.trainParam.goal=0.01;
% training of the network is performed
% training happens until a maximum quantity of epochs takes place
% performance goal has been met, or any other stop condition met
net1_c=train (net1_c, d_b,mef);
net2_c=newff (minmax(d_b),[12,1],{'tansig','purelin'},'trainlm');
net2_c.trainParam.epochs=1000;
net2_c.trainParam.goal=0.01;
net2_c=train(net2_c,d_b,bef);
net3_c=newff(minmax(d_b),[12,1],{'tansig','purelin'},'trainlm');
net3_c.trainParam.epochs=1000;
net3_c.trainParam.goal=0.01;
net3_c=train(net3_c,d_b,t);
net4_c=newff(minmax(d_b),[12,1],{'tansig','purelin'},'trainlm');
net4_c.trainParam.epochs=1000;
net4_c.trainParam.goal=0.01;
net4_c=train(net4_c,d_b,co2);
%========================================Prediction of Output Parameter Values for a
Given Blend %Percentage
%========================================% A loop is created so that user can simulate
values based on users wish
Choice = 1;
while choice == 1;
% loop is created
clc
%clear screen
fprintf('\n*************************************');
d=input('\n\n Enter the disel percentage in the blend');
b=input('\n Enter the Biodisel percentage in the blend');
fprintf('\n*************************************');
test=[d;b];
% A test array is created for the input
op1=sim(net1_c,test);
op2=sim(net2_c,test);
op3=sim(net3_c,test);
op4=sim(net4_c,test);
% simulation of efficiency value
```

```
fprintf('\n\n SIMULATED OUTPUT:');
fprintf('\n MECHANICAL EFFICIENCY=%f',op1);
fprintf('\n BRAKE THERMAL EFFICIENCY=%f',op2);
fprintf('\n TORQUE=%f',op3);
fprintf('\n CARBON DI OXIDE=%f',op4);
fprintf('\n***********************************');
choice=input('\n do you want to continue press"1":');
end
% end of loop
```

2. CONCLUSION

a) The performance and emission test for Mahua Methyl Ester was conducted on single cylinder diesel engine successfully.

b) Mahua Methyl Ester could be directly added utilized in the diesel engine unless making any alteration up to 30% blend.

c) Brake thermal efficiency at varying dissimilar loads was identified to be greater for diesel and other blends B10, B20, B40 when compared to B30.

d) Mechanical efficiency at different loads was similar for diesel as compared to blend B30.

e) Specific fuel consumption is increased by increase of blends of Mahua Methyl Ester with diesel as compared to diesel.

f) CO, CO_2, HC, O_2, NO_X at dissimilar loads have been identified to be similar for diesel as assessed with blend B30.

g) Engine performance and emission is predicted utilizing ANN. To train network, blends are used as the input layer, while output layers Torque, Mechanical efficiency, Brake thermal efficiency, Carbon-di-oxide. Values are predicted for various blends of diesel and Bio-diesel.

h) Emission of HC and temperature distribution inside the engine is predicted using the ANSYS – CFD FLUENT.

The future of Bio-diesel is growing. More companies are offering this solution to the customers. In current stage only diesel powered automobiles could be used in new fuel which has been predictable for changing in the forthcoming years. Mounting anxiety of off-shore oil together with environmental troubles possess groups in an uproar. Previously numerous kinds of companies utilize Biodiesel as their chief source to transport. The Yellowstone National Park bus system utilizes a combination of Bio-diesel and petroleum for running the entire fleet. Tests conducted by the government encompass the proven that this kind of fuel is entirely much functional and protected than petroleum beds products. As the fossils bed runs dry, each day Scientists goes near the novel alternative. Rapidly Biodiesel would form the novel power source. Though research and steady testing, Biodiesel is highly productive than the petroleum dependent products. This kind of product would become the new power source. For diesel automobiles together with other individuals power sources very much necessitate surviving and living. Previous to long, this supply type will be in vehicles and also in homes.

REFERENCES

Najafi, Ghobadian G, Yusaf B, Rahimi T, Combustion Analysis of a C.I. Engine Performance Using Bio-Diesel Fuel with an Artificial Neural Network aid, American Journal of Applied Sciences, 2007.

Pugazhvadivu M, and K. Jeyachandran K, Investigations on the Performance and Emission of a Diesel Engine Using Preheated Mahua Oil as Fuel, Renewable Energy, 30, 2005, 2189-2200.