# STUDIES ON NANO TECHNOLOGY AND WASTE COOKING OIL USING NANO MATERIALS

**SHREEDHAR S BANDE[1] RAJSHEKHAR B SAJJAN[2]**

"[1] Lecturer, Department of Mechanical Engineering, Government Polytechnic Vijayapura, Vijayapura-586101, India"

"[2] Lecturer, Department of Mechanical Engineering, Government Polytechnic Vijayapura, Vijayapura-586101, India"

**A B S T R A C T**

In this work, research is being done on the effect of various nanomaterials on waste cooking oil (WCO) biodiesel. The nanomaterial considered in this work is magnesium oxide. In addition, the above nanomaterials are mixed with WCO biodiesel using a utrasonicator at a dose of 30 mg. Subsequently, properties such as flash point, fire point, density, viscosity and caloric value of the WCO body dispersed by the nanomaterial mentioned above are examined. It has been observed from the result that the density of the prepared sample increased slightly compared to the diesel. The viscosity of the prepared sample (of 30 mg doping) increases as the mixture increases and is less than diesel. The estimated amount of the prepared sample (30 mg doping) increases as the mixture increases and is less than diesel. It has been observed from the result that the flash point and fire point increase as the combination increases and is less than diesel.

**Keyword: WCO, ANN, IC, ULTRASONICATOR.**

## 1.0 Introduction

The inception of artificial neural networks (ANNs) originated from the working of the human brain. It uses neurons organized in a structured way to carry out certain computations Gives an idea of research to give materials with sizes less than 100 nm called nanomaterials. The nanomaterials term consists of nanocrystalline-materials, nanocomposites, & carbon-nanotubes. Generally, there are 4- types of nanomaterials: nanomaterials (carbon based), nanomaterials (Metal based), Dendrimers & Composites. When these nanoparticles included in conventional fluids defined as Nano fluids. Nano fluids clearly gives increased thermo-physical-properties depends on the volume fraction of nanoparticles, shape & size of the nanomaterials.

WCO termed to the utilized vegetable oil obtained after cooking of food. WCO has many demerits like: Water & soil pollution, Concern of human health and Disturbance to the aquatic system. So, rather throwing into and polluting the atmosphere, it is used as less cost raw material for the production of biodiesel. WCO is small expensive than pure-vegetable oil. If these WCO is utilized by the animals, then it reverses into the chain through the animal meat. So, this WCO must put carefully that is not harmful to human. In this paper, an overview of Multilayer neural network, Feed-forward network, Weight determination and the procedure involved in it. The concept of nanotechnology and Waste Cooking Oil is discussed.

In this paper, discusses in detail the research works reported in the literature and state of art regarding the Artificial Neural Network for the parameters from CI/SI Engine.

The paper discusses the Methodology and experimentation of preparation of biodiesel using WCO and dispersion of nanomaterial, Property evaluation and development of neural network model.

### 1.2. Objectives of the Present Study

The purpose of the project is to develop a Multilayer Neural Network Model for the estimation of properties of WCO Biodiesel dispersed with nanomaterial. The blow are the specific objectives

- To produce WCO (Waste Cooking Oil) based biodiesel.
- To disperse the nanomaterial in biodiesel from WCO using ultrasonicator.
- To evaluate the properties of WCO biodiesel dispersed with nanomaterial
- To develop a multilayer neural network model for the estimation of properties of WCO biodiesel fuel dispersed with nanomaterial.

## 2.0. Literature Review

Systematic review of the literature concerned to neural network development for the parameter estimation of IC engines The nomenclature used by various authors in the original work has been retained. The works reported in the literature are discussed below:

In the present scenario, due to continued & limited supply of petroleum, prices are increasing. Because of this reason, there is a need to find some alternate fuels for diesel which can be used to run the diesel engines [1]. The emissions and performance parameter investigation of CI engine make use of biodiesel as a fuel has been carried out through testing and experiments [2-3]. Nevertheless, testing of compression ignition (CI) engine over an entire operating range requires lots of fuel, time and money [2-3]. Alternatively, mathematical models [4-5] and artificial neural networks (ANNs) [6-15] employed to predict the performance-emission characteristics. However, implementation of mathematical models, requires the computational effort to solve the mathematical equations which can prevent the use of mathematical models in the engine controller [5]. Alternative, emission and performance parameters of internal combustion (IC) engine has been estimated by using ANN [7-13] as it has some advantages over conventional modelling techniques.The brief description of ANNs used in the literature to estimate the emissions, performance and other parameters using diesel blended with biodiesel. Sekmen et. al. [7] generated two back propagation algorithms to compute the performance and emission parameters. It is concluded that Levenberg Marquart (LM) is better to predict the parameters. The modification to diesel engine has been done to operate with CNG and diesel fuels combination thereafter developed an ANN for the estimation of performance-emission parameters discussed in [8]. Some of the authors [9-10] have estimated performance-emission characteristics of diesel engine employing various blends of biodiesel

The ANN is modelling to predict combustion characteristics and emission constituents of light duty CI engine has been discussed and the key factors like transfer function type, algorithm for training and neurons number and methods for optimum network settings has also been highlighted in this paper [11]. Further, some of the authors [12-13] investigated the performance-emission analysis of CI engine runs on diesel, biodiesel dispersed with nanoparticles employing artificial neural network. The work related to blend of diesel and single biodiesel has been appeared in the previous articles. However, mixing or of two biodiesels may improve the inferior property of one biodiesel by blending with other biodiesel, which has the superior property, another motivation for blending two or more biodiesels is that different varieties of tree born oilseeds of biodiesel are available; they may be in small quantity. The quantity of biodiesel, which are less in quantity, so these biodiesels can be mixed and used in engines by blending with diesel. Srithar et al examined the performance-emission characteristics of diesel engine, experimentally by two biodiesel mixture blended with diesel blend as an alternative fuel [14]. However, no work has been carried out related to the estimation of fuel properties using ANN.

## 3.0 Material and Methods

## 3.1 Selection of Materials

### 3.1.1 Selection of Nanomaterials

Magnesium Oxide (MgO) was chosen as base Nanomaterial for preparation of WCO biodiesel blends in this study.

### 3.1.2 Selection of Modifiers

In this thesis, one nanomaterial is chosen to blend with the WCO biodiesel. The selected nanomaterial is listed below,

1. Magnesium Oxide (MgO)

## 3.2 Types of equipment used

For producing biodiesel from various oils which require the following types of equipment

Table 1 Types of equipment

| S. No. | Name of equipment | Quantity |
|---|---|---|
| 1 | Magnetic stirrer | 1 |
| 2 | Thermometer | 1 |
| 3 | Beakers | 2 |
| 4 | Flask | 1 |
| 5 | Conical flask | 1 |
| 6 | Separating funnel | 1 |
| 7 | Digital balance | 1 |

Figure 1.0: Set up for the preparation of biodiesel.

## 3.3 Transesterification for the preparation of biodiesel.

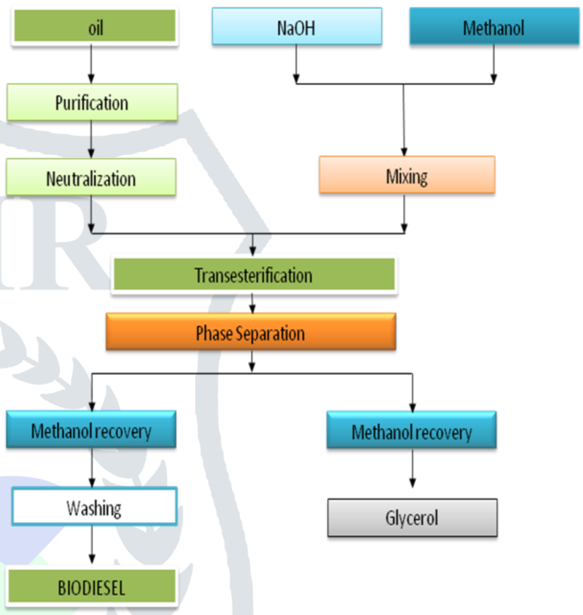


Figure 2.0: preparation of biodiesel


## 3.4 Prepared samples of biodiesel.

Figure 3.0: Sample of Biodiesel

### 3.4.1 Steps involved in biodiesel production

Step1: Preheating of feedstock.
Step 2: NaOH pellets and methoxide solution.
Step3: Transesterification reaction.
Step4: Settlement of different layers.
Step5: Three time washing of biodiesel.

### 3.5 Magnesium Oxide (MgO)

The technical specifications are given in Table 2. Further, the image of XRD Analysis, UV Spectrometer analysis and TEM analysis are depicted in Figures 4 to 5.

Table 2: Technical specifications of magnesium oxide

| Sl. No. | Specifications | Value/Quantity |
|---|---|---|
| 1. | Molecular Formula | MgO |
| 2. | Average Particle Size | 30-60 nm |
| 3. | SSA | 30-50 $m^2/g$ |

From Fig. 4 desipites they are having amorophus in nature and from the Fig. 5 it is reveals that Magnesium Oxide material are having spherical in shape and their size ranges about 30 to 60 nm.

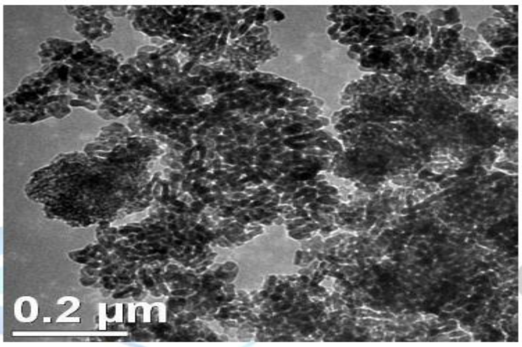


Figure 4.0: TEM analysis of Magnesium oxide


Figure 5.0: XRD analysis of Magnesium oxide

Magnesium oxide nanoparticles: are weighed to a predefined weight say 50mg dispersed into the blends of WCO biodiesel with the use of ultrasonicator @ a frequency of 20 kHz for 50 minutes. The resulted nanoparticles blended WCO biodiesel is named as WCO biodiesel + nanomaterial. The nanomaterial blends were kept in container under static conditions to check the stability.

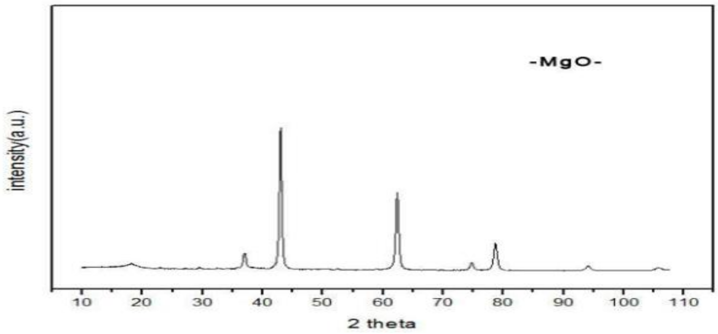


Figure 6.0: Mgo with weighing machine


Figure 7.0: Dispersion of Nano-particles with bio diesel

### 3.6 Multi-Layer Neural Network Model

The Multilayer Neural Network (MLNN) shown in Fig. 8.0. model employed for mapping purpose since it is a universal approximate for demonstration of non-linear plants. The advantages of ANN that is used for the nonlinear system, helpful to provide input-output relationship, adaptive and fault tolerant. The parameters are modeled are using one MLNN. The NN output is denoted by equation (3.1).

$$P(\mathbf{w}) = f[x_1, x_2, ... x_n, \mathbf{w}] \quad (3.1)$$

where $P \times (\mathbf{w})$ be the expected output of multilayer neural network. The hyper-bolic tangent function denoted by Eqn (3.2) is used as the starting function for the unseen layer whereas linear starting function specified by Eqn (3.3) be employed for the output layer [23,24].

$$\phi_{\tanh}(v) = \tanh(v) \quad (3.2)$$

$$\phi_{lin}(v) = v \quad (3.3)$$

where, $v$ is input to the neuron. Further, w is the weight factor vector and $x_1, x_2, ... x_n$ characterize the system inputs.

The inputs to MLNN are B10, B20, B30, B40. The weights $\mathbf{w}$ are determined by minimizing the cost function $\xi(\mathbf{w})$ given by equation (3.4).

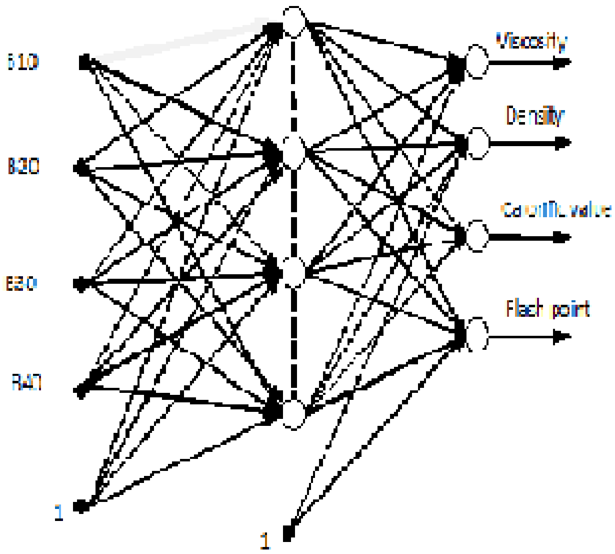


Figure 8.0: Multi-layer neural network

$$\xi(\mathbf{w}) = \frac{1}{2N}\sum \varepsilon(\mathbf{w})^2 + \frac{1}{N}\mathbf{w}^T D\mathbf{w} \quad (3.4)$$

where $\varepsilon(\mathbf{w}) = y - \hat{y}^*(\mathbf{w})$ and $D$ is the weight decay matrix and is given by equation (3.5).

$$D = \beta \times [I]_{m\times m} \quad (3.5)$$

where, $\beta$ is the weight decay term and $I$ is the identity matrix. To get better of the overview, data on network points are separated arbitrarily into three subsets consists of 70%, 15% and 15% of data. The early stopping technique is employed to choose most excellent epoch (Fig.9.0).

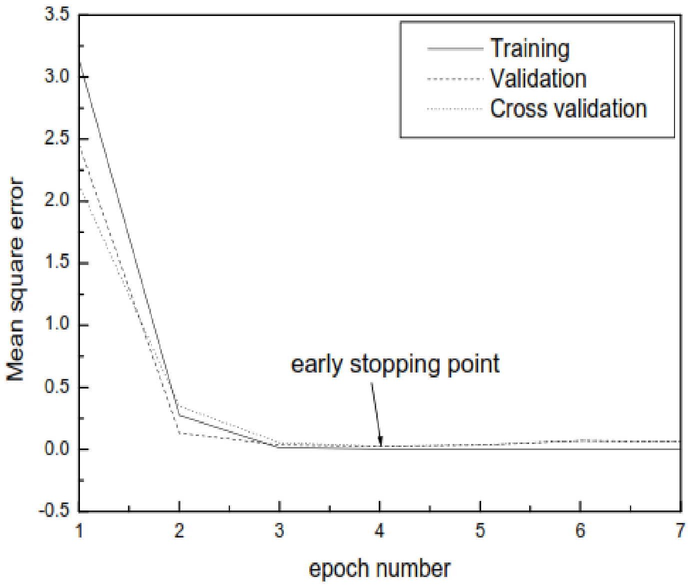


Figure 9.0: Performance of network.

Table 3. Results of MLNN model to calculate the properties

| S. No. | Parameters | Architecture | MSE-Validation |
|---|---|---|---|
| 1 | Viscosity, Density, CV, Flash point | 2_2H_5 | 0.1263 |
| 2 | Viscosity, Density, CV, Flash point | 2_4H_5 | 0.1066 |
| 3 | Viscosity, Density, CV, Flash point | 2_6H_5 | 0.0957 |
| 4 | Viscosity, Density, CV, Flash point | 2_8H_5 | 0.0473 |
| 5 | Viscosity, Density, CV, Flash point | 2_10H_5 | 0.0953 |

Different structures of MLNN are varying from 2 to 10 are trained using neural network toolbox of MATLAB®2013. The topology that gives minimum MSE for validation data is selected as the best topology to predict the parameter (Table 3). The best architectures as found above are used for predicting emissions at any given operating points of engine.

## 4.0. RESULTS

### 4.1 Testing of prepared diesel samples

Testing of the samples have been done to find out flash point, fire point, density, viscosity and calorific value by using different experimental setup.

#### 4.1.1. Flash and fire Point

The cup is filled with the fuel sample up to the mark. The cup is heated electrically. The rise of temperature is controlled by regulator and rise on thermometer is constantly watched. Test flame is lighted. The test flame is first applied at a temperature about 100°C. Test for the flash point is carried for every 5°C to 10°C rise. The temperature at which the liquid catches fire is gives the flash point of the fuel. Fire point is estimated by continuing heating further at the same rate. Note down the temperature at which air vapor mixture gets ignited and continue to burn for at least five seconds when the test flame is brought near to it.

#### 4.1.2 Viscosity

Viscosity of the fuel is measured by using Redwood viscometer. The viscosity of the oil to be measured is poured in to a cup surrounded by water jacket. The thermometer is clamped in position. Weight of empty 50ml measuring flask is noted. The heater is switched on and temperature of oil in the cup is monitored. When the oil reaches the temperature at which viscosity is to be determined, heating is stopped.50ml measuring flask is placed below the jet. The ball valve is lifted and simultaneously the stop watch is started. The stop watch is stopped and ball valve is closed when the oil in the flask crosses the 50ml mark. Then weight of the flask with 50ml of oil is noted.

#### 4.1.3 Calorific value (CV)

Calorific value (CV) of the fuel is measured by using Bomb calorimeter. Approximately1 gm of a given fuel sample is taken into a pellet. The pellet is weighed accurately and placed in the crucible. Sufficient length of cotton thread and fuse wire are weighed carefully. One end of the cotton thread is kept in contact with the pellet and the other end is attached to the fuse wire. The fuse wire is attached to the leads and electric ignition system circuit is completed. The bomb is assembled and filled with oxygen. The calorimeter vessel is filled with water and thermometer is inserted. Initial reading of thermometer is noted and the fire button is pressed to ignite the fuel. Then the temperature readings of the water are taken down till it reaches a maximum value.

Table 4. Properties of Diesel and WCO blends with Mgo(30mg)

| Sl. No. | Property | Diesel (B0) | WCO+MgO | | |
|---|---|---|---|---|---|
| | | | B10 | B30 | B50 |
| 1. | Density (kg/m3) | 832 | 839.6 | 858.8 | 878 |
| 2. | Viscosity (cSt) | 2.27 | 2.86 | 4.03 | 5.2 |
| 3. | Calorific value (kJ/kg) | 44000 | 43320 | 41960 | 40600 |
| 4. | Flash point ( °C) | 69 | 66.7 | 85.8 | 99.6 |
| 5. | Fire point ( °C) | 53.4 | 68.9 | 109 | 131 |

The criterion used for measuring the model accuracy in regression analysis is coefficient of determination (R2) or Correlation Coeficient (R). The COD measures the strength of relationship between estimated and measured variables and can be expressed as Eq. (4.1)

$$R^2 = \left( \frac{N \times \sum X_{meas} \times X_{est} - \sum X_{meas} \sum X_{est}}{\sqrt{\left[ N \times \sum X_{meas}{}^2 - \left( \sum X_{meas} \right)^2 \right] \left[ N \times \sum X_{est}{}^2 - \left( \sum X_{est} \right)^2 \right]}} \right)^2 \tag{4.1}$$

where, N, $X_{meas}$, and $X_{est}$ are number of operating points in a data set, measured variable and estimated variable, respectively and R2 represents coefficient of determination.

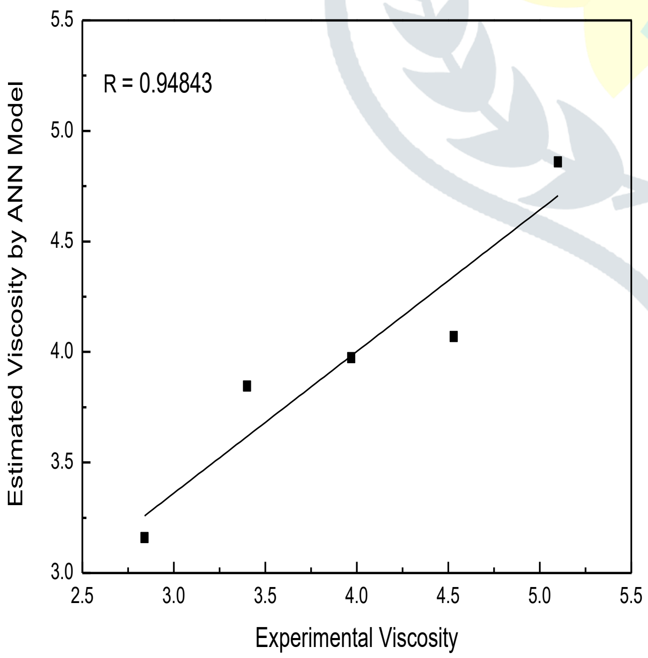


Figure 10.0: Experimental and estimated viscosity

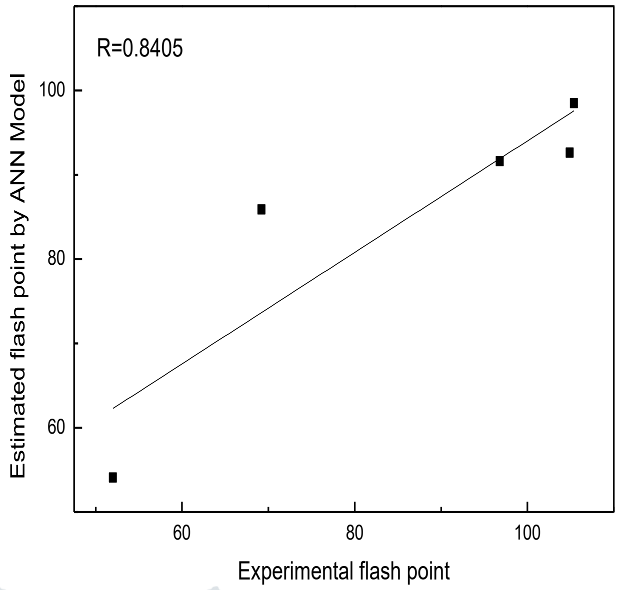


Figure 11.0: Experimental and estimated flashpoint

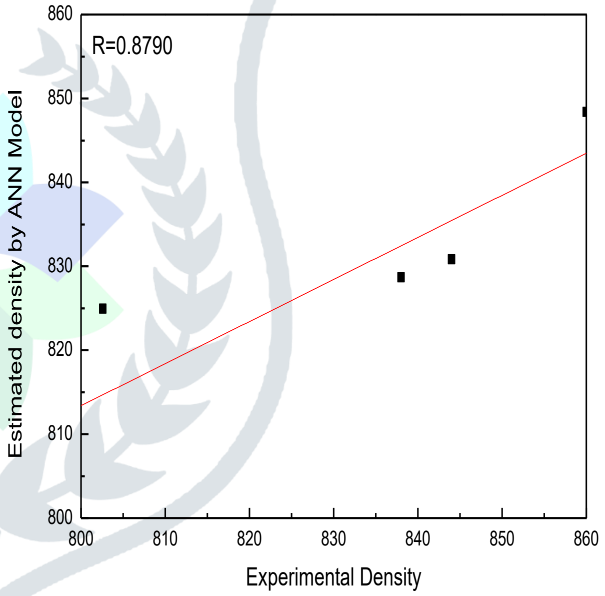


Figure 12.0: Experimental and estimated density

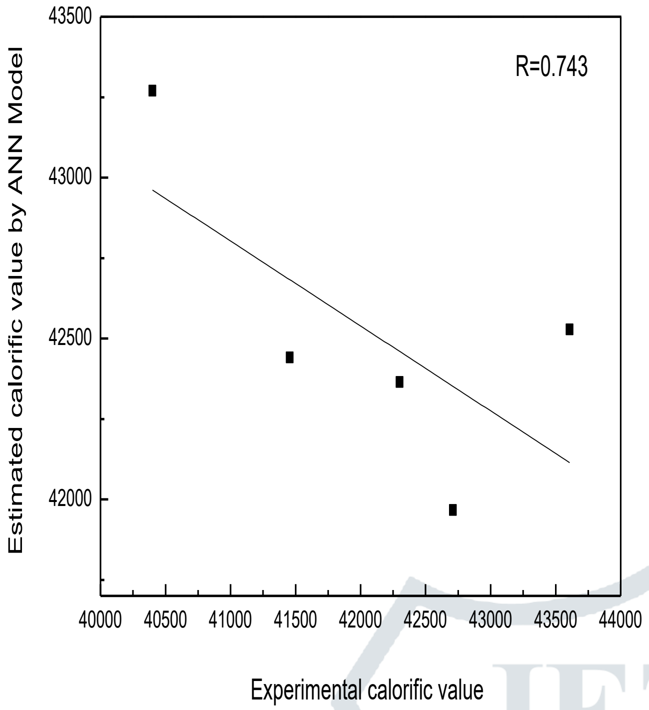


Figure 13.0: Experimental and estimated calorific value

## 5. Conclusions

The following conclusions are highlighted from the present work:

1. In this study, biodiesel is produced through transesterification process from waste Cooking oil.
2. The properties of biodiesel are tabulated to train the neural network.
3. The Neural Network Model is developed for the estimation of properties of WCO biodiesel.
4. The developed MLNN models are capable of predicting Viscosity, Density, CV and Flash Point for inputs as it gives good R value.

## 6.0 Reference

[1] S.P. Singh, D. Singh, Biodiesel production through the use of different sources and characterization of oils and their esters as the substitute of diesel: A review, Renew. Sust. Energ. Rev. 14 (2010) 200-216.

[2] M. Mofijur, A.E. Atabani, H.H, Masjuki, M.A.Kalam, B.M. Masum, A study on the effects of promising edible and non-edible biodiesel feed stocks on engine performance and emissions production: a comparative evaluation, Renew. Sustain. Energ. Rev. 23 (2013) 391–404.

[3] S. Cenk, G. Metin, C. Mustafa, Influence of injector number on the performance and emissions of a DI diesel engine fuelled with biodiesel-diesel fuel blends, Appl. Therm. Eng. 61 (2013) 121-128.

[4] S. Arumugam, G. Sriram, P.S. Subramanian, Application of artificial intelligence to predict the performance and exhaust emissions of diesel engine using rapeseed oil methyl ester, Procedia. Eng. 38 (2012) 853–860.

[5] K.P. Rao, T.V. Babu, G. Anuradha, B.V.A. Rao. IDI diesel engine Performance and exhaust emission analysis using biodiesel with an artificial neural network (ANN), Egypt. J. Pet. 26 (2017) 593–600.

[6] J.I. Ramos, Internal combustion engine modeling. Hemisphere Publishing Corporation, Washington DC; 1989.

[7] Y. Sekmen, M. Golcu, P. Erduranli, Y. Pancar, Prediction of performance and smoke emission using artificial neural network in diesel engine, Math. Comput. Appl. 11(3) 2006 205-214

[8] T.F. Yusaf, D.R. Buttsworth, K.H. Saleh, B.F. Yousif, CNG-diesel engine performance and exhaust emission analysis with the aid of artificial neural network, Appl. Energy 87(5) 2010 1661–1669.

[9] H. Og˘uz, I. Sarıtas, H.E. Baydan, Prediction of diesel engine performance using biofuels with artificial neural network, Expert. Syst. Appl. 37 2010 6579–6586.

[10] H.M. Ismail, H.K.Ng, C.W. Queck, S. Gan, Artificial neural networks modelling of engine-out responses for a light-duty diesel engine fuelled with biodiesel blends, Appl. Energy. 92 (2012) 769-777.

[11] S. Roy, R. Banerjee, B.K. Bose, Performance and exhaust emissions prediction of a CRDI assisted single cylinder diesel engine coupled with EGR using artificial neural network, Appl. Energy. 119 (2014) 330–340.

[12] C.M. Kshirsagar, R. Anand, Artificial neural network applied forecast on a parametric study of Calophyllum inophyllum methyl ester-diesel engine out responses, Appl. Energy. 189 (2017) 555–567

[13] S.H. Hosseini, A. Taghizadeh-Alisaraei, B. Ghobadian, A. Abbaszadeh-Mayvan, Artificial Neural Network Modelling of Performance, Emission, and Vibration of CI Engine Using Alumina Nano Catalyst Added to Diesel – Biodiesel Blends, Renew. Energy. 149 (2019) 951-961.

[14] K. Srithar, K.A. Balasubramanian, V. Pavendan, B.A. Kumar, Experimental investigations on mixing of two biodiesels blended with diesel as alternative fuel for diesel engines, J. King Saud Univ. Eng. Sci. 29 (2018) 50-56.

[15] S. Haykins, Neural networks: a comprehensive foundation, Pearson Education Inc, ISBN 81-7808-300-0, 2002.