Performance Characteristics of Biodiesel Blend in CI Engine using Artificial Neural Network (Karanja Oil)

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***Abstract*— The rise in price and consumption of petroleum products and their effects on the industrialization and modernization of the world have been one of the key issues of the researchers. CI (Diesel) engine, one of the sectors based on the fossil fuel, is a prime issue for environmentalists and economists. To overcome this problem and as a substitute for diesel, biofuel is a better option to conserve the limited reserve of fossil fuels such as petroleum, coal and natural gas. Biodiesel, which is produced from variety of vegetable oils and animal fat through transesterification, has a lot of technical advantages over fossil fuels such as lower overall exhaust emission and toxicity, biodegradability, derivation from a renewable and domestic feedstock and negligible sulphur content. This paper deals with artificial neural network (ANN) modelling of a diesel engine using variable Karanja oil blends to predict the engine performance. To acquire data for training and testing the proposed ANN, a Single cylinder, four-stroke diesel engine was fuelled with blended diesel and operated at different engine speeds and loads. The experimental results exposed that blends of Karanja oil with diesel fuel provide better engine performance. Using some of the experimental data for training, an ANN model was developed based on standard Back-Propagation algorithm for the engine. Analysis of the experimental data by the ANN showing that there is a good correlation between the predicted data resulted from the ANN and with the measured ones. Therefore, the ANN proved to be a desirable prediction method in the evaluation of the tested diesel engine parameters.**

***Keywords*— Artificial Neural Network; b p- Brake Power; bsfc- Brake Specific Fuel Consumption; mse- Mean square Error; KO- Karanja Oil**

I. INTRODUCTION

The world is moving towards a sustainable energy era with major emphasis on energy efficiency and use of renewable energy sources. Liquid bio-origin fuels are renewable fuels coming from biological raw material and have been proved to be good substitutes for oil in transportation and agriculture sector. These fuels are gaining worldwide acceptance as solution for the problem of environmental degradation, energy security, restricting import, rural employment and agricultural economy. The most promising available biofuels market sans subsidy is ethanol, methanol, vegetable oil based fuel. Researchers are also striving to develop second generation biofuels from cellulosic materials using different conversion processes [1].

The world is getting modernized and industrialized day by day. As a result vehicles and engines are increasing, but energy sources used in these engines are limited and decreasing gradually. This situation leads to seek an alternative fuel for diesel engine. Biodiesel is an alternative fuel for the diesel engine. The esters produced from vegetables oil and animal fats are known as Biodiesel. This paper investigates the prospect of making of biodiesel from karanja oil. Karanja curcas is a renewable non-edible plant [2].

Artificial neural networks (ANN) are used to solve a wide variety of problems in science and engineering, particularly for some areas where the conventional modeling methods fail. A well trained ANN can be used as a predictive model for a specific application, which is a data-processing system inspired by biological neural system. The predictive ability of an ANN results from the training on experimental data and then validation by independent data. An ANN has the ability to re-learn to improve its performance of new available data [3].

An ANN model can accommodate multiple input variables to predict multiple output variables. It differs from conventional modeling approaches in its ability to learn about the system that can be modeled without prior knowledge of the process relationships. The prediction by a well-trained ANN is normally much faster than the conventional simulation programs or mathematical models as no lengthy iterative calculations are needed to solve differential equations using numerical methods but the selection of an appropriate neural network topology is important in terms of model accuracy and model simplicity. In addition, it is possible to add or remove input and output variables in the ANN if it is needed. The objective of this study was to develop a neural network model for predicting engine parameters like brake power, fuel consumption and torque in relation to input variables such as engine speed and biofuel blends. This model is of a great importance due to its ability to predict engine performance under varying conditions [4].

A K Aggrawal et al have analyzed the performance and emission characteristics of a compression ignition engine fuelled with Karanja oil and its blends (10%, 20%, 50% and 75%) vis-a-vis mineral diesel. The effect of temperature on the viscosity of Karanja oil has also been investigated. Fuel preheating in the experiments – for reducing viscosity of Karanja oil and blends has been done by a specially designed heat exchanger, which utilizes waste heat from exhaust gases. A series of engine tests, with and without preheating/pre-conditioning have been conducted using each of the above fuel blends for comparative performance evaluation. The performance parameters evaluated include thermal efficiency, brake specific fuel consumption (BSFC), brake specific energy consumption (BSEC), and exhaust gas temperature. Karanja oil blends with diesel (up to 50% v/v) without preheating as well as with preheating can replace diesel for operating the CI engines giving lower emissions and improved engine performance [5].

T.K. Gogoi et al have developed that a cycle simulation model incorporating a thermodynamic based single zone combustion model to predict the performance of diesel engine. The effect of engine speed and compression ratio on brake power and brake thermal efficiency is analysed through the model. The fuel considered for the analysis are diesel, 20%, 40%, 60% blending of diesel and biodiesel derived from Karanja oil (Pongamia Glabra). The model predicts similar performance with diesel, 20% and 40% blending. However, with 60% blending, it reveals better performance in terms of brake power and brake thermal efficiency[6].

Mustafa Canakci et al have discussed that the prediction of the engine performance and exhaust emissions is carried out for five different neural networks to define how the inputs affect the outputs using the biodiesel blends produced from waste frying palm oil. PBDF, B100, and biodiesel blends with PBDF, which are 50% (B50), 20% (B20) and 5% (B5), were used to measure the engine performance and exhaust emissions for different engine speeds at full load conditions. Using the artificial neural network (ANN) model, the performance and exhaust emissions of a diesel engine have been predicted for biodiesel blends [7].

B Ghobdian et al deals with artificial neural network (ANN) modeling of a diesel engine using waste cooking biodiesel fuel to predict the brake power, torque, specific fuel consumption and exhaust emissions of the engine. To acquire data for training and testing the proposed ANN, a two cylinder, four-stroke diesel engine was fuelled with waste vegetable cooking biodiesel and diesel fuel blends and operated at different engine speeds. It was observed that the ANN model can predict the engine performance and exhaust emissions quite well with correlation coefficient (R) 0.9487, 0.999, 0.929 and 0.999 for the engine torque, SFC, CO and HC emissions, respectively. The prediction MSE (Mean Square Error) error was between the desired outputs as measured values and the simulated values were obtained as 0.0004 by the model [8].

II. EXPERIMENTAL SET UP

The experimentation was carried out on single cylinder four stroke direct injection medium speed naturally aspirated water cooled diesel engine.

A computerized automatic testing and acquisition system was installed so that the speed, fuel feed, air consumption and output torque could be controlled and the combustion process, different points pressure measurement, speed (rpm) measurement and cooling water flow measurement transported to this acquisition system could be measured as well.

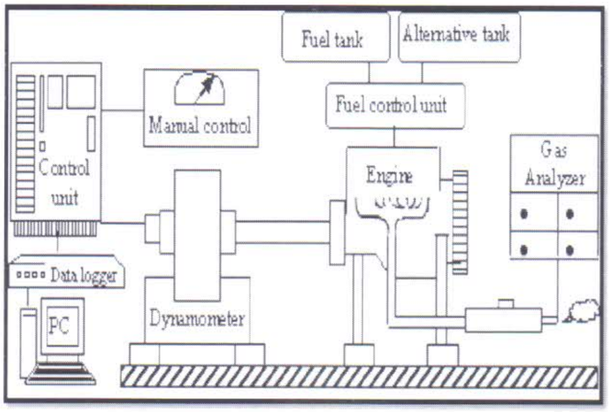

Fig.1 Experimental Setup

The data were displayed promptly on the monitor as well as stored by the computer. The schematic layout of complete experimental set up is shown in figure- 1. The basic data of the engine are given in table no. 1.

TABLE I
SPECIFICATION OF THE ENGINE

S.No.	Parameter	Specification
1	Make	Kirloskar Oil Engines Limited
2	Model	AV1
3	Type	1 Cylinder 4 Stroke
4	Bore	0.08 m
5	Engine No	10.1012/0600106
6	Stroke	0.11 m
7	Displacement	500 cc
8	Fuel	H.S.Diesel
9	Lubricating oil	SAE 30 / SAE 40
10	Rated Power	3.7 kW (5 hp)
11	Injector operating Pressure	15 MPa
12	Injector Timing	220 BTDC(Static)
13	Compression Ratio	17:1
14	Engine Speed	(1400-1600)rev/min
15	IVC	370 ABDC or (217 deg)
16	EVO	300 BBDC or (510 deg)

An engine dynamometer is used to measure the performance of the Single Cylinder Four Stroke Diesel engines. The engine is clamped on test bed and a shaft is connected to the dynamometer rotor. An electric brake dynamometer or electric generator is a device that converts mechanical energy to electrical energy. The specifications of the dynamometer are given in table no. 2.

Dynamometer was used to apply the load on the engine. The applied load causes the engine to produce a reaction torque (Newton's third law of action and reaction).

The product of the torque with the engine speed gives the output power. Figure 2 illustrates the operating principle of a dynamometer.

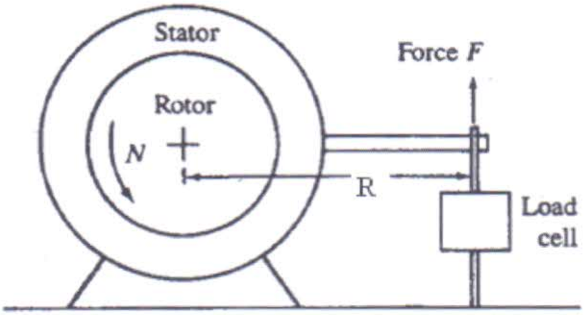

Fig. 2 Schematic diagram of Dynamometer

The rotor is coupled electromagnetically to a stator, which is supported in low friction bearings. [9]

The stator is balanced with the rotor stationary. The torque is exerted on the stator with weights. Using the notation in figure 2, if the torque exerted by the engine is T:

$\tau = F \times R$ 1

The brake power (bp) delivered by the engine and absorbed by the dynamometer is the product of torque and angular speed:

$\text{Brake Power} = 2\pi N\tau$ .... 2.

TABLE II
THE MAIN SPECIFICATION OF THE DYNAMOMETER

S.No.	PARAMETER	SPECIFICATION
1	Make	Kirloskar Brothers Limited
2	S. No.	07WKJD0013
3	Model	KBM-104
4	Type	Electric Brake air cooled
5	Output	4 KVA
6	Rated Speed	1500 rpm
7	Volt	250 V
8	Ampere	17.4 A
9	P.F.	1
10	Frequency	50 Hz
11	Arm Length	215 mm

A. Data acquisition computer set up

All computation is performed by a personal computer and a LABVIEW software customized by K.C. Engineers is shown in figure 3. A computational thread performs cycle analysis on full 720' cycles of pressure data, and makes the data available to a control thread through a status object.

Fig. 3 Data acquisition computer set up

A Lab View data acquisition system is used to condition and log signals from all of the sensors. Analog signals are amplified and low-pass filtered using a National Instruments SCXI 1327 instrumentation amplifier. Thermocouple signals are amplified using a National Instruments SCXI 1112 thermocouple amplifier. Analog to digital conversions are performed using an eight channel, 16 bit card resident in a PC. Pulses from the flow meter are counted using a TDS 3034B digital oscilloscope and converted into flow rate using the sensor's calibration factor. Acquisition of data from the oscilloscope is also controlled through the Lab View software. Figure 4 of the LABVIEW user interface was used to set user inputs and record engine data. Data from the dynamometer is recorded in one of two modes. In the default strip chart mode, the channels are scanned once per second and the data are written in a file which provides a record of everything that happened in the course of an experiment. These data are also written on virtual indicators and strip charts displayed on a software panel to provide real-time graphical indications of the state of the experiment.

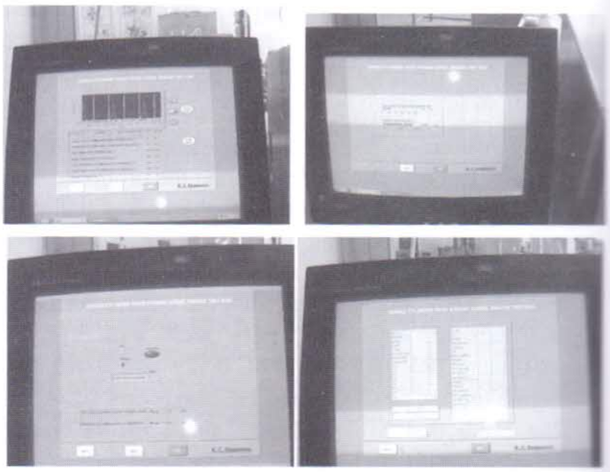

Fig. 4 LabView custom graphical user interface (GUI)