Performance and Emissions Characteristics of Cotton Seed Oil Biodiesel Blend in CI Engine using Artificial Neural Network (Back Propagation)

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Abstract: ***Unique the ascent in cost and utilization of petroleum items and their impacts on the industrialization and modernization of the world have been one of the key issues of the specialists. CI (Diesel) engine, one of the parts in light of the fossil fuel, is a prime issue for tree huggers and financial experts. To defeat this issue and as a substitute for diesel, bio fuel is a superior alternative to ration the constrained store of fossil energizes, for example, petroleum, coal and common gas. Biodiesel, which is created from assortment of vegetable oils and creature fat through transesterification, has a considerable measure of specialized focal points over fossil fills, for example, lower general fumes discharge and harmfulness, biodegradability, inference from a renewable and residential feedstock and immaterial sulphur content. This paper manages simulated neural system (ANN) demonstrating of a diesel engine utilizing variable Cotton seed oil mixes to foresee the engine execution. To obtain information for preparing and testing the proposed ANN, a Single chamber, four-stroke diesel engine was fuelled with mixed diesel and worked at distinctive engine speeds and loads. The exploratory results uncovered that mix of cotton seed oil with diesel fuel give better engine execution. Utilizing a percentage of the trial information for preparing, an ANN model was created taking into account standard Back-Propagation algorithm for the engine. Examination of the exploratory information by the ANN demonstrating that there is a decent connection between's the anticipated information came about because of the ANN and with the deliberate ones. Subsequently, the ANN turned out to be an attractive expectation system in the assessment of the tried diesel engine parameters.***

Keywords: Artificial Neural Network; BP - Brake Power; BSFC - Brake Specific Fuel Consumption; MSE - Mean square Error; CO - Cotton seed Oil; BTE – Brake warm efficiency; Emissions – CO, HC, NOx, SMOKE and EGT.

1. Introduction

The world is moving towards a feasible vitality time with real accentuation on vitality productivity and utilization of renewable energy sources. Fluid bio-inception fills are renewable energizes originating from natural crude material and have been turned out to be great substitutes for oil in transportation and agribusiness area. These energizes are increasing overall acknowledgment as answer for the issue of ecological corruption, energy security, limiting import, rustic job and rural economy. The most encouraging accessible bio fuels market sans sponsorship is ethanol, methanol, and vegetable oil based fuel. Specialists are additionally endeavouring to grow second era bio fuels from cellulosic materials utilizing distinctive change forms [1].

The world is getting modernized and industrialized step by step. Therefore vehicles and engines are expanding, however energy sources utilized as a part of these engines are constrained and diminishing progressively. This circumstance prompts look for an option fuel for diesel engine. Biodiesel is an option fuel for the diesel engine. The esters delivered from vegetables oil and creature fats are known as Biodiesel. This paper examines the possibility of making of biodiesel from cotton seed oil. Cotton seed oil is a renewable non-consumable plant [2].

Counterfeit neural systems (ANN) are utilized to take care of a wide assortment of issues in science and designing, especially for a few territories where the ordinary displaying routines come up short. An all around prepared ANN can be utilized as a prescient model for a particular application, which is an information handling framework roused by natural neural network. The prescient capacity of an ANN results from the preparation on trial information and after that approval by free information. An ANN can re-figure out how to enhance its execution of new accessible information [3].

An ANN model can suit various data variables to foresee numerous yield variables. It contrasts from routine demonstrating methodologies in its capacity to find out about the framework that can be displayed without former information of the procedure connections. The forecast by a very much prepared ANN is typically much quicker than the traditional reproduction projects or scientific models as no extensive iterative figuring's are expected to illuminate differential mathematical statements utilizing numerical routines however the choice of a fitting neural system topology is essential as far as model precision and model effortlessness. Also, it is conceivable to include or evacuate info and yield variables in the ANN on the off chance that it is required.

The target of this study was to build up a neural system model for foreseeing engine parameters like brake force, fuel utilization and torque in connection to information variables, for example, engine velocity and bio fuel mixes. This model is of an extraordinary significance because of its capacity to anticipate engine execution under changing conditions [4].

AK Aggrawal etal have dissected the execution and emanation qualities of a pressure ignition engine fuelled with Karanja oil and its mixes (10%, 20%, half and 75%) versus mineral diesel. The impact of temperature on the consistency of Karanja oil has additionally been researched. Fuel preheating in the analyses – for lessening thickness of Karanja oil and mixes has been finished by a uniquely outlined warmth exchanger, which uses waste warmth from fumes gasses. A progression of engine tests, with and without preheating/pre-molding have been directed utilizing each of the above fuel mixes for similar execution assessment. The execution parameters assessed incorporate warm proficiency, brake particular fuel utilization (BSFC), brake particular vitality utilization (BSEC), and fumes gas temperature. Karanja oil mixes with diesel (up to 50%v/v) without preheating and with preheating can trade diesel for working the CI engines giving lower outflows and enhanced engine execution [5].

T.K. Gogoi etal have added to that a cycle re-enactment model in corporating a thermodynamic based single zone burning model to foresee the execution of diesel engine. The impact of engine pace and pressure proportion on brake power and brake warm effectiveness is examined through the model. The fuel considered for the examination are diesel, 20%,40%, 60% mixing of diesel and biodiesel got from Karanja oil (Pongamia Glabra). The model predicts comparative execution with diesel, 20% and40% mixing. Be that as it may, with 60% mixing, it uncovers better execution as far as brake power and brake warm efficiency [6].

Mustafa Canakci et al have examined that the forecast of the engine execution and fumes discharges is completed for five diverse neural systems to characterize how the inputs influence the yields utilizing the biodiesel mixes created from waste browning palm oil. PBDF, BI00, and biodiesel mixes with PBDF, which are 50 % (B50), 20 % (B20) and 5% (B5), were utilized to quantify the engine execution and fumes emanations for diverse engine paces at full load conditions. Utilizing the simulated neural system (ANN) model, the execution and fumes discharges of a diesel engine have been anticipated for biodiesel mixes [7].

B Ghobdian et al manages simulated neural system (ANN) displaying of a diesel engine utilizing waste cooking biodiesel fuel to anticipate the brake force, torque, and particular fuel utilization and fumes outflows of the engine. To gain information for preparing and testing the proposed ANN, a two barrel, four-stroke diesel engine was fuelled with waste vegetable cooking biodiesel and diesel fuel mixes and worked at distinctive engine rates. It was watched that the ANN model can anticipate the engine execution and fumes emanations entirely well with relationship coefficient (R) 0.9487, 0.999, 0.929 and 0.999 for the engine torque, SFC, CO and HC outflows, separately. The expectation MSE (Mean Square Error) blunder was between the coveted yields as measured qualities and the mimicked qualities were acquired as 0.0004 by the model [8].

2. Experimental Setup

The study was completed in the IC engine research facility on a test engine test apparatus comprising of a solitary chamber, water cooled, four strokes, vertical, stationary and consistent rate diesel engine joined with whirlpool flow sort dynamometer for stacking. It likewise contains the fuel supply framework for supplying fuel, water cooling framework for engine cooling, oil framework and different sensors and instruments incorporated with information procurement framework for online estimation of burden, air and fuel stream rate, fumes gas temperature, cooling water temperature.

The setup empowers the assessment of thermal performance and emission constituents of the engine. The thermal performance parameters incorporate brake power; brake thermal efficiency, brake specific fuel consumption, and fumes gas temperature. Thermocouples are given at fitting positions and are perused by a computerized temperature marker with channel selector to choose position. The setup likewise incorporates the important measuring instruments for the estimation of smoke thickness and fumes gas discharges. The fumes discharges of the engine are investigated by utilizing a fumes gas analyser. The constituents of the fumes gas like CO, HC and NOx are measured with fumes gas analyzer. The basic line graph and photographic perspective of the exploratory setup are appeared in Fig.1 and 2 individually.

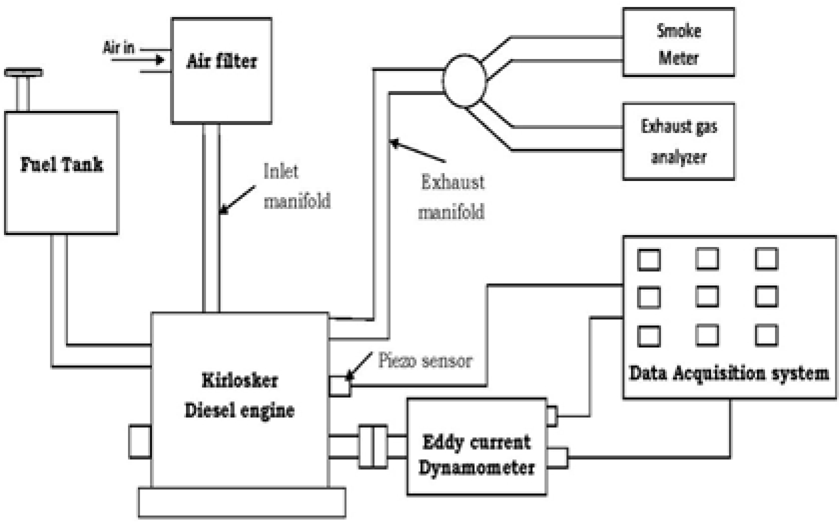


Figure 1: Experimental Setup

Figure 2: Single Cylinder Four Stroke Diesel Engine

The test engine utilized as a part of the present work is a solitary chamber, normally suctioned, direct infusion pressure ignition engine of Kirloskar make. This diesel engine has a drag of 80mm and stroke of 110mm.The detail of the engine is demonstrated supplement - A. The engine has an appraised yield of 5HP at a rate of 1500rpm. The engine was coupled to a swirl current sort dynamometer to apply the heap on the engine with an electrical board. The engine is mounted on a stationary edge with a suitable cooling framework. The greasing up framework is inbuilt in the engine is associated with a swinging – field electrical generator meter with Ward – Leonard control that permitted the engine to be begun and engineed in like manner. The heap is controlled by element changing the field part current. The perusing of burden (voltage and current) is noted from the information securing board altered to engine test setup by the producer and the force retained is computed.

The trial study is led at different burdens and henceforth an exact and solid burden measuring framework is an absolute necessity. The heap measuring arrangement of this test apparatus comprises of a dynamometer of vortex current sort, a heap cell of strain gage sort and a stacking unit. The heap is connected by supplying current to the dynamometer utilizing a stacking unit. The heap connected to the engine is measured by a heap cell.

A dynamometer is a gadget which is utilized for measuring power, torque or force created by a engine. It can likewise be utilized to apply load or torque on the engine. The dynamometer utilized as a part of this study is a whirlpool flow sort with a water cooling framework. The swirl current dynamometers give favourable position of faster rate of burden change for quick load setting.

The pace of the engine is measured by utilizing an electro-attractive pickup as a part of conjunction with a computerized pointer settled to information securing board. An attractive pickup is fitted close to the fly wheel of the engine with pins mounted on the fringe. The signs produced are bolstered to the show unit that is graduated to point the pace specifically in scope of cycles every moment (rpm).
Fuel is given to the engine from the fuel tank through the measuring instrument settled to information securing board. The rate of fuel stream is found by measuring the time required for the utilization of a known measure of fuel i.e. 10 cc from the measuring instrument.

A Nickel-Nickel chromium thermocouple settled to the ventilation system of the engine fumes valve is utilized for measure of fumes gas temperature. The perusing of Exhaust gas temperature is noted from the information procurement board settled to engine test setup by the producer.

The outflow estimation framework is utilized to gauge the constituents of fumes gas and its darkness (smoke number). This framework comprises of a fumes gas analyzer and a smoke meter. The fumes gas analyzer measures the fumes gas constituents of Carbon monoxide (CO), Oxides of nitrogen (NOx) and Unburnt Hydrocarbons (HC). The smoke meter is utilized to gauge the force of fumes smoke

Bosch smoke meter is utilized to quantify the smoke thickness. The fumes screen comprises of a smoke chamber which contains the smoke section through which the smoke from fumes channel of the engine is passed and smoke thickness is measured. The gas to be measured is encouraged into the smoke chamber. The gas enters the smoke segment at its inside. The smoke segment is a tube, which has a light source and a finder set toward one side. The murkiness of smoke is specifically relative to the lessening of light between a light source and an indicator. The brake force of the engine at distinctive working conditions was resolved utilizing the accompanying mathematical statement:

$$BP = (V * I)/1000 \text{ - kW.}$$

Where,
BP = Brake power in kW.
V = Voltmeter perusing in Volts.
I = Ammeter perusing in Amps.
Mass of fuel utilization:

$$Mf = Xcc * \text{Specific gravity of fuel}/1000 * t \text{ - kg/sec}$$

Where,
Xcc is the volume of the fuel devoured = 10ml
T is the time taken in seconds
The brake particular fuel utilization of the engine at distinctive working conditions was resolved utilizing the comparison as given beneath:

$$BSFC = mf * 3600/B.P \text{ - kg/kW – hr.}$$

Where,
mf is mass of fuel devoured in kg/sec.
B.P is brake power in kW.
The brake warm productivity of the engine at diverse working conditions was resolved utilizing the accompanying comparison:

$$BTE = 3600/(CV \times BSFC)$$

Where,
BTE = Brake warm productivity, %
CV = Calorific estimation of fuel utilized, kJ/kg
BSFC = Brake particular fuel utilization, g/kW – hr

3. Experimental Procedure

In the first phase of examination analyses were directed at evaluated engine velocity of 1500 cycles for every moment with the mixes of aforementioned biodiesels.

Execution and emanation qualities of Cotton seed biodiesel mixes with diesel as fuel in CI engine tests are led at 75%

burden with diesel and Cotton seed biodiesel mixes [B5, B10, B15, B20, B25 and B30] for breaking down changed parameters like brake warm proficiency, brake particular fuel utilization (BSFC), fumes gas temperature, outflows of CO, HC, NOx and smoke thickness.

The warm intensity of diesel is 27.82%, where concerning Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 27.58%, 27.35%, 27.06%, 26.8%, 26.2% and 22.5% separately.

The BSFC of diesel is 0.305 kg/kW-hr, where concerning Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 0.304 kg/kW-hr, 0.308 kg/kW-hr, 0.312 kg/kW-hr, 0.316 kg/kW-hr, 0.324 kg/kW-hr and 0.379 kg/kW-hr separately.

The fumes gas temperature for the diesel is 2850C, where concerning Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 2870C, 2900C, 2920C, 2960C, 3050C and 3200C separately.

The smoke thickness for the diesel is 0.62 Bosch, where concerning Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 0.625 Bosch, 0.63 Bosch, 0.64 Bosch, 0.65 Bosch, 0.67 Bosch and 0.67 Bosch separately.

The HC outflow for diesel oil is 72 ppm and for Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 71 ppm, 69 ppm, 67 ppm, 65 ppm, 64 ppm and 62 ppm separately.

The CO outflow for diesel oil is 0.63% volume and for Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 0.63% volume, 0.62%, 0.61% volume, 0.6% volume, 0.58% volume and 0.56% volume.

The NOx outflow for diesel oil is 680ppm and for Cotton seed biodiesel mixes B5, B10, B15, B20, B25 and B30 are 685ppm, 690ppm, 695ppm, 700ppm, 710ppm and 715ppm separately.

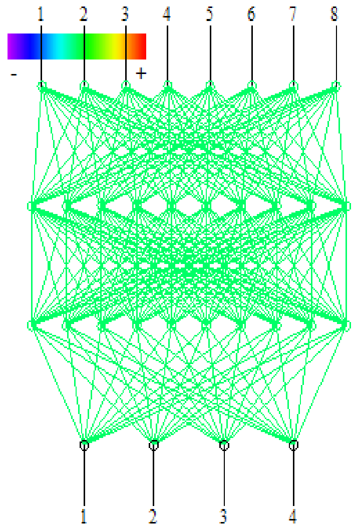
4. ANN Model for Single Cylinder Four Stroke Diesel Engine

The utilization of ANNs for demonstrating the operation of interior burning motors is a later advance. This methodology was utilized to foresee the execution and outflows of diesel motor. Essentially, an organic neuron gets inputs from different sources, joins them somehow, performs by and large anon-direct operation on the outcome, and after that yields the last result.
The system for the most part comprises of an information layer, some shrouded layers, and a yield layer. A well known calculation is the back-proliferation calculation, which has distinctive variations. Back-spread preparing calculations inclination plummet and slope drop with energy are regularly too moderate for handy issues in light of the fact that they require little learning rates for stable learning. Moreover, accomplishment in the calculations relies on upon the client subordinate parameters learning rate and force consistent. Speedier calculations, for example, conjugate angle, semi Newton, and Levenberg-Marquardt (LM) use standard numerical streamlining methods.

These calculations dispose of a portion of the disservices said above. ANN with back-spread calculation learns by changing the weights, these progressions are put away as information. LM strategy is truth be told a guess of the Newton's technique. The calculation utilizes the second-arrange subordinates of the expense work so that better merging conduct can be gotten.

In the customary angle drop look, just the first request subordinates are assessed and the parameter alter data contains exclusively the course along which the expense is minimized, though the Levenberg-Marquardt procedure removes more critical parameter change vector. Assume that we have a capacity E(X) which should be minimized concerning the parameter vector x. The blunder amid the learning is called as root-mean squared (RMS)[II].

OUTPUT



INPUT

Figure 3: ANN model of the Diesel Engine

To get the best forecast by the system, a few architectures were assessed and prepared utilizing the test information. The back-engendering calculation was used in preparing of all ANN models. This calculation utilizes the managed preparing procedure where the system weights and predispositions are instated arbitrarily toward the start of the preparation stage. The blunder minimization procedure is accomplished utilizing an inclination plunge principle. There were four data and eight yield parameters in the test tests. The four data variables are fuel, the rate of biodiesel mixing, burden in amps and calorific worth in KJ/Kg. The eight yields for assessing motor execution and outflows are Brake power in KW, Brake warm effectiveness, Specific fuel utilization in Kg/Kw-hr, CO in rate of volume, HC in ppm, NOx in ppm, Smoke thickness in Bosch and EGT in 0C. In this manner, the data layer comprised of 4 neurons and the yield layer had 8 neurons. The quantity of shrouded layers and neurons inside of every layer can be outlined by the multifaceted nature of the issue and information set. Game plan of the model is appeared in figure 6.

In this study, the quantity of concealed layers changed from one to two. To guarantee that every info variable gives an equivalent commitment in the ANN, the inputs of the model were pre-handled and scaled into a typical numeric extent. The initiation capacity for the shrouded layer was chosen to be logsig straight capacity suited best for the yield layer.

This course of action of capacities in capacity estimation issues or displaying is regular and yields better results. In any case, numerous different systems with a few capacities and topologies were inspected. Three criteria were chosen to assess the systems and accordingly to locate the ideal one among them. The preparation and testing execution (MSE) was been 0.00001 for all ANNs. The unpredictability and size of the system was likewise essential, so the littler ANNs had the need to be chosen.

At last, a relapse examination between the system reaction and the comparing targets was performed to research the system reaction in more detail. Diverse preparing calculations were additionally tried lastly Levenberg-Marquardt (trainlm) was chosen. The PC program MATLAB, neural system tool stash was utilized for ANN outline.

In this study, for every one of the systems, the learning calculation got back to engendering was connected for the single concealed layer. Scaled conjugate slope (SCG) and Levenberg-Marquardt (LM) have been utilized for the variations of the calculation. These standardized both for the inputs and yields are acknowledged between the estimations of 0 and 1. Neurons in the information layer have no exchange capacity. Logistic sigmoid (logsig) exchange capacity has been utilized.

ANN was prepared and tried by method for the MATLAB programming on a standard Pc. With a specific end goal to recognize the yield correctly to train stage expanded number of neurons (5-8) in the shrouded layer was attempted. Firstly, the system was prepared effectively, and after that the test information were utilized to test the system. By method for the outcomes concluded by the system, an examination was did utilizing the measurable techniques. Blunders that happened at the learning and testing stages are depicted as the RMS and R', mean mistake rate values, which are characterized as takes after, separately.

$$R^2 = 1 - \frac{\sum_j (t_j - o_j)^2}{\sum_j (o_j)^2} \quad \text{------------1}$$

$$RMS = \left(\left(\frac{1}{P}\right) \sum_j (t_j - o_j)^2 \right)^{1/2} \quad \text{-------2}$$

$$\text{Mean \% Error} = \frac{1}{P} \sum_j \left(\frac{t_j - o_j}{t_j} \times 100 \right) \quad \text{----3}$$

Where t is the objective quality, o is the yield worth, and p is the example. Exploratory results for diverse fills and biodiesel mixes are utilized as the preparation and test information for the ANN. The RMS, R2 and the mean blunder rate qualities were utilized for looking at all of them.

5. Result and Discussion

The test tests in the scope of 0% to 30% mixes were tried in the research facility and demonstrate the accompanying contrasts, while contrasting and standard diesel.

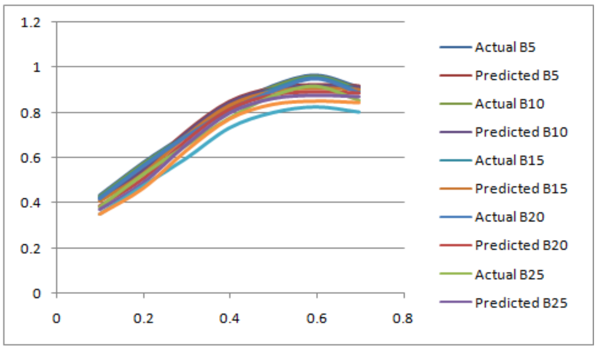


Figure 4: Load vs. BTE

- In Figure 4, appears at steady speed of 1500 rpm it is watched that the brake warm effectiveness (B.T.E.) diminishes with the increment in Cotton seed oil content in diesel. This decline in productivity is less; contrasted with the capacity of the ignition framework to acknowledge the Cotton seed oil mixes as fuel. This may be because of the high thickness of Cotton seed oil content in the mixes, and this may corrupt fuel splash qualities and lead to ill-advised ignition,

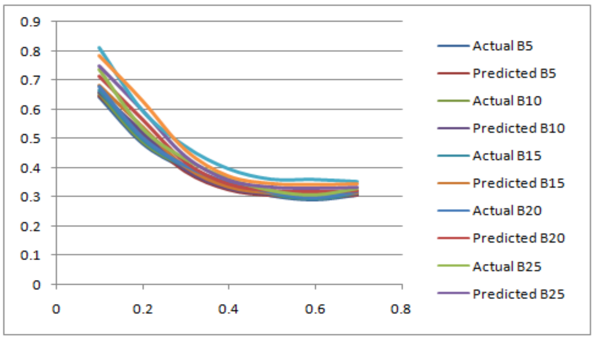


Figure 5: Load vs. BSFC

- Figure 5 demonstrates variety of BSFC as for motor burden. The bigger measure of biodiesel is supplied to the motor contrasted with that of diesel. Thusly, BSFC is higher for biodiesel than diesel. Brake particular vitality utilization (BSEC) is a perfect variable in light of the fact that it is autonomous of the fuel.

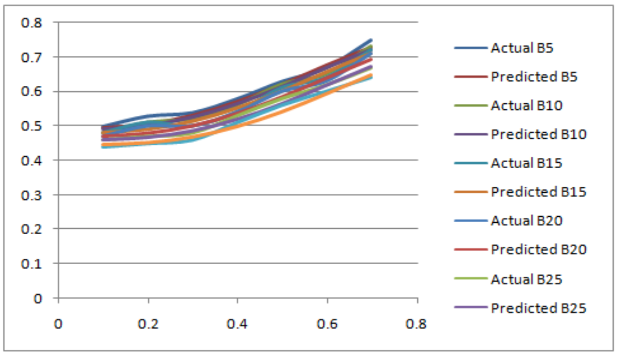


Figure 6: Load vs. CO

Figure 6 demonstrates variety of CO regarding motor burden. The CO discharges are expanded with expansion in motor load and diminish with the ascent in measure of biodiesel inside of the mixes. The lower CO emanation of biodiesel mixes contrasted with diesel oil is because of the vicinity of oxygen in biodiesel that aides in complete oxidization of fuel. The increment in the amount biodiesel will builds the oxygen vicinity in the fuel, encourage this rich oxygen reasons to lessen CO discharge

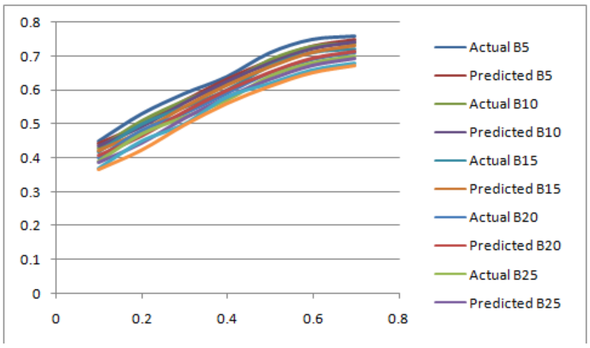


Figure 7: Load vs. HC

Figure 7 indicates variety of HC concerning motor burden. The HC discharges depend on blend quality i.e. measure of oxygen accessible. The HC emanations increments with expanding the heap on the motor and lessen with expansion in amount of bio diesel in the blend. Lower warming worth of biodiesel prompts infuses more amounts of fuel for a comparable burden condition. Contrasted with diesel, the oxygen content with in the bio diesel is extra. More measure of biodiesel prompts more oxygen either natural in fuel or present inside of the charge. This abundance oxygen helps for better burning fuel. So that the HC discharges of Cotton seed biodiesel mixes are not exactly the diesel oil.

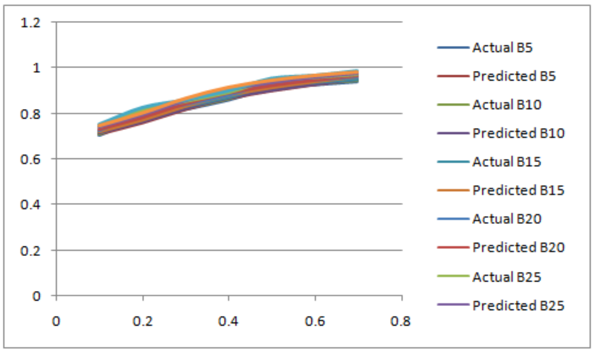


Figure 8: Load vs. NOx

Figure 8 demonstrates variety of NOx as for motor burden. The NOx outflow will increment with expansion in burden on the motor for every diesel and Cotton seed biodiesel mixes. These higher NOx outflows could be because of the higher temperature inside of the burning chamber at higher burdens. The NOx emanations are marginally higher for Cottonseed biodiesel mixes as contrasted and immaculate diesel.

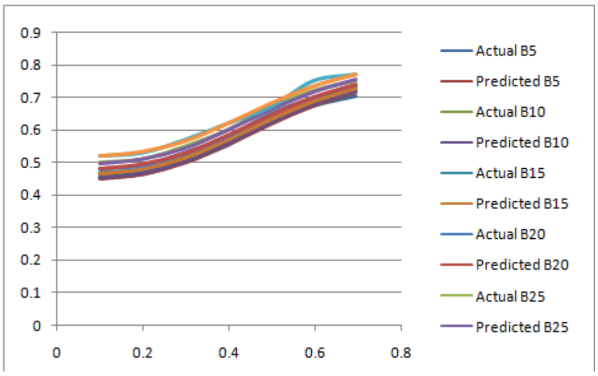


Figure 9: Load vs. SMOKE

Figure 9 indicates variety of Smoke as for motor burden. The smoke thickness will increment with the ascent of motor burden. For all heaps the smoke thickness of the biodiesel mixes was perpetually on top of that of diesel oil. The smoke thickness will increment because of incline burning and high ignition delay. The biodiesel blend has high viscousness, bigger fuel bead development and diminishes in fuel air consolidating rate. These are the components worried to expand the smoke thickness of biodiesel mixes. The smoke thickness of the motor with diesel fuel is lower as contrasted and the Cottonseed biodiesel mixes.

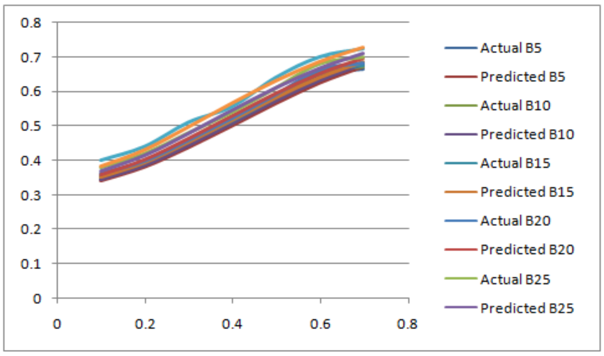


Figure 10: Load vs. EGT

The fumes gas temperature was found to reach out with expansion in both the centralization of biodiesel inside of the blend and motor burden. The ascent in EGT with motor burden is because of the real truth that a more amount of fuel is required inside of the motor to get extra power required to take up contingent stacking. Fumes gas temperature for B-25 is most elevated. For the diesel oil the fumes gas temperature is most reduced as contrasted and the biodiesel mixes.

6. Conclusions

A test examination was led to investigate the execution of Cotton seed oil and its fuel mixes with diesel in an immediate infusion single-chamber diesel motor and the outcomes acquired recommend the accompanying conclusions:

- Pure Diesel and mixes of Cotton seed oil and diesel oil displayed comparative execution and extensively comparable emanation levels under similar working conditions.
- A fake neural system (ANN) was produced and prepared with the gathered information of this exploration work.

The outcomes demonstrated that the preparation calculation of Back-Propagation was sufficiently adequate in anticipating particular fuel utilization, Brake warm effectiveness, Emissions CO, HC, NOx, Smoke thickness and EGT for distinctive motor rates and diverse fuel mixes proportions.

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