International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 06 | Jun 2022 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL AND COMPUTATIONAL ANALYSIS ON PERFORMANCE AND EMISSION CHARACTERISTICS OF PLASTIC OIL- NEEM OIL AND ITS BLEND WITH DIESEL IN MULTI FUEL ENGINE

VH AKSHAY[1], ELDHO RAJ[2]

[1]VH AKSHAY Student M.Tech Thermal Power Engineering, Mar Athanasius College Kothamangalam
[2]Professor Eldho Raj, Dept. of Mechanical Engineering, Mar Athanasius College, kerala, India

---

Abstract - *An In this work. Compositions of individual alternative fuels are taken with reference to the calorific value, specific gravity, cetane number etc. they are blended in the suitable proportion. Is that their properties correlate with each other for perfectly blending with diesel fuel, as per the international standards and with reference to various other parameters, fuels are selected, which are (Plastic oil, Neem oil and their 10% blends). They are considered in blend ratio of B20, (which is 20% blend and 80% diesel fuel), Plastic oil B20, Neem oil B20 and their blends forming Plastic-Neem oil blended with 80% diesel. The objective is to create a fuel alternative to diesel. The performance and emission characteristics were taken from a multi fuel engine model Kirloskar AV1 having 5hp power produced from this single cylinder, constant speed, naturally aspirated engine whose compression ratio is 17. And the emissions like NOx, CO, CO2, HC, NO2, Smoke etc. taken separately from AVL smoke meter C47 and Di gas analyzer. Since testing in an engine involves a lot of efforts, time and cost, CFD analysis on ANSYS Forte is tried. Modelling of a combustion chamber for a bowl-shaped profile is initiated. The fuel is added by understanding the chemical reactions and physical properties exhibited by the considered fuel through the chemkin fuel library, blend fuels mixture ratios are selected based on the mass fraction of the considered species and afore mentioned emission. Graphs validates the results to suggest for an alternative fuel.*

Key Words: Chemkin, Multi-Fuel Engine, Performance and Emission, Forte, Bowl geometry, B20.

1. INTRODUCTION

Reaping fuels by crude oil extraction process is the phenomenon of past, the world is in the rally to quench the thirst of never-ending source of alternative fuel methods, though a lot of research advancements have led the way to and some are in the stage of developing alternative fuels, but faces difficulties from the initial phase of finding raw materials to the process where the fuels getting fully ready to be used in engines, polluting substances, mushy and toxic effluents, particular matter etc., contribute to the greenhouse gasses which is a cause of ozone layer depletion, melting of polar ice caps etc. Charging of electric vehicle batteries cannot be accomplished without the presence of strong sources, even storing of energy requires a lot of effort and storage spaces apart from high C rate discharges, which involves the complication of battery explosions if not properly maintained and used, oil imports put a huge burden on foreign exchange and thus cast negative effects on our economy. This increases the country's dependency on other nations which decreases the net revenue of India and causes huge unemployment status. Availability and infrastructure are the weak points of this scenario, for that Neem oil is widely available as it contains almost 35% of oil, broad area cultivation produces enough oil that could be blended with diesel, besides neem grows in almost all topographic and climatic conditions and are flourished into a fully grown plant within a short span of time, this contributes towards enhancing the forestation which helps in reducing the greenhouse gas emission thus decreasing the ozone depletion potential. Neem contains triglycerides and triterpenoid compounds, saturated fatty acids which are; palmitic, stearic and also contains polyunsaturated fatty acids like; oleic and linoleic acids. Neem is processed by transesterification method by minding the presence of free fatty acids (FFA). The then obtained neem oil is rich in specific gravity and viscosity, and with a lower calorific value range they cannot be directly blended with diesel or petrol as the flash point of neem is too low, this increases the emission and reduces the engine power and in long run clogs the engine. A similar fuel with chemical properties matching to neem is found to be plastic oil, besides considering the economical benefits plastic oil can be availed abundantly its calorific value is higher than that of diesel and plastic oil if blended with neem could be an alternate viable solution for the engine. [2]Fuel oil from plastic waste is a kind of heavy oil which has heating value greater than 10000 kcal/L. Waste plastic such as PE (polyethylene) PP (polypropylene) PS (polystyrene), etc. [3]has higher oil yield above 50%, which means from the above 10-ton waste plastic, you can extract at least 5-ton pyrolysis fuel oil, the plastic oil can be processed by pyrolysis through pyrolysis decomposition of long chain hydrocarbons molecules (polymer) into smaller sizes (monomer) using high temperature range from (450°C–800°C). both plastic and neem oils together give quality fuel properties similar to diesel, the low CV of neem can be tolerated with high CV of plastic oil, thus the blended fuel will have a compromised CV and other properties that is similar to diesel. The plastic oil and neem oil can be together blended in varying proportions to find the most promising fuel that has performance and emission properties in similar with diesel. Since this involves time as engine testing is time consuming process this tested using computational analysis, using Ansys Forte the proceedings were tested, the same engine details are used to model the engine and test the blends.

1.1 Neem oil an alternative.

[1] There are mainly four ways to use neat vegetable oils in diesel engine they are:

i. Direct use or blending in diesel fuel

ii. Micro emulsions in diesel fuel

iii. Thermal cracking of vegetable oils

iv. Trans esterification.

Among which trans esterification method is the mostly used and widely accepted method to be used in neem.

Trans esterification, producing mono alkyl esters as neem oil contains high amounts of free fatty acids resulting in soap formation due to its affinity towards alkali catalyst. The, neem oil cannot be directly used so a pre-esterification catalyzed by homogenous acids such as sulfuric acid, sulfonic acid or phosphoric. Acid is used to reduce the free fatty acids so that Neem oil can be trans esterified by an alkali catalyst to fatty acid methyl esters (FAME), firstly its viscosity is reduced. Due to high free fatty acid contents in the neem oil, a two-step trans esterification is done which are acid trans esterification followed by a base trans esterification process;

Acid trans esterification: Here the methanol (50ml) and concentrated sulphuric acid (0.2ml) are mixed in a conical flask of 250ml capacity, this is placed in a water bath kept at 50°C this mixture is further mixed with the preheated neem oil (200ml) in a conical flask of 500ml capacity which gets continuously stirred for almost an hour using a magnetic stirrer to speed up the reaction process. The end products obtained after the acid reaction process are treated with a known amount of sodium hydroxide which acts as catalyst and methanol; this mixing is known as the base trans esterification that constitutes glycerin. Separation of ester from glycerin is the next step using a separating funnel, the glycerin settled at the bottom is filtered out to take out the ester contained at the top. After removing methanol, washing and drying of biofuel by adding water at 50°C into the separating funnel the water settled at bottom is drained out, this is repeated a few times to get the end result as pure biodiesel. Separation of esters and glycerol, glycerol contains soap catalysts and other impurities to be separated so it is treated with HCL. The free fatty acids (FFA) contents in the glycerin are not soluble, they are to be removed, for effective removal of the FFA they undergo two step trans esterification process

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

1.2 Free Fatty Acid Determination using Gas Chromatography

[5]50 mg of the oil sample hydrolysed for 5 minutes at 95°C with 3.4 ml of the 0.5 M of potassium hydroxide in dry methanol. The mixture was then neutralized using titrimetric method by using 0.7 M hydrochloric acid and then methylated using 3 ml of 14% of boron trifluoride in methanol. The mixture was heated for 5 minutes at 90°C to complete the methylation process. The fatty acid methyl esters were extracted from the mixture with redistilled n-hexane, the hexane extract was concentrated to 1 μl for gas chromatography analysis, and 1 μl was injected into the injection port of gas chromatography.

2. Selection of Plastic Oil as a Blend Fuel

The fuel properties like; Calorific value, Cetane Number, Specific Gravity, Kinematic viscosity etc. are much suitable to make it to use as an alternative fuel, but the value of Cloud Point is much higher than diesel this results in wax formation. The disagreement in Calorific value, density and various other properties of plastic oil to be independently used in engines can be sorted by blending with a fuel that shows better mixing property.

2.1. Plastic Oil pyrolysis.

High-density polyethylene (HDPE), polyethylene terephthalate (PET), polystyrene (PS), and polypropylene (PP) are the various classifications of plastics. HDPE is extracted from milk jugs, body wash bottles etc. (PET) is collected from food containers, (PP) is found in, car parts, disposable diapers. (PS) is found in cups, insulation materials etc. The collected plastic is shredded and crushed into small pieces to reduce the volume of the plastic in the reactor it is then washed to remove the presence of toxic materials, and is heated through a process called thermal degradation of waste plastic in the absence of oxygen. Pyrolysis is a chemical activity, during which combustion of various fuels, wood, paper, and plastics takes place. Through pyrolysis decomposition of long chain hydrocarbons molecules (polymer) into smaller sizes (monomer) using high temperature range from (450°C–800°C), the emission results in the form of carbon, as residues and volatile hydrocarbons which condensate as fuel and also with emission of fewer quantities of gaseous fuels. The reaction of this polymer is a weak bond chain and can be damaged by increasing temperature. The free radicals formed will then separate again to form smaller ones which produce more stable compounds. Smaller free radicals produce stable compounds in the form of paraffin compounds, isoparaffins, olefins, naphthenes and aromatics. Since the fuels obtained through the pyrolysis cannot be directly used, due to the presence of impurities (ash) and wax from the feedstock. The purification of the pyrolysis products is done.

2.2. Instruments Used.

The instruments used for testing fuel properties were; Instruments by the 'EIE instruments' manufactured Bomb Calorimeter was used to check the Calorific Value, Density/ Specific gravity readings were taken from meter made by Kyoto Electronics and Viscometer was manufactured by Canon Instrument Company. The readings were finalized after careful evaluation. The separate values of neem and plastic oils were tested in the facility of NIT Calicut Heat engine laboratory.

Table -1: The Experimental Investigation

Experimental properties			
Parameters	**ASTM**	**Diesel**	**NOB20**
Specific Gravity	D1298	0.830	0.875.3
Kinematic Viscosity at 40°C (mm2/s)	D445	2.77	5.3
Calorific Value [MJ / Kg]	D4809	42.37	38.34

[6] as in Table -1

Flash point: Flash point is the lowest temperature at which it can vaporize to form a combustible mixture. The flash point of Waste Plastic Oil (WPO) is about 15°C. A low flash point indicates the presence of highly volatile materials in the fuel. By removing lighter components (such as naphtha/gasoline) the flash point of WPO can be increased.

Kinematic Viscosity: This denotes the momentum diffusivity, always a lower value of kinematic viscosity is preferred as this reduces the fuel droplet size that improves the combustion

Specific Gravity: Lower value of specific gravity allows faster rate of combustion.

Cetane Number: Lower cetane number decreases the combustion rate due to more ignition delay period, always high cetane number fuel is required while blending.

Cloud Point: This is the temperature point at which wax formation begins this happens when the oil is cooled to a lower temperature beyond the point wax forms in the oil and affects the combustion and the engine operation

2.2. Selection of Blend Ratios

Contribution of neem, plastic with diesel as individual blends could only be identified by choosing different blend ratios and testing it. Researches claims that with increasing blend the emission parameters increases so a lower percentage of blends are preferred, the specific fuel consumption increases in neem-diesel blend, and the emission parameters like CO, HC, etc. will increase which is against the emission norms. A blend ratio of between 10 to 20 percent is the region where significant results are obtained. With increase in blend the combustion improves and emits less pollution compared to the conventional fuel. Additives increases the combustion by enhancing the ignition, due to the increase in surface area, the heat transfer rate increases which improves the evaporation rate. Nano fuel additives creates micro explosion that increases the atomization thus improving the thermal efficiency due to improved flash point, also the brake thermal efficiency increases due to the increased temperature during combustion. B20 (20% blended oil in 80% diesel), NOB20 (Neem Oil B20), POB20 (Plastic Oil B20).

2.3. Computational Analysis.

Experimenting with fuels in engines requires time, hard work, patience and money. A computational analysis saves some efforts since it's also convenient. Here computational fluid analysis is done using CFD software Ansys Forte, simulating an IC engine is more convenient in forte and choosing fuel can be accomplished by using its chemkin library. Blend ratios of plastic, neem oil and diesel as individual fuels and as a constituent of their respective blends of 10% from each bio fuels and 80% diesel are used for the engine. Results are obtained with almost 85% accuracy, since IC engine working conditions cannot be completely obtained in the software. Experiments were carried out in a PC based single cylinder, four stroke, naturally aspirated diesel engine Kirloskar AV1 engine. Engine was loaded with following conditions of 0Kg load, 3.8Kg, 7.5Kg, 11.3Kg and 15Kg respectively. With blend ratios of D100, NOB20, POB20, NOB10-POB10 respectively.

Table -2: Engine Parameters

Make	Kirloskar AV1
power	5 HP
Speed	1500 rpm
Compression Ratio	17

Initially the engine cranked with diesel for an hour, later blended fuels are tested and at the end the engine was tested with the composition blend. The emissions were tested using DI GAS 444 N Five analyzer, smoke opacity was measured using AVL 437C smoke meter.

Fig -1: Kirloskar AV1 single cylinder Engine

As presented by M.Kannan et al. [1] the Computational analysis on IC engine using Mahua oil, the work has carried on using Ansys Forte as the CFD medium for the simulation process here the engine is simulated as it is in the above figure Kirloskar AV1 single cylinder is used, the similar engine patterns and conditions are generated using the Software setup. The results of different mass fraction and blend ratios are given as input to the software, the Forte Chemkin allows the user to give fuel chemical properties. The properties are entered as CSV file. The similar conditions and patterns are followed in this work as well. The engine parameters and working conditions are modelled into the software the chemical conditions are entered using the forte Chemkin library, the values are based on the property values such as, calorific value, viscosity, cetane number and density etc.

The software is modelled for the bowl-shaped geometry, the inlet conditions are fixed to 362K temperature, 1.5 bar pressure along with the composition of gas mixture entered through the chemkin library these conditions are for the piston. The injector sprays fuel as parcels.

The results are evaluated experimentally by the primary test runs of B20 blend ratios of bio fuels in the IC engine, the graph just showed 10 percent variation between experimental and software analysis.

3. CONCLUSIONS

The experimental evaluations were first analyzed by comparing with simulations results. The results claims to show close proximity between the experimental and software, so the higher blends can be evaluated through the software, as it claims to give a promising result.

On evaluating the experiment with Ansys forte for the B20 blends of Plastic Oil and Neem oil, and the results for B10 is proven to be contributing as the best alternative fuel.

REFERENCES

[1] : M. Kannan, R.Balaji, R.T.Sarath Babu et al., Computational analysis on combustion, characteristics and ignition analysis on IC engine using mahua oil, Materials Today:Proceedings,https://doi.org/10.1016/j.matpr.2020.09.525

[2] Physical and chemical characteristics of neem oils extracted from seed, whole fruit and flesh Egypt. J. Agric. Res., 93 (3), 2015

[3] Papari, S.; Bamdad, H.; Berruti, F. Pyrolytic Conversion of Plastic Waste to Value-Added Products and Fuels: A Review. Materials 2021, 14, 2586. https:// doi.org/10.3390/ma14102586R.

[4] Kumar, S.; Panda, A.K.; Singh, R. A Review on Tertiary Recycling of High-Density Polyethylene to Fuel. Resour. Conserv. Recycl.2011, 55, 893–910.

[5] K. Elissa, "Title of paper if known," unpublished.

[6] Physical and Chemical Characteristics of Neem Oils Extracted from Seed, Whole Fruit and Flesh Article 14, Volume 93, Issue 3, September 2015, Page 887-899

[7] Experimental investigation on synthesis of biodiesel from non-edible Neem seed oil: Production optimization and evaluation of fuel properties S.K. Dash a, P.V. Elumalai a , P.S. Ranjit a , P.K. Das a , R. Kumar a , S. Kunara,N.H.Papub https://doi.org/10.1016/j.matpr.2021.04.551