THE EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIRECT INJECTION VCR DIESEL ENGINE USING "NEAM OIL METHYL ESTER"

MADAKASIRA SAIRANGA, NAGASAMUDRAM PHANI RAJA RAO,
VARDIREDDY VISWESWARA REDDY,
ASSISTANT PROFESSOR[1] ASSOCIATE PROFESSOR[2] ASSOCIATE PROFESSOR[3]
sairanga342@gmail.com, phaniraja.ns@gmail.com, vvrindustries@gmail.com
Department of Mechanical Engineering, Sri Venkateswara Institute of Technology,
N.H 44, Hampapuram, Rapthadu, Anantapuramu, Andhra Pradesh 515722

Abstract

Finding viable substitute fuels for diesel engines is becoming more important as global petroleum supplies continue to dwindle, crude oil prices continue to rise, and the environmental toll of rising exhaust emissions continues to mount. Vegetable oil reduces CO and HC emissions from CI engines in comparison to diesel fuel. This research looks at how well a VCR (Variable Compression Ratio) diesel engine runs on neem biodiesel and what kinds of emissions it produces. The transesterification technique is used to transform crude neem oil into methyl esters of neem oil. Experimental measurements and analysis using diesel are used to determine the biodiesel's characteristics. In the first phase, a four-stroke, one-cylinder, water-cooled diesel engine was used to produce baseline data under varied loads while maintaining a constant speed. In the second phase, we tested the engine's performance and emissions with varying concentrations of Neem seed oil methyl esters (NSOME10, NSOME20, NSOME30, and NSOME40) while keeping all other operating parameters same. After comparing several biodiesel blends with diesel in terms of performance and emission metrics, the study concluded that a mix including Neem seed oil produced the best results.

Keywords:*Neemoil,Biodiesel,transesterificationprocess,PerformanceofVCREngine withBiodiesel.*

1. Introduction

The world's energy demands are now being satisfied by petroleum products to the tune of 40%. It was estimated that demand would increase by 7%. Astonishingly, all predictions, forecasts, and estimations have been wrong about the rate of expansion in this industry. Within the next ten years, global oil consumption is projected to soar from 68 million barrels per day to 94 million barrels per day.

In addition to having more than enough refining capacity, India is actively exploring offshore and onshore oil and gas production, since it is facing a severe shortage of these vital contemporary resources. Importance is placed on the effective discovery of natural gas and crude oil in the country's desert regions, followed by the construction of infrastructure for commercial production and the establishment of facilities. It would be challenging to fulfil demand, which is expected to rise to 150 MMT in the next 8 years, with indigenous reserves, which account for just 0.6% of the world's reserve, given current imports of 80 MMT and projected use of 350 MMT by 2025 AD (as per Hydro Carbon Vision 2025). Because of this, the import bill is going to reach record highs in the next decade. There are limits to India's energy producing capability and sources.

You may mix biodiesel with petroleum diesel fuel in whatever ratio you choose, or use it as a substitute for petroleum diesel fuel entirely. To run on biodiesel, a diesel engine needs no adjustments. There are few things that can compare to biodiesel: its ease of use, nontoxicity, biodegradability, and lack of sulphur and aromatics.6 Biodiesel, a sustainable fuel produced from plants, burns cleanly. To produce biodiesel, a an organic chemical reaction that produces FAME from fatty acids and oils of natural origin. The oil used to make biodiesel is not derived from plants. Vegetable oils as motor fuels may have seemed like a minor detail in the past. Nonetheless, these oils have the potential to eventually become just as significant as petroleum and the coal tar byproducts of today.

It is difficult to reduce NOx and PM emissions from traditional diesel engines at the same time [1]. It is necessary to discover ways to decrease diesel exhaust particles and oxides of nitrogen in order to benefit from reduced carbon dioxide (CO2) emissions and higher fuel efficiency. Researchers have considered a wide variety of alternative fuels, including alcohol and its derivatives [2], dimethyl ether (DME), biodiesel fuels (transesterified vegetable oils), and many more. For diesel engines, vegetable oil has many advantages over petroleum-based fuels, including being a renewable energy source, biodegradable, and non-toxic [3]. Biodiesel is widely regarded as one of the best alternative fuels for diesel engines, among many others. From a SWOT (Strengths, Weaknesses, Opportunities, and Threats) perspective, biodiesel's potential as a replacement for fossil diesel is highlighted by its improved ignition quality (higher cetane number), lack of sulphur and aromatic contents, renewable capacity, biodegradability, and reduced greenhouse gas emissions of 30–71% [4]. Additionally, the diesel engine may be easily converted to run on biodiesel fuel with few adjustments.

The following are additional benefits of biodiesel:

• It is readily available locally and has a high miscibility with diesel without any blending agent. • It has a content of fuel bound oxygen (O2), which is around 11% by mass. • It has excellent lubricity, which reduces wear and increases the life of the fuel injection pump. In comparison to fossil fuel, it either reduces CO2 emissions or remains CO2 neutral, is easy to handle and transport, and can be stored safely.

Nevertheless, non-edible seed oils such as Jatropha, Karanja (Pongamia pinnata), and Neem are being investigated by many Asian nations who do not produce enough edible oil to meet their own needs [5]. Jatropha curcus, Pongamia pinnata, Neem, Mahuya, Castor, Linseed, and Kusum are non-edible oils that have the potential to be turned into biodiesel in considerable quantities in India [6].

The power output and engine torque of JOME are lower than diesel fuel, according to Kasaby et al. [7] in a four-stroke, single-cylinder, direct injection variable compression ratio diesel engine. Because of its lower calorific value and higher fuel consumption, JOME has a lower brake thermal efficiency. This fuel's reduced CO emissions and full combustion are because of its higher cetane number [8] and extra oxygen content, respectively.

2. TRANSESTERIFICATIONPROCESS

Recent years have seen a plethora of research on bio-diesel production using unconventional oil feedstocks. For the sake of introduction, we have included a brief summary of the transesterification process used to make biodiesel. It has been found that processes may be catalysed by enzymes, alkalis, or acids. Quick processing is achieved using alkalis. Although the catalysed process is simple, the superior results are obtained by using the supercritical approach. There are four ways to convert vegetable oil into a fuel for CI engines. Microemulsification, transesterification, dilution, and pyrolysis will be covered. This research use the transesterification method for one of them.

2.1 StepsInvolvedinTransesterification

Step one involves dissolving the catalyst in alcohol with the use of a mixer or agitator.

The second step is to charge an alcohol catalyst mix into a closed reaction vessel. Then, you may add bio lipid, which can be either vegetable or animal oil or fat.

3. With a temperature slightly over the alcohol's boiling point, the reaction mixture is maintained.

suggested response time of around 1 to 8 hours.

4. Distillation is used to recover any surplus or unreacted alcohol, which is then recycled.

Fifth, a continuous decanter is used to separate the biodiesel and glycerin products, with the former flowing into it and the latter out of it. To separate the two substances more quickly, a centrifuge is used. To eliminate any remaining catalyst or soaps, biodiesel is gently washed with warm water after being separated from glycerin. After drying, it is transferred to storage for further purification.

Table1.Propertiesoffuelsamples

Property	Units	Diesel	Crude	NSOME10	NSOME20	NSOME30	NSOME40
Density	kg/m3	0.835	0.91	0.842	0.849	0.851	0.87
Heating Value	kJ/kg	42500	38596	41389	40900	40362	39230
Flash point	^{0}C	70	152	78	90	98	112
Fire Point	^{0}C	76	159	93	121	134	151
Viscosity	Cst	4.3	13.2	3.412	5.036	6.484	7.254

3. ExperimentalSetupandProcedure

Figure1.VCR4-Strokedieselengine

The eddy current dynamometer was used to load this water-cooled, single-cylinder VCR diesel engine. The temperature may be measured using the designated cooling water pipes. A gasoline measurement system includes a three-way cock, a burette, and a fuel tank that is set on a pedestal. A U-tube water manometer detects the pressures within a mild steel tank that has an opening in it, and thus allows for the measurement of air consumption. In addition to a digital speedometer and temperature indicator, the panel board also has a digital rpm indication and a selection switch for measuring temperature. The steady speed may be maintained with the help of the governor. Connecting the gas analyzer to the exhaust flow allows for the measurement of emissions.

3.1 Procedure

Make a note of the temperature outside and the engine's specs. Based on the engine specs, determine the maximum load (W) that the engine can handle.

2. Take off the air lock and clean the fuel filter.

3. Make sure there is gasoline, lubricating oil, and water for cooling.
4. After making sure the engine is not under any load, start it up using the decompression lever. Then, make sure the cooling water is supplied.
5. Give the engine ten minutes to stabilise while not in use.
6. While maintaining a steady compression ratio, record the following: total load, speed, ammeter and voltmeter readings, fuel consumption in cubic centimetres, and manometer readings.
7. From light to heavy, then again from light to full, repeat the previous procedure.
8. Before taking readings, let the engine stabilise after each load adjustment.
9. Make sure the engine is stabilised and remove any weights before shutting the engine.
10: Turn off the engine by bringing the governor lever to the side of the engine that is cranking. When coming to a halt, make sure the engine is not under any strain.

4. ResultsandDiscussions

Operating at a constant speed of 1500 rpm, the trials include altering diesel loads and various mixes of Neem seed oil, such as NSOME10, NSOME20, NSOME30, and NSOME40. The engine is a four stroke VCR single cylinder water cooled diesel engine. Graphs displaying computed performance metrics, including thermal efficiency of the brakes and brake specific fuel consumption, mechanical efficiency, and volumetric efficiency, are shown. The measured values of the other emissions parameters, including hydrocarbons, carbon monoxide, and oxides of nitrogen, as well as carbon dioxide, smoke opacity, and exhaust gas emissions, were plotted on graphs.

4.1 BrakeThermalEfficiency

Figure 2 shows the relationship between load and brake thermal efficiency. The graph clearly shows that the BTE grows substantially with increasing load. At full load, diesel's BTE is 34.20%, whereas the corresponding mixes of NSOME had BTEs of 32.04%, 33.57%, 31.41%, and 31.43%, with NSOME20 achieving the highest BTE of the blends. At full load, NSOME's BTE may be as much as 1.8% lower than diesel's. Blended fuel has a low calorific value, which would explain the little drop in thermal efficiency.

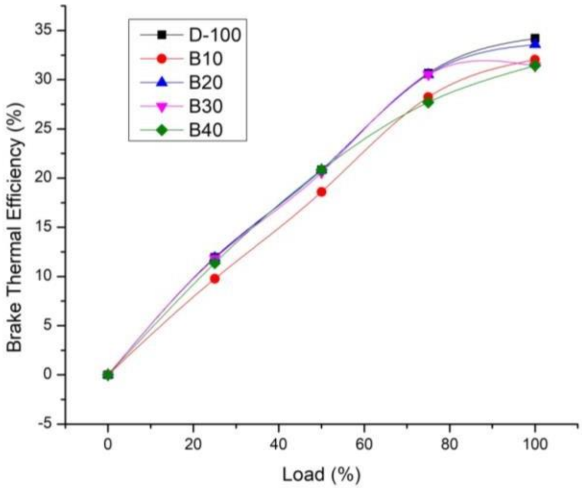


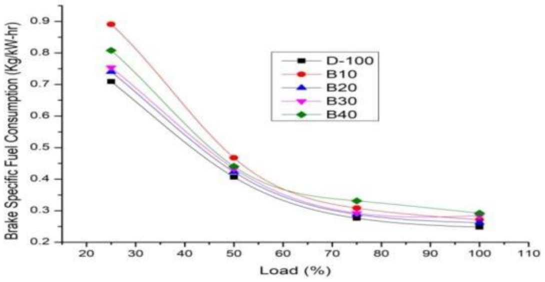
Figure2. Variationof Brakethermal efficiencywithLoadUsingNSOMEBlends

4.2BrakeSpecificFuelConsumption

Figure.3 shows the variation of the brake specific fuel consumption with load. When twodifferent fuels of different heating values are blended together, the fuel consumption maynot be reliable, since the heating value and density of the two fuels are different. In suchcases, the brake specific fuel consumption (BSFC) will give more reliable value .Thebrake specific fuel consumption was determined for Need seed methyl ester-diesel fuelblendsastheproductofthespecificfuelconsumptionand the calorific value.

AtfullloadconditiontheBSFCobtained are0.247kg/kW-hr,0.271kg/kW-hr, 0.262kg/kW-hr,0.283kg/kW-hrand0.291kg/kW-hrforfuelsofdiesel,NSOME10,NSOME20,NSOME30andNSOME40 respectively.Itcanbeobservedfromthefig.6.2thattheBSFCforNSOMEis higherforallblendsascomparedtothat of diesel fuel at full load. Due to low calorific value of Neem seed methyl ester -dieselfuelblendrequireadditionalfuelairmixturetoproducethesamepoweroutputasthatofdieselfuelthatmay bethereasonforthehigherBSFC.

Figure 3. Variation of Brake specific fuel consumption with Load Using



NSOMEBlends

4.3 Air-FuelRatio

Thevariationofair-fuelratiowithloadisshowninFigure.4fromtheplotisobservedthatslightlyequalatfullloadconditionsatallblendscompare withDiesel.Atfullload condition the air-fuelratiovaluesare 25.59, 24.33,23.41,22.15and24.61forthefuels ofdiesel,NSOME10,NSOME20,NSOME30andNSOME40,theairfuelratiodecreasesduetoincreaseinload,becauseof fuelinjectiontodevelopthepowerrequiredtobaretheload.

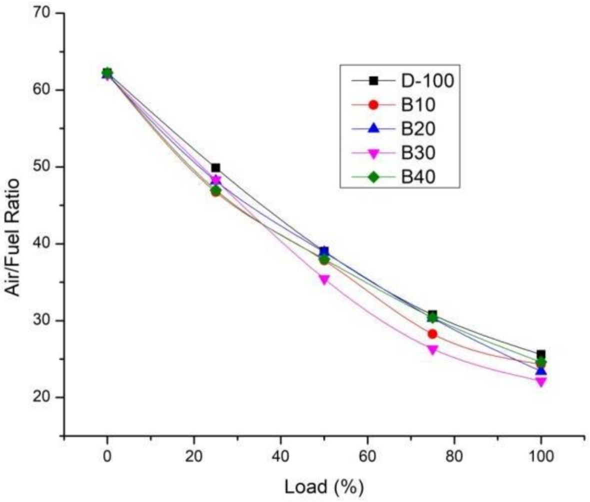


Figure4.VariationofAir-fuelratiowithLoadUsingNSOMEBlends

4.4 OxidesofNitrogen

As shown in Figure.5, the NOx emission varies according to the load. It is clear from the graph that many mixes are represented. Diesel, NSOME10, NSOME20, NSOME30, and NSOME40 generated NOx emissions of 1476 ppm, 1492 ppm, 1509 ppm, 1530 ppm, and 1542 ppm, respectively, at full load conditions. Nox emissions increased as a function of load for all fuels evaluated. Possible causes include longer residence times under greater load circumstances and higher average gas temperatures. Due to diesel's lower oxygen concentration compared to its NSOME mixes, NOx emissions were shown to be reduced when comparing the two. Nitrogen oxide emissions rise in direct proportion to the NSOME concentration in the gasoline.

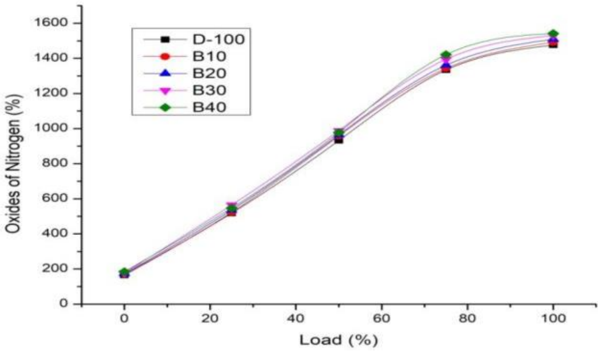


Figure5.VariationofOxidesofNitrogenwithLoadUsingNSOME blends

4.5 CarbonMonoxideEmissions

You can see the carbon monoxide emissions for different mixes and loads in Figure 6. Diesel has somewhat more emissions than all NSOME mixes. The greater viscosity of the fuel causes poor atomization and incomplete combustion, leading to CO emission readings of 0.163%, 0.155%, 0.147%, and 0.137% for diesel, NSOME10, NSOME20, NSOME30, and NSOME40 fuels, respectively, under full load conditions. Carbon monoxide levels are somewhat greater at higher loads because increased fuel consumption reduces the relative availability of oxygen for fuel combustion.

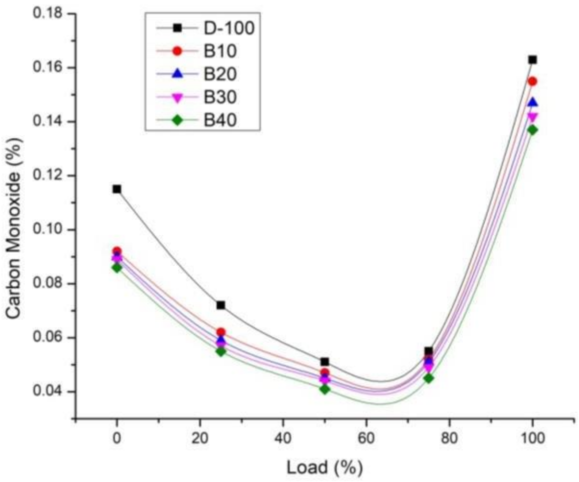


Figure6.VariationofCarbonMonoxideEmissionwithLoadUsing NSOMEBlends

4.6 HydrocarbonEmissions

ThevariationofHCemissionwith loadisshowninFigure.7.Theplotitis observed that the HC emission variation for differentblends is indicated. Because ofdieselcontainsmorehydrogenthanNSOMEblends,theHCemissionis moreascompared with NSOME blends. At full load condition theUHC are obtained 52ppm,48ppm, 45ppm, 41 ppm and 38 ppm for the fuels of diesel, NSOME10, NSOME20,NSOME30 and NSOME40 respectively. The oxygen contained in the biodiesel wasresponsibleforthereductioninHCemissions.

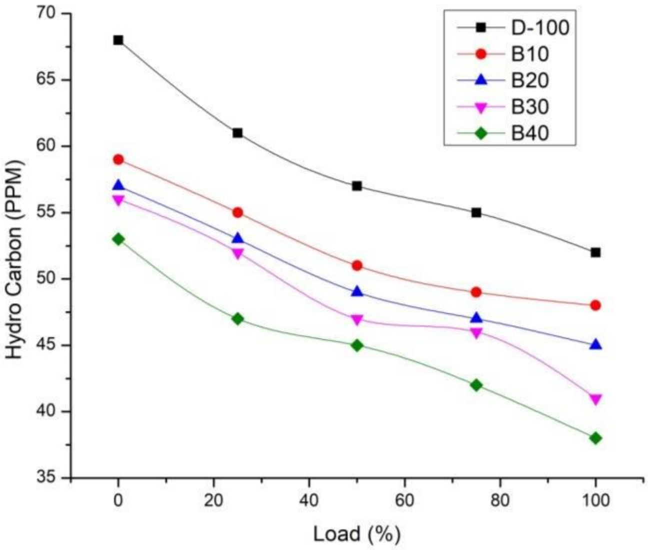


Figure7.VariationofHydrocarbonEmissionswithLoadUsing NSOMEBlends

4.7 CarbonDioxideEmission

Figure8.illustratesthevariationofcarbondioxideemissionforvariousblendsatvaryingloads.Thecarbondioxideemissionfortheblendsislowerthandieselforallloads.Carbondioxideis formedlowbecauseofhigherviscosityoffuelleadstoincompletecombustionandthebiodieselishavinglesscontentofcarbonwhencomparedtodieselthismaybealsoonereasonforlessemissionofCO_2.

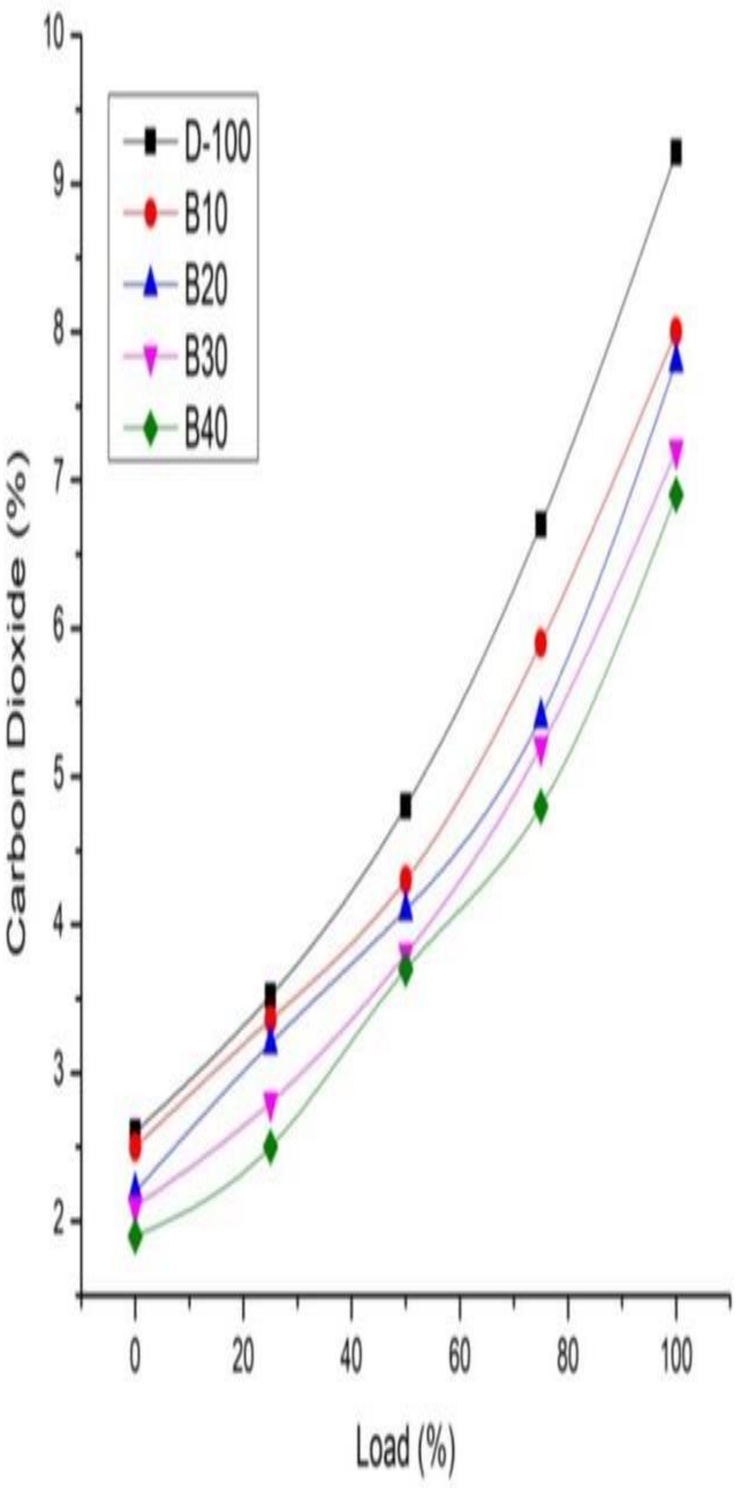


Figure8.VariationofCarbondioxideEmissionwithLoadUsing NSOMEBlends

Conclusions

To find out how an engine will run on alternative fuel, this study uses a variable compression ratio (VCR) four-stroke, one-cylinder, water-cooled diesel engine running at a constant speed using NSOME mixes. Here we compare the results of our study to full-load diesel base line data:

- When contrasted with diesel, B20's brake thermal efficiency fell 1.84 percentage points.
- Blended fuels provide an increase in brake specific fuel consumption. The BSFC in NSOME20 fuel is 6.07 percent higher than diesel fuel.
- The use of NSOME20 mix resulted in a significant decrease in both smoke level and CO emissions. Even while running at full throttle, NSOME40 produced less smoke than diesel.

However, when contrasted with diesel fuel, NSOME20 resulted in 2.23% higher NOx emissions.

At 45 ppm B20 SiO2, the greatest braking thermal efficiency is 34.95%, which is greater than NSOME20 and diesel. When compared to diesel and NSOME20, the brake thermal efficiency improved by 2.19% and 4.11%, respectively. References

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