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EXPERIMENTAL INVESTIGATION TO EXAMINE THE PERFORMANCE BEHAVIOUR OF COMBUSTION IGNITION ENGINE USING WATER-ADDED BIODIESEL AT FIXED CR.

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Abstract

Contamination in the air is majorly caused by combustion ignition engines but researchers have shown interest in the area of producing environmentally friendly fuels to reduce the risk to human life as well. To do so the production of energy-efficient fuels adds higher engine performance and lesser pollution to the environment with unmodified combustion ignition engines. Continuous efforts are being made towards the research in water-added fuels which has a glimpse of match-able engine performance criteria. The current experimentation was performed for the detailed analysis of engine performance characteristics to prove that the water-added mahua biodiesel can engine performance by adding a little amount of water of 2%, 4%, 6% and 8% by volume. The BSFC declined by 22% for 8% of water addition in the Mahua fuel mixture. The BTHE increased by 14% (Mahua fuel mixtures) and by 5% (Karanja fuel Mixtures) was observed for 2%, 4%, 6% and 8% of water addition respectively. The EGT of Karanja biodiesel (B20) declined by 10% and 11% for 8% of water addition in both Karanja and Mahua fuel mixtures, all the above results are compared with pure diesel. These results have shown a significant sign for becoming these water-added biodiesel mixtures as probable Eco-friendly fuel that too without any modifications in conventional CI engines.

Graphical Abstract

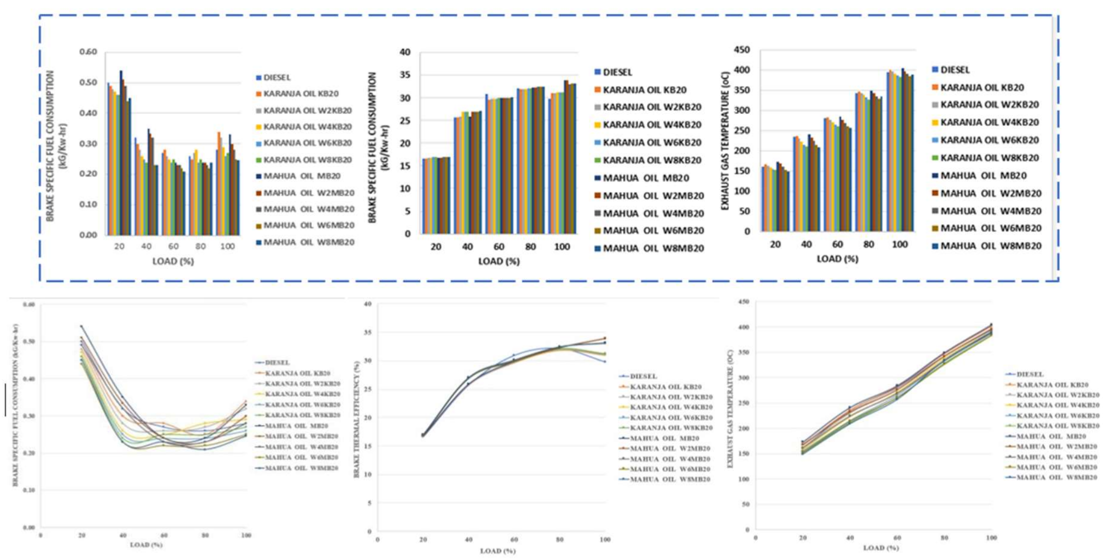

Figure No. 01. Graphical Abstract.

Keywords: Water-added biodiesel, Karanja biodiesel, Mahua biodiesel, Performance characteristics.

Acronyms

KB	-	Karanja Oil Biodiesel
KB20	-	20% Karanja biodiesel + 80 % Pure diesel
W5KB20	-	2% Water + 20% Karanja biodiesel + 78% Pure diesel
W10KB20	-	4% Water + 20% Karanja biodiesel + 76% Pure diesel
W15KB20	-	6% Water + 20% Karanja biodiesel + 74% Pure diesel
W20KB20	-	8% Water + 20% Karanja biodiesel + 72% Pure diesel
MB	-	Mahua Oil Biodiesel
MB20	-	20% Mahua biodiesel + 80 % Pure diesel
W5MB20	-	2% Water + 20% Mahua biodiesel + 78% Pure diesel
W10MB20	-	4% Water + 20% Mahua biodiesel + 76% Pure diesel
W15MB20	-	6% Water + 20% Mahua biodiesel + 74% Pure diesel
W20MB20	-	8% Water + 20% Mahua biodiesel + 72% Pure diesel
BSFC	-	Brake-Specific Fuel Consumption
BTE	-	Brake Thermal Efficiency
EGT	-	Exhaust Gas Temperature

1. Introduction

A vehicle's propulsion system in the logistic industry is frequently a diesel-powered one [1,2] and these engines are leading in the areas of generation of power and logistics because of their competence and robustness over spark ignition engines but the contribution in emission is also high and hazardous to ecological life and its balance therefore strict guidelines are to be given to control the level of emissions of compression ignition engines. Air pollution from these kinds of engines can be extensively diminished by lowering emission levels. A possible substitute for diesel-powered vehicles that can lessen emissions is biodiesel [3–6]. A green energy and their source are capable of significantly reducing pollution of particulate matter, Hydrocarbons, carbon monoxide, and smoke [7–9]. However, this kind of fuel possesses the potential of raising Nitrogen emission levels [10], that are hazardous to the planet and to people's health [11–15]. As an outcome, in the past few decades, a growing number of scholars have given biodiesel as a fuel their attention [16,17]. The suggestive way is water addition in existing fuel for diesel powered engines which is also an active field in research for the last 10-15 years. There are other factors which are responsible such as variables of the engine with the usage of water addition in engine fuel but ahead it needs to be examined properly and compare the results between the fuels (with or without water addition) without any changes or any upgradation in these engines. This will surely provide a future scope in the area of this specific fuel.

2. Literature Review

In this work, water was added with diesel in the proportion of 5-10% along with surfactant ranging between 0.5-2% and the best blend was found to be 93% diesel+5% water+2% surfactant and this mixture has the stable and sustainable for 18 days. This best blend witnessed the engine performance, BTE and BSFC as +5.19% and +7.3% correspondingly [18]. In this method, water was added with pure diesel in the percentage of 5, 10 and 15% and by stirring process the mixture has been prepared. The higher results were witnessed with a combination of 15% water and pure diesel showing an appreciation in engine performance by 6.8% for the blending B20. This has happened due to the higher availability of oxygen in fuel in comparison with other mixtures with different proportions of water addition [19]. In this study, water addition with pure diesel in the percentage of 2, 5, 8 and 10 and due to the availability of molecules of water in the fuel mixture, the heating value is decreased along with viscosity and fuel density maintained to somewhat similar to pure diesel. This has increased the engine performance, BThE by 7.8% for the mixture of blending ratio of 20% with 10% of water addition in comparison with pure diesel [20]. In this work, the addition of water was done with pure diesel in a variety of proportions for the analytical study and the results had a comparative analysis. Researchers found better engine performance characteristics in the blend of 90% biodiesel + 8% water + 2% of surfactant because of the increase of water molecules in this mixture, the heating value gets declined and BThE reduced by 5.8% in comparison with pure diesel [21]. In this examination, the two biodiesels were taken of Jatropha oil and wood oil with an addition of water in 5%, 10%, and 15%, respectively to test the variety of mixture without any changes in the test engine. The results found for the biodiesel proportion (90% biodiesel+10% water) are BThE is 5.5% higher than pure diesel because of the presence of more oxygen in this mixture [22]. In this experiment, the biodiesel made by the transesterification process from soyabean oil was added with water at two different proportions of 10% and 20% for the compression ignition engine. 1% surfactant was also used. The mixture with 10% water content results in the enhancement of engine performance by 14.2% in comparison with pure diesel [23]. In this study, the biodiesel made from palm oil was added with water in percentages of 5%, 10%, 20%, and 30%, respectively. The biodiesel [B20] mixture with 5% water has enhanced the engine torque by 28.4% and declined the BSFC by 7.27% in comparison with pure diesel due to lesser delay in the ignition, BThE is shot up by 8.8% at 20% load by comparing with pure diesel [24]. In this study, the two biodiesels were made from jatropha oil and wood oil and added with 15% of water with surfactant in 4% to test this fuel in a compression ignition engine. The blending proportion with 81% biodiesel + 15% water +4% surfactant results in a decline in EGT and maximum BThE attend of 11.3% in comparison with pure diesel because of more presence of oxygen in the fuel mixture [25]. In this research, the biodiesel made of canola oil is being investigated along with the addition of water in the proportions of 5% and 10% along with two surfactants. The blend B20 with 10% water along with surfactants results in an increase in glycerine and enhanced BThE by 10% in comparison with pure diesel because of excess oxygen content in the fuel mixture [26]. In this investigation, the optimum blend was treated by the WNE method in the percentage of 5%, 10% and 15% while keeping the optimum blend ratio constant. The results revealed that engine performance is enhanced significantly with the use of a 15% water nano-emulsified blend [27]. With the above results, the novelty of the current work is that the test was carried out on the biodiesel made by Mahua and Karanja oils along with water addition. The above results witnessed that all the various proportions of water addition provide an increase in the engine performance and reduce the EGT because of excess oxygen content in the fuel mixture. The four types of fuel mixtures with B20 blend along with each biodiesel are prepared for the investigation are 2% Water + 20% Karanja/Mahua biodiesel + 78% Pure diesel, 4% Water + 20% Karanja/Mahua biodiesel + 76% Pure diesel, 6% Water + 20% Karanja/Mahua biodiesel + 74% Pure diesel and 8% Water + 20% Karanja/Mahua biodiesel + 72% Pure diesel was tested to investigate the effect of fuel mixtures on engine performance characteristics.

3. Preparation of fuel mixture [biodiesel (B20) + water addition]

Eighty millilitres of neat diesel have been taken in a flask, and 20 mL of Mahua/Karnja biodiesel has been blended with it to form a water-in-oil suspension. The water content of 2 ml, 4 ml, 6 ml and 8 ml is added to form the final mixture for evaluation. The mixture has been stirred well at 5000 rpm for 30 min. The prepared suspension fuel has been kept for visual observation for 24 hours to check. The volume percentage of diesel, water, and KO/MO20 biodiesel is mentioned below Table No. 1. Figure No. 2 shows that flow diagram of preparation of fuel mixture.

S. No.	Constituents For Water Added Biodiesel	W2B20 (% by Volume)	W4B20 (% by Volume)	W6B20 (% by Volume)	W8B20 (% by Volume)
1	Diesel	78	76	74	72
2	Water	2	4	6	8
3	Karanja / Mahua Biodiesel	20	20	20	20

Table No. 1. Constituents of Mixture: Diesel, Water and Biodiesel (Karanja/Mahua) in water added biodiesel.

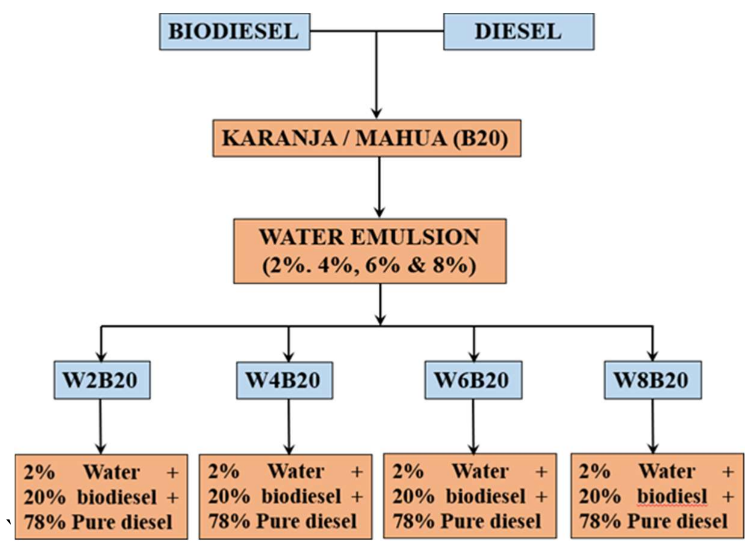

Figure No.02. Flow diagram of preparation of fuel mixture.

4. Results and Discussion

The variations of the performance parameters concerning load are represented in Fig. 3 to 11, at a compression ratio of 17. Figure No. 03 to 05 represents the variations in BSFC, Figure No, 06 to 08 represents variations in BThE, and Figure No. 09 to 11s represents variations in EGT, all these graphs are represented with various fuel mixture with Karanja/Mahua/combined Biodiesel blend (B20) and are prepared with different proportions of water 2%, 4%, 6% and

8% against load percentages of 20%, 40%, 60% 80% and 100% at a constant engine speed of 1500 rpm.

4.1. Brake-Specific Fuel Consumption

BSFC measures the fuel efficiency calculated against the amount of fuel supplied for producing the work output. All three figures (03 to 05) show the trend that the BSFC for all test fuels is higher at 20% load, getting decreased at fuel mixture with 6% water and the mixture of 8% water is quite similar at lower engine loads but slightly increased with increase in load. In figure No. 3, the BSFC of Karanja oil at 17 CR, KO-B20 is least with W6KB20 at 60% and 80% load is 0.24 kg/kW-hr and highest for W2KB20 at 20% load is 0.48 kg/kW-hr. Amongst all the fuel mixtures the lowest BSFC at all the loads for W6KB20 are 0.46 kg/kW- hr, 0.25 kg/kW-hr, 0.24 kg/kW-hr, 0.24 kg/kW-hr and 0.26 kg/kW-hr. In figure No. 4, the BSFC of Mahua oil at 17 CR, MO-B20 is least with W6MB20 at 60% and 80% load is 0.22 kg/kW-hr and highest for W2MB20 at 20% load is 0.51 kg/kW-hr. Amongst all the fuel mixtures the lowest BSFC at all the loads for W6MB20 are 0.44 kg/kW-hr, 0.23 kg/kW-hr,

0.22 kg/kW-hr, 0.22 kg/kW-hr and 0.25 kg/kW-hr. In figure No. 5, the BSFC of combined Karanja and Mahua oil at 17 CR, MO-B20 is least with W8MB20 at 60% load is 0.21kg/kW-hr and highest for W2MB20 at 20% load is 0.51 kg/kW-hr. Amongst all the fuel mixtures for both KO and MO, the lowest BSFC at all the loads for W6MB20 are 0.44 kg/kW-hr, 0.23 kg/kW-hr, 0.22 kg/kW-hr, 0.22 kg/kW-hr and 0.25 kg/kW-hr. W6KB20 has similar BSFC values but on a little higher side.

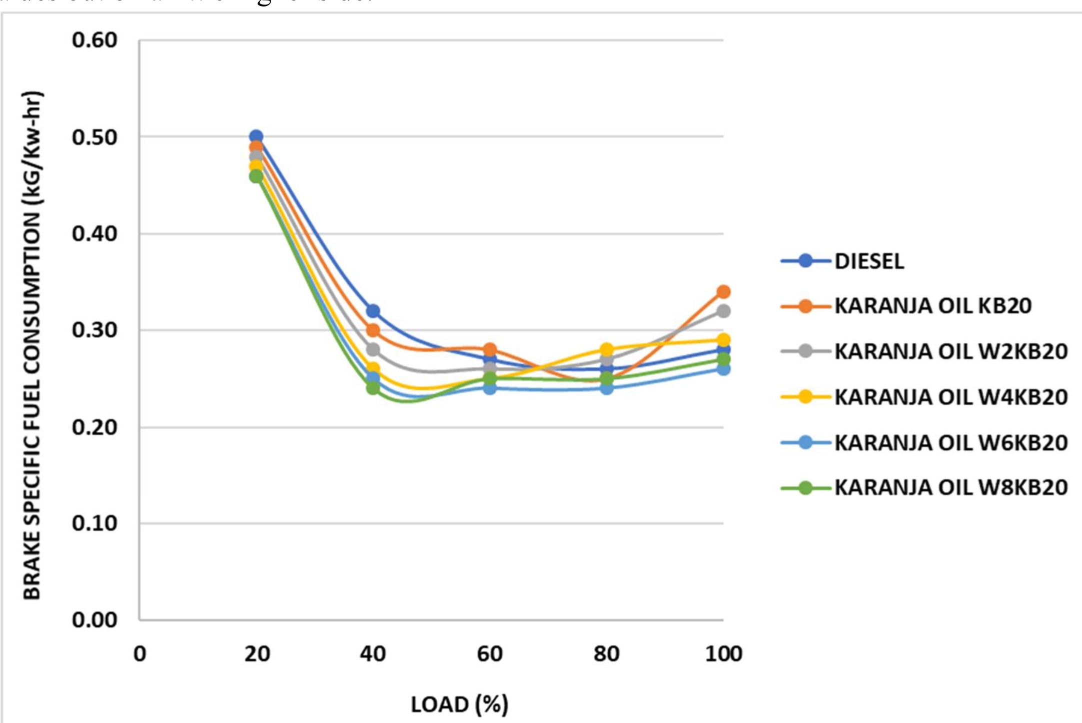

Fig. No. 3: Variation of BSFC Vs Engine Load for Karanja oil Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

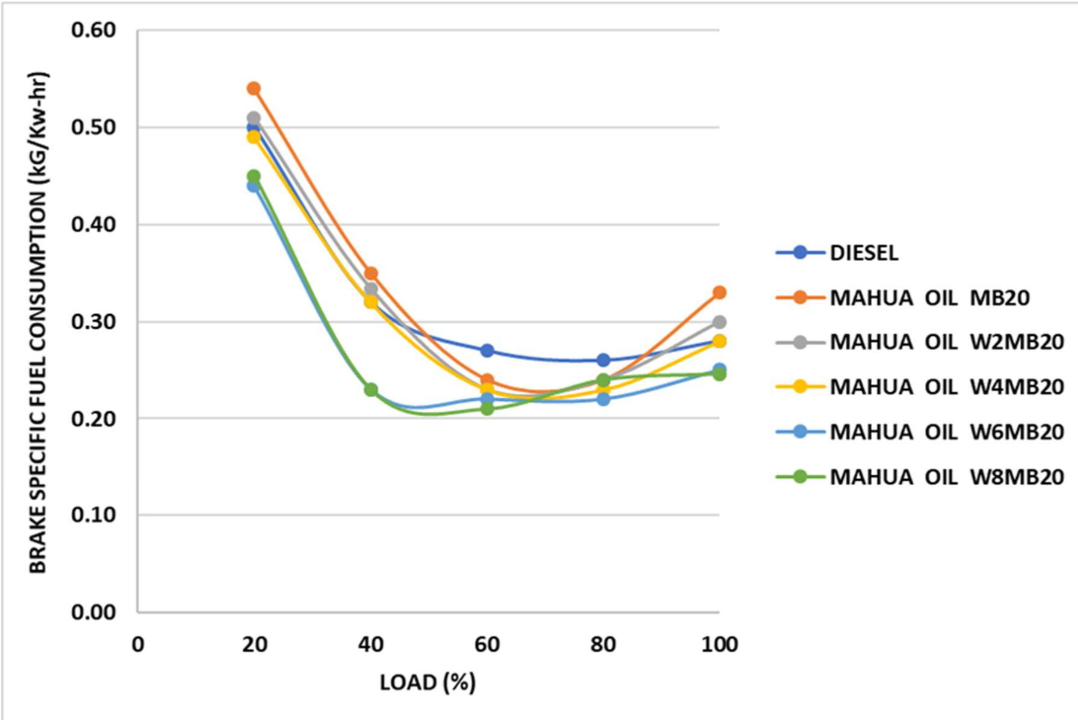

Fig. No. 4: Variation of BSFC Vs Engine Load for Mahua oil Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

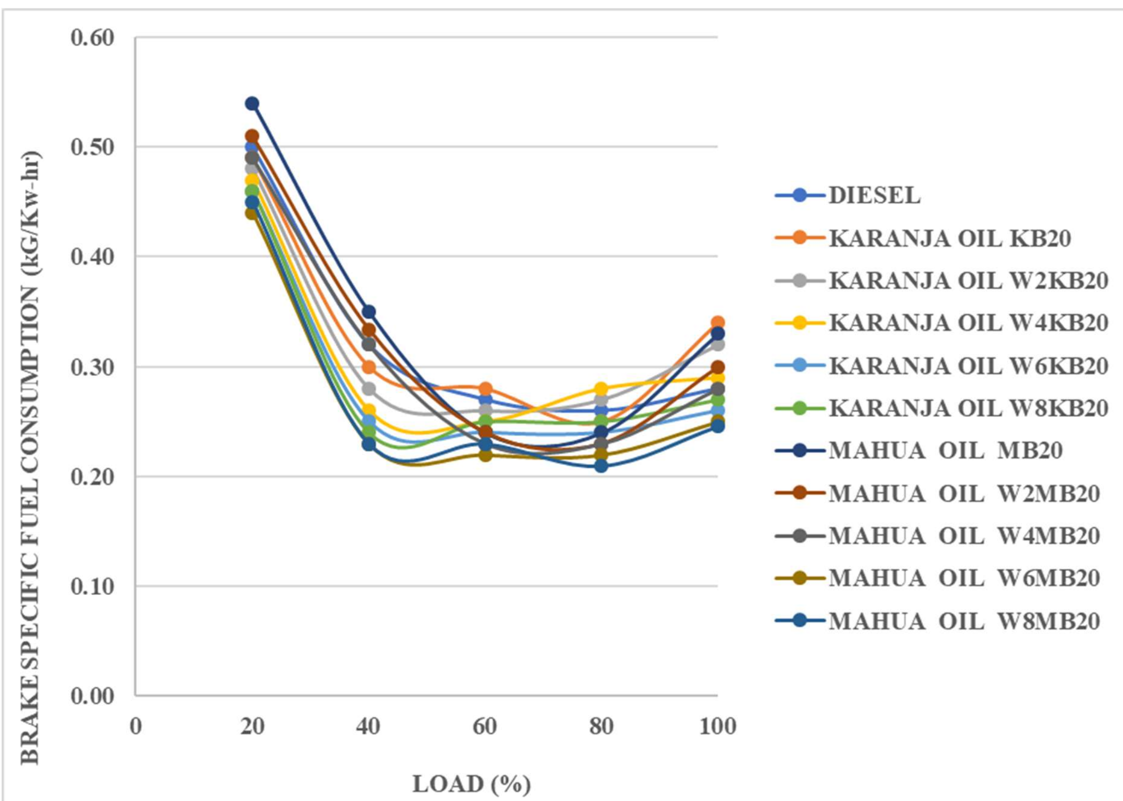

Fig. No. 5: Variation of BSFC Vs Engine Load for both oils (Karanja and Mahua) Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

4.2. Brake Thermal Efficiency

BThE is the ratio of power output to the energy input as fuel, which finally will be the product of the mass flow rate of injected fuel and the lower heating value. All three figures (06 to 08) show the trend that the BThE for all test fuels is higher at 80% load and is lowest at 20% load. The curve getting increased at the fuel mixture with 6% water and further slightly with a mixture of 8% water at all the engine loads. In figure No. 6, the BThE of Karanja oil at 17 CR, KO-B20 is the least with W2KB20 at 20% 16.71 % and highest for W8KB20 at 80% load is 32.15 %. Amongst all the fuel mixtures the highest BThE at all the loads is for W8KB20 are 16.89 %, 26.95 %, 29.87 %, 32.15 % and 31.26 %. In figure No. 7, the BThE of Mahua oil at 17 CR, MO-B20 is the least with W2MB20 at 20% is 16.81 % and highest for W2MB20 at 100% load is 33.92 %. Amongst all the fuel mixtures the highest BThE at all the loads for W8MB20 is 16.98 %, 27.04 %, 30.12 %, 32.45 %, and 33.15 %. In figure No. 8, the BThE of combined Karanja and Mahua oil at 17 CR, KO-B20 is least with W2KB20 at 20% load is 16.71% and highest for W2MB20 at 100% load is 33.92%. Amongst all the fuel mixtures for both KO and MO, the highest BThE at all the loads for W8MB20 are 16.98 %, 27.04 %, 30.12 %, 32.45 %, and 33.15 %. W6MB20 has similar BThE values but on the slightly lower side.

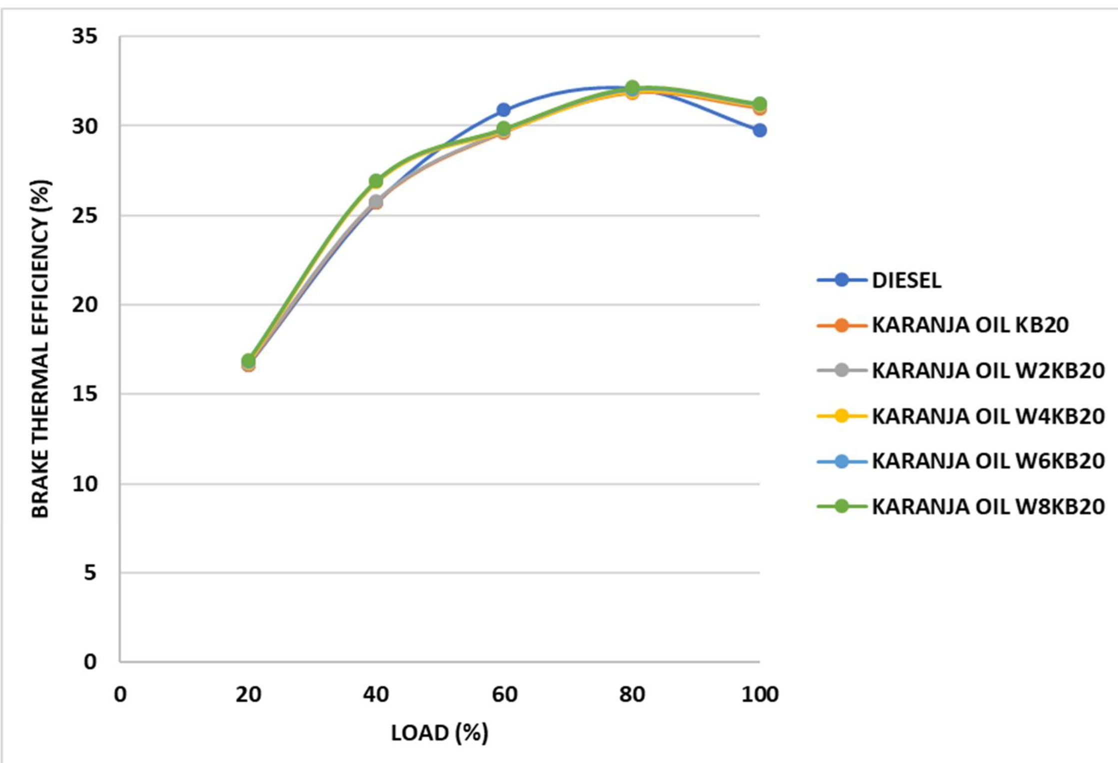

Fig. No. 6: Variation BThE Vs Engine Load for Karanja oil Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

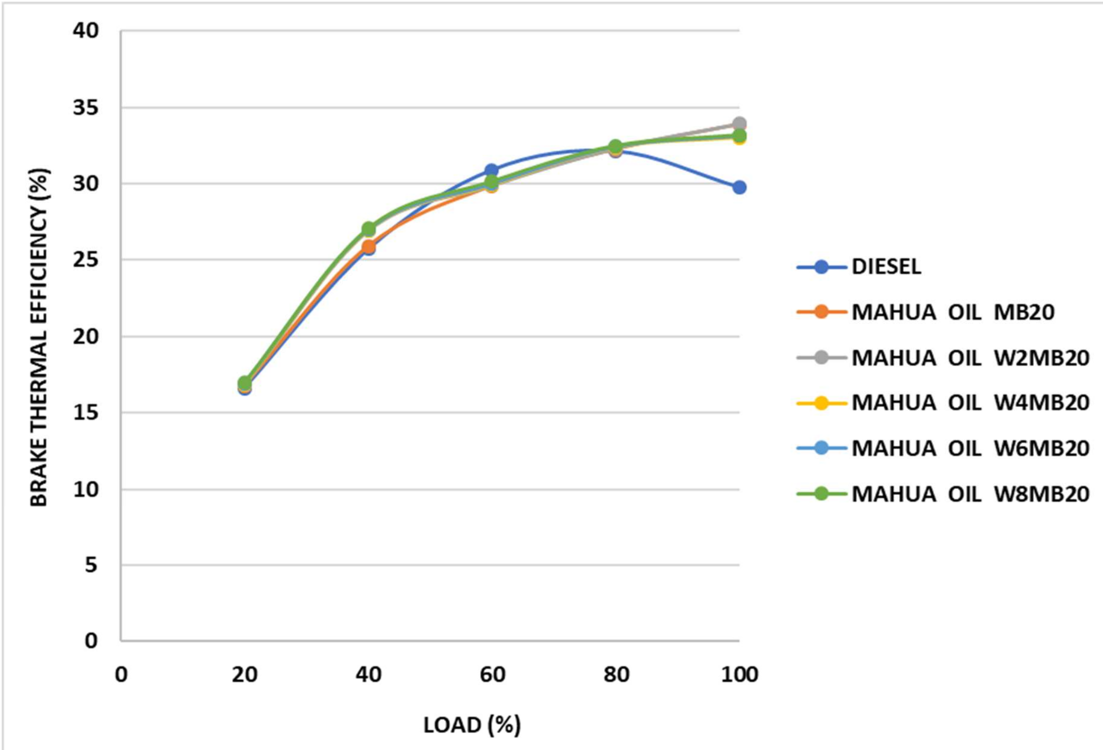

Fig. No. 7: Variation of BThE Vs Engine Load for Mahua oil Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

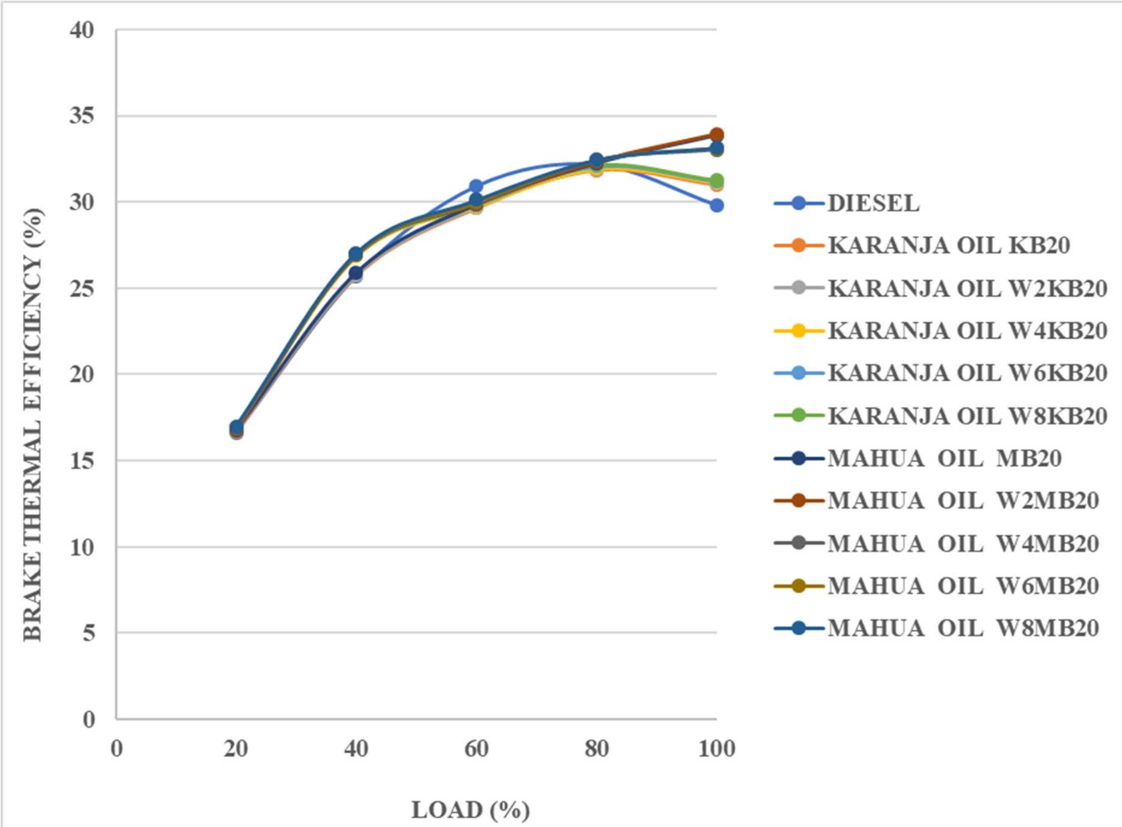

Fig. No. 8: Variation of BThE Vs Engine Load for both oils (Karanja and Mahua) Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

4.3. Exhaust Gas Temperature

It can be seen from the graphical representation that with an increase in percentages of water in all the fuel mixtures, the EGT decreases as the heat absorption capacity is increased and hence decrease the value of the parameter. All three figures (09 to 11) show the trend that the EGT for all test fuels is highest at 100% load and is lowest at 20% load. The curve getting increased at the fuel mixture with 6% water and 396oC further slightly with a mixture of 8% water at all the engine loads. In figure No. 9, the EGT of Karanja oil at 17 CR, KO-B20 is least with W8KB20 at 20% is 152oC and highest for W2KB20 at 100% load is 396oC. Amongst all the fuel mixtures the Lowest EGT at all the loads for W8KB20 is 152oC, 211oC, 261oC, 326oC and 383oC. In figure No. 10, the EGT of Mahua oil at 17 CR, KO-B20 is least with W8MB20 at 20% is 149oC and highest for W2MB20 at 100% load is 396oC. Amongst all the fuel mixtures the Lowest EGT at all the loads for W8MB20 is 149oC, 209oC, 257oC, 334oC and 388oC. In figure No. 11, the EGT of combined Karanja and Mahua oil at 17 CR, KO-B20 is least with W8MB20 at 20% load is 149oC and highest for both W2MB20 & W2KB20 at 100% load is 396oC. Amongst all the fuel mixtures for both KO and MO, the Lowest EGT at 20%, 40% and 60% load for W8MB20 are 149oC, 209oC, and 257oC. The lowest figures at 80% and 100% load for W8KB20 are 326oC and 383oC.

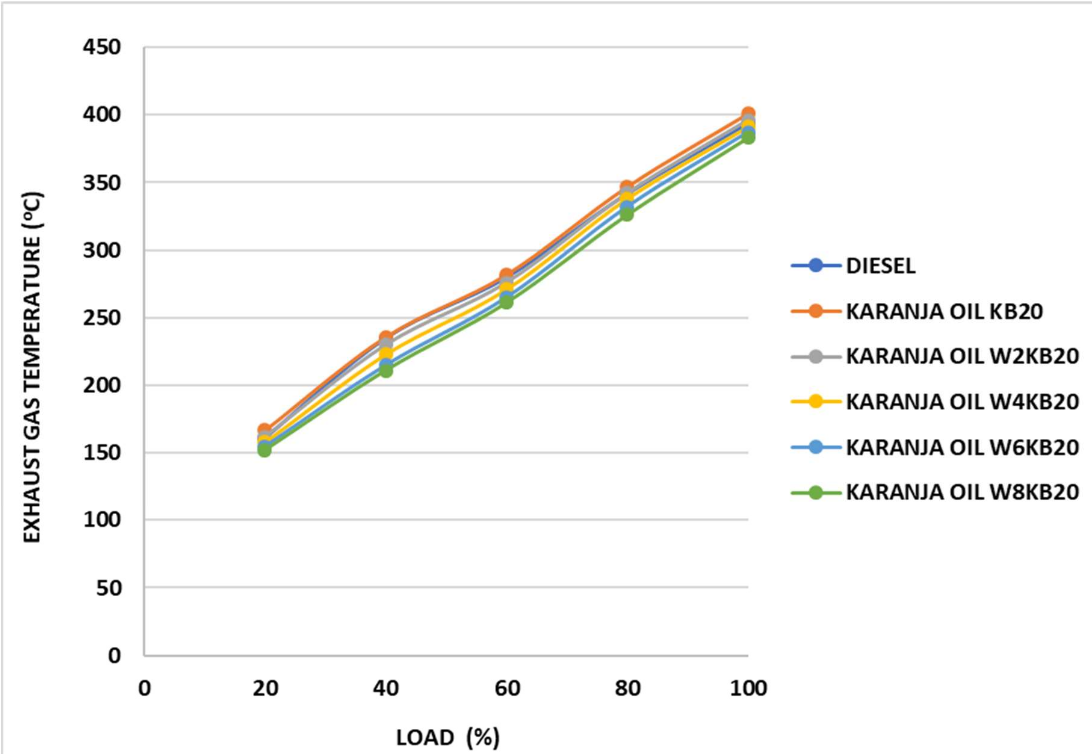

Fig. No. 9: Variation of EGT Vs Engine Load for Karanja oil Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

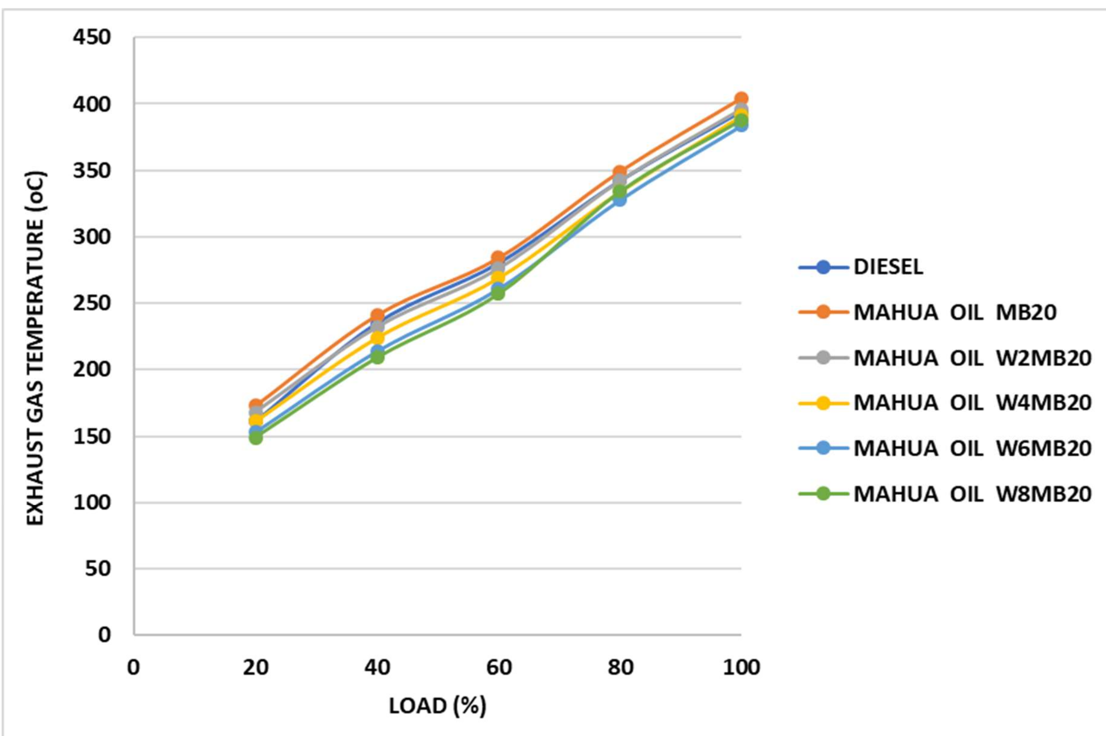

Fig. No. 10: Variation of EGT Vs Engine Load for Mahua oil Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

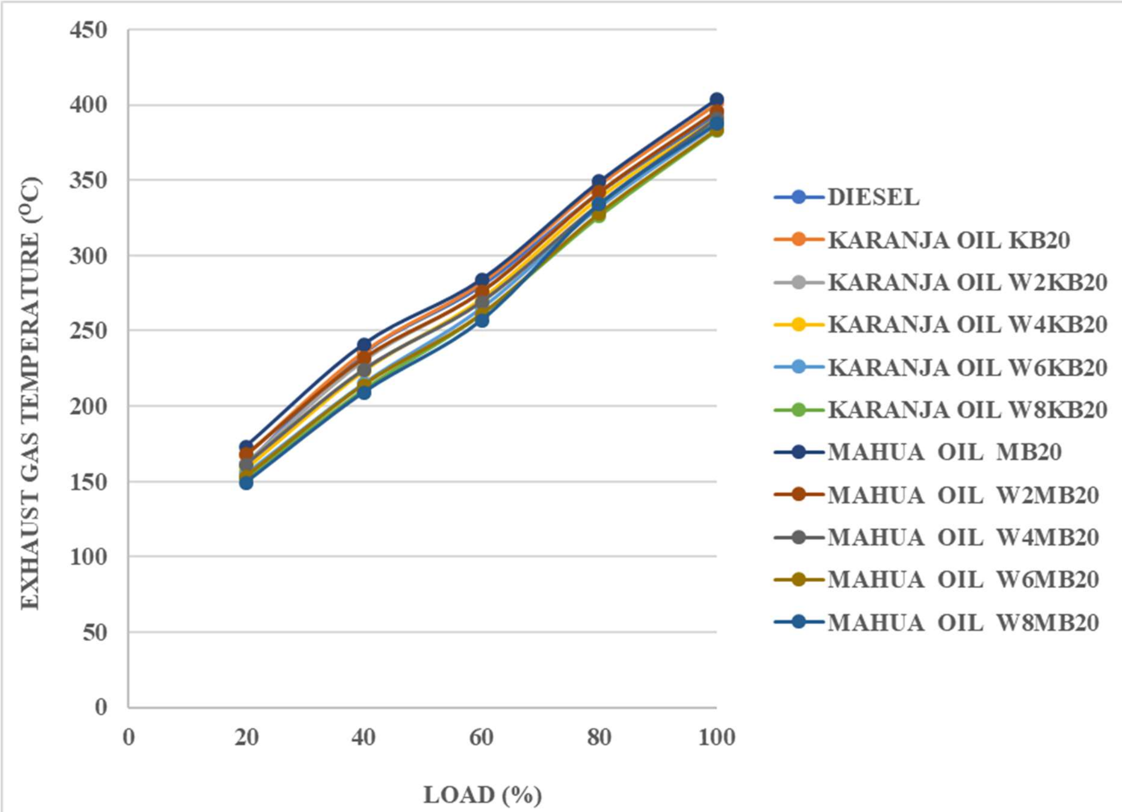

Fig. No. 11: Variation of EGT Vs Engine Load for both oils (Karanja and Mahua) Biodiesel (B20) with water addition (2%, 4%, 6% and 8%) at constant speed 1500 rpm along with CR 17.

Conclusions

In this experimentation task, it was witnessed that water-added biodiesel can be certainly utilised as a nice fuel option in conventional CI engines. The performance parameters such as BSFC, BThE and EGT have seen significant advancement. This promises eco-friendly fuel for CI engine without any engine modification. Figure No. 3 to 11 shows the comparison with all the fuel mixtures at different proportions of water (2%, 4%, 6% and 8%) with two biodiesel (Mahua and Karanja) B20.

1. The results of BSFC of Pure Diesel were compared with different proportions of water-added KB20 fuel mixtures increases at W2KB20 and W4KB20 are 3.85%, 7.69% and declines at W6KB20 and W8KB20 are 7.69%, 3.85% respectively. Similarly in the case when Pure Diesel was compared with different proportions of water added MB20 fuel mixtures declines by 11.54%, 11.54%, 15.38%, 19.23% respectively.
2. The results of BThE of Pure Diesel were compared with different proportions of water-added KB20 fuel mixtures declined at W2KB20, W4KB20 and W6KB20 are 0.75%, 0.59%, 0.16% and increases at W2KB20 by 0.62% respectively. Similarly in the case when Pure Diesel was compared with different proportions of water added MB20 fuel mixtures increased by 0.59%, 0.78%, 0.90%, 1.00% respectively.
3. The results of EGT of Pure Diesel were compared with different proportions of water-added KB20 fuel mixtures declined at increases at W2KB20 by 0.62% and declines at

W4KB20, W6KB20 and W8KB20 are 1.86%, 3.73%, 5.59% respectively. Similarly in the case when Pure Diesel was compared with different proportions of water added

MB20 fuel mixtures increased at W2MB20, W4MB20 by 4.35%, 0.00% and declines at W6MB20, W8MB20 are 4.97%, 7.45% respectively.

Scope for future work

The authors would like to recommend for the upcoming researches that alcohol can also be used as fuel for blending with biodiesel with water addition as well and this will surely increase atomization rate resulting better combustion, performance and emission characteristics. Other parameters for the study or experimentation could be compression ratio variability, variation in injection pressure and injection timing will provide another level to this research.

Declaration of effort contribution credit

Dinesh Ramchandani: Visualisation, Experimentation, Writing, Gathering Readings, and Plotting Graphs Dr. Dinesh Kumar Soni: Offered guidance and support in conducting experiments, writing, and reviewing. Dr. Yogendra Rathore: collaboration when experimentation, authoring, evaluating, and editing experiments.

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