

Investigation of 5hole nozzle fuel injection using vegetable oils in diesel engine

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Abstract : Present experimental work is on investigating the influence of Retrofit and various biodiesel blends on Kirloskar TV-1 diesel engine for performance and emission characteristics. Biodiesel blends like (B10) Biodiesel-10%, (B20) Biodiesel-20% and (B30) Biodiesel-30% of Pongamia/ Honge and Neem at varying loads were tested. Performance parameters such as brake thermal efficiency (BTHE), Total fuel consumption, Specific fuel consumption Mechanical efficiency, Indicated power, Indicated Thermal efficiency (ITHE), Break thermal efficiency and Break specific fuel consumption (BSFC/SFC). The results revealed about the improvement in performance at the initial stage with minimal emissions and later as continued the performance is observed to be decreased as system was ineffective at heavy loads and there was increase in emissions and smoke obesity, with different fuel blends which was because of carbon deposits on the retrofit.

The reduction of smoke opacity, Hydrocarbon (Hexane), Carbon monoxide (CO) with slight increase of Nitrogen oxides (NO_x) emissions was observed for initial low and medium loads while using the biodiesel blends. In summary, it is optimized that engine running on biodiesel blend of Biodiesel-10% (B10) with retrofit reduces Carbon monoxide (CO), Hydrocarbon (HC) emissions and culminates Nitrogen oxides (NO_x) reductions without affecting engine efficiency and other emissions along with the smoke opacity..

IndexTerms – 5hole Nozzle, Injector modifications, nozzle modifications.

I. INTRODUCTION

The fuel injection system is basically related to the compression ignition engines where the air is compressed to a sufficiently high pressure. (Higher than the ignition point of the fuel)

The commonly used fuel in CI engines is Diesel which has an viscosity varied around 2-6 centistokes (cSt) at around 100°F and 1-3.97cSt at 130°F thus the available fuel injectors in DI engines are sufficient for good atomization of the fuel but when it comes to Biodiesel the viscosity will be much higher than expected thus the atomization from a 3-5 hole nozzle fuel injectors won't be sufficient enough there comes the necessity of injector modifications but a question arises but of what kind, thereby here we discuss about the modifications on fuel injector and how it effects on the engine parameters and its emissions.

As such comparatively to the basic Diesel fuel the properties of the fuel like viscosity, density and Calorific value (CV) of the fuel varies differently with different oils and in here we use bio-fuels of various kinds like Honge and Neem, thus in order to atomize the fuel all-over the combustion chamber which would result in complete combustion of fuel and further gives less carbon emissions since the bio-fuels contains dissolved oxygen in them and thereby increasing the performance of the engine.

1.1. EXPERIMENTAL METHODOLOGY

The experimental investigation is done on briefly studying the existing and default 3hole (Bosch Part No.ULL 110 S 639) and 5hole nozzle in the fuel injector used for kirloskar TV-1 Engine and an in order to split/spread the spray injected in all directions, an 3D model of a fit is created which is discussed in upcoming chapters so that spray is made to split up and spread in all directions inside the combustion chamber. The designed model is to be fitted on to the nozzle body in order to do so the diameter of the nozzle is reduced within permissible limits and fitted inside the injector and experiment is carried out expecting the outcome of better results.

1.2. SCOPE OF PRESENT WORK

The present work is majorly focused on decreasing the carbon monoxide (CO), Hydrocarbon (HC) and Nitrogen oxides (NO_x) emissions and also optimize the smoke obesity from the engine while maintaining the same engine performance (Performance without retrofit of diesel) and this is achieved by implementing an device (Herein called as Retrofit) which does the job of splitting up the fuel droplets and improve the atomization of fuel inside the engine cylinder.

Thus as we know Emission board is about to implement Bharat stage 6 skipping the Bharat stage 5 (BS-5) which is similar to Euro-6 standards as it is known to all in these days, and thereby most of the light diesel vehicles like Maruthi Suzuki most popular models Swift and Baleno are about to stop its production by next year (i.e. 2020) so in order to compete with the market the present work might help the light diesel vehicles to be usable so that they are made to produce the emissions and smoke with n the permissible range.

Thereby in simple words the main motive/objective of our work is to the decrease emissions from engine while in the mean time trying to maintain constant engine performance which can be accomplished by the usage of Bio-fuels (In this work Bio-fuels which are used are crude oils)

2. MODIFICATIONS ON FUEL INJECTOR

The Basic motive of the modification is to improvise the atomization process and thereby increasing the efficiency of the engine which invariably decreases the amount of pollutants (emissions) releasing in to atmosphere by accomplishing even better combustion of the air-fuel mixture inside the engine.

The modifications on fuel injector is a very sensitive work which is carried out only on CNC (Computer numerically controlled) machines or 3D printing are the only options where the accuracy of the machining is obtained in μm thus modifications on fuel injector is a very complicated thing. Modification involves the design of the fuel injector mountings/fit which can be attached or mounted to the nozzle of the fuel injector by making some of the necessary arrangements so it fits over it and thereby giving it a try.

Thus even better combustion of air-fuel mixture is achieved by the whirling motion within the combustion chamber which can be accomplished by a special designed part which is to be fitted in such a manner that as soon as the fuel is injected inside the cylinder it impact the blades of the parts and by the effect of the pressure of the impact an whirl is created and this helps in further atomization of the fuel. Similarly there are various number of ideas on designing of the mounting part.

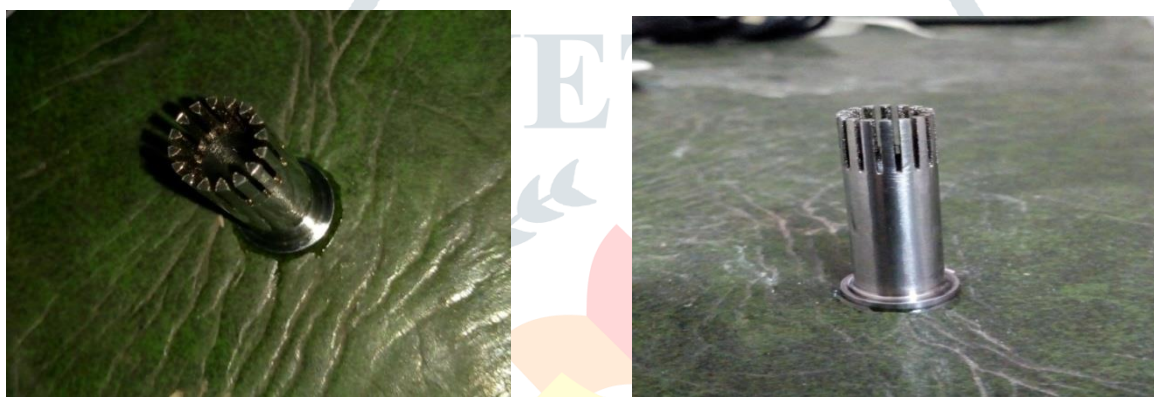


Fig: Actual extrafitting after machining

2.1. WORKING OF THE MODEL/RETROFIT:

When it comes to working as we all know the fuel gets injected in the form of droplets with a high velocity from the spray nozzles which would be 3, 4 and 5 hole nozzles so as soon as the fuel is injected from the nozzle it is impacted to the sharp edge of the lengthy pyramids which makes the fuel droplets split up in to further fine small drops thus helps in further atomization and wide spread of the fuel within the cylinder hopefully.

3. INTRODUCTION TO BIO-FUEL/ BIO DIESEL

Bio-energy is the energy produced by burning the bio-fuel and in simple words bio fuel is the oil/ fuel obtained from the biological source i.e. Sources like plants, plant seeds, (vegetable oils) and animal produce (animal fat), sugarcane, corn, maize etc.

In near future the biofuels can also obtained from alge which are easily grown in the backwaters of the sea/ waste or polluted water thereby can be used in vehicles and other places.

3.1. BIO-FUEL/DIESEL FROM PLANT SOURCE

The very basic source of producing bio-fuel is from plant seeds and it is possible to produce bio-fuels by extracting oils from the seeds the seeds may be of various kinds like sunflower seeds and groundnuts however these are basic food materials thus it would pose food security problems thus biological cycle to be balanced we use oils extracted from non-edible seeds

The plant seeds from which we obtain oil to process it further in to bio fuel and its details are as follows:

1. Neem/Bevu
2. Pongamia/Honge.

In these above seeds mentioned Nagasampige and Surahonne are the two seeds which have the high oil content almost about 60% but the problem they yield only after 7-8 years after plantation

In the above seeds the Government of Karnataka has approved some of the oils which can be used directly or as blends in the compression ignition engines.

The oil content of the seeds may vary from 28-35%. Generally the tree starts giving seeds just after 5 years after plantation and due to its abundance in nature the neem seeds costs about 3-6 Rs/Kg.

4. PROPERTIES OF OIL

Further the oils which are to be used as whole or as blends are given for property checks and the two important properties which are to be used in this experiment are tabulated as below:

The calorific values are obtained from the MSV Analytical laboratory, Moka road, Gandhinagar, Bellary. Where the samples of the oils were submitted by Nazim shaik who is the co-author of this technical paper

5. EXPERIMENTAL SETUP



Fig: Experimental setup.

The above picture is captured at Research advanced laboratory it is an experimental setup on the left side of the picture DI diesel engine can be seen and on the right side of the picture an setup consists of all indicators like pressure, load and the RPM, fuel consumption tube, and water level indicator can be seen. The loads which are applied on the engine are by electrical dynamometer and finally on the extreme left an operator along with the Personal computer can be seen in which IC engine software is installed and with the help of which the data can be collected and finally results are generated.

Results are generated by uploading the data file in to the software and entering the values of the calorific value and the densities of the oil and the blends on which test is carried out and result is generated.

5.1. TESTING APPARATUS:

The testing of the performance is carried out on the Kirloskar TV-1 Engine and its specifications are as mentioned below:



Name of the engine: KIRLOSKAR TV-1

Power rating: 7HP

Cooling system: Water cooled engine

Number of Cylinders: 1

Cubic capacity of the engine (Litres): 0.661

Rated speed (rpm): 1500

Governing: Class: A2/B1

Starting of engine: Hand start

Engine Type: Vertical single cylinder, Water cooled, four stroke cycles, compression ignition diesel engine (Direct injection)

Overall dimension (Standard): 617*504*877cms

6. RESULTS AND DISCUSSION

6.1. THE SPRAY PATTERN

The below images shows the spray patterns of the fuel from the nozzle when fitted inside injector as it can be seen in the images the fuel spray is neatly spread in all direction when compared to the spray without retrofit.

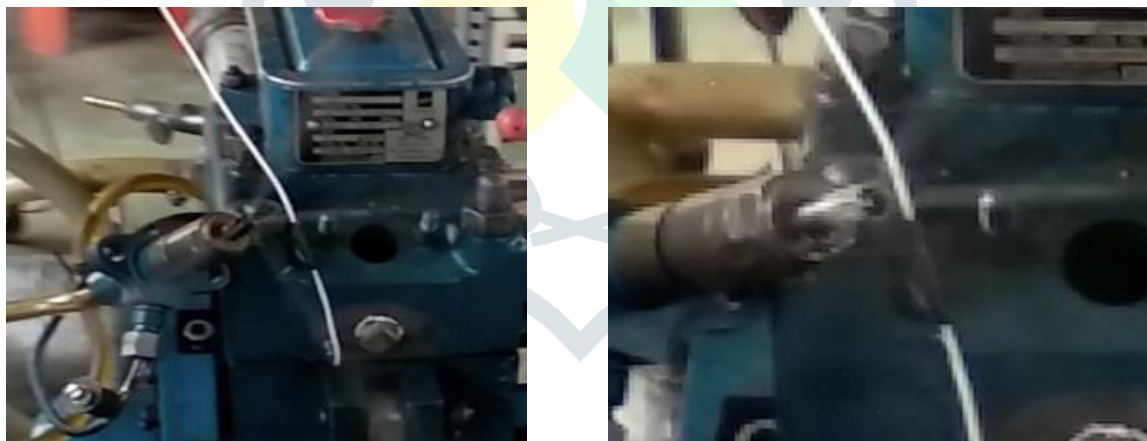


Fig: Image on the left shows the spray pattern without retrofit and image on the right shows the spray pattern with retrofit.

The spray pattern varies for different retrofit models and as in the picture it can be seen in the left picture and , on the left image the spray is travelling at high velocity in 4 directions and in the image on the right the spray is bifurcated into many different streams of spray thereby causing more even distribution of fuel within the engine cylinder.

6.2. PERFORMANCE RESULTS

Note: The performance results of Oil and it's blends are hereby compared and represented graphically with diesel

An graphical representation is been made for the above generated results, which is been represented as below:

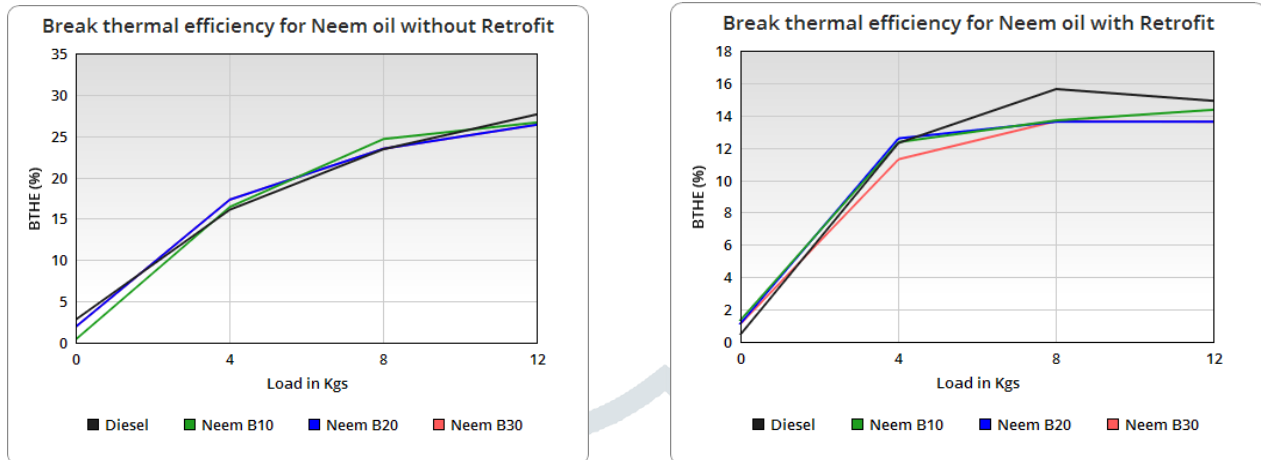


Fig: BTHE for Neem with and without Retrofit

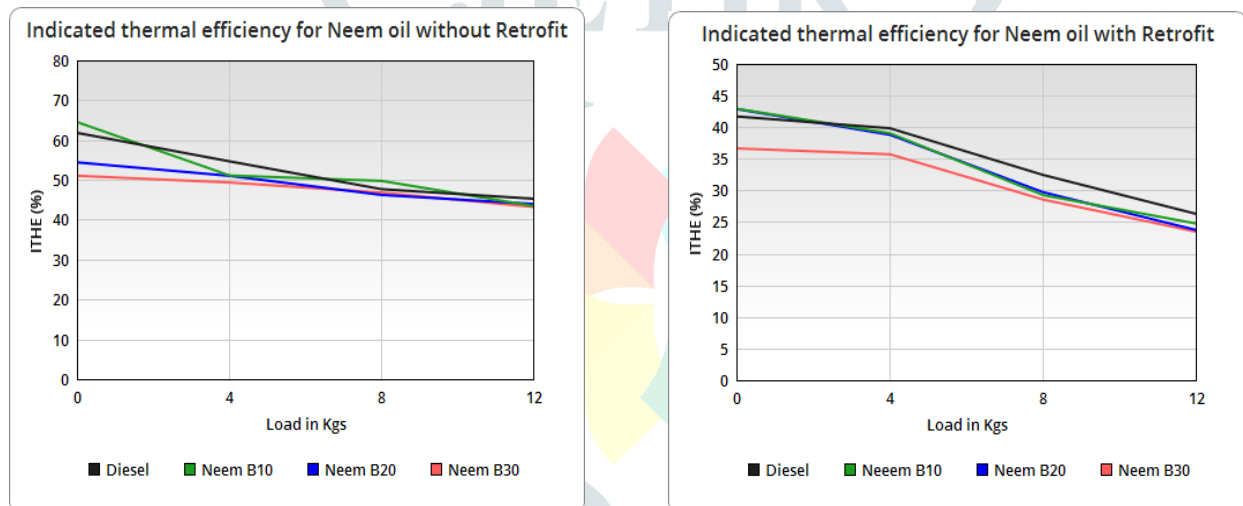


Fig: ITHE for Neem with and without Retrofit

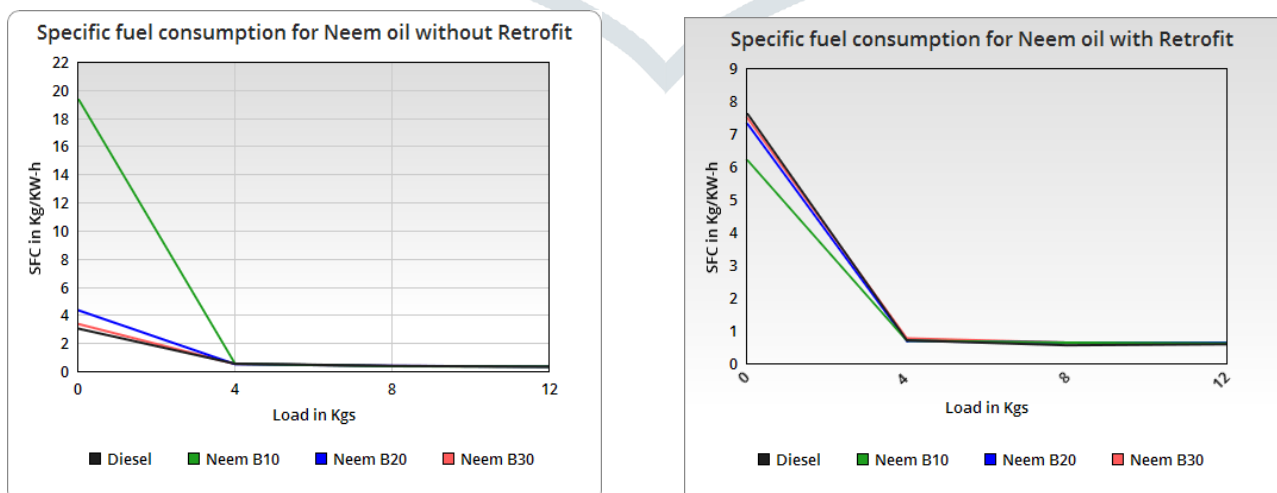


Fig: SFC for Neem oil with and without Retrofit

Similarly for Honge oil;

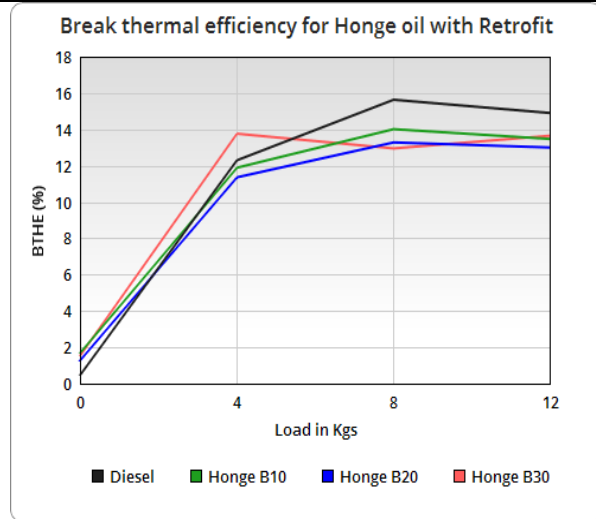
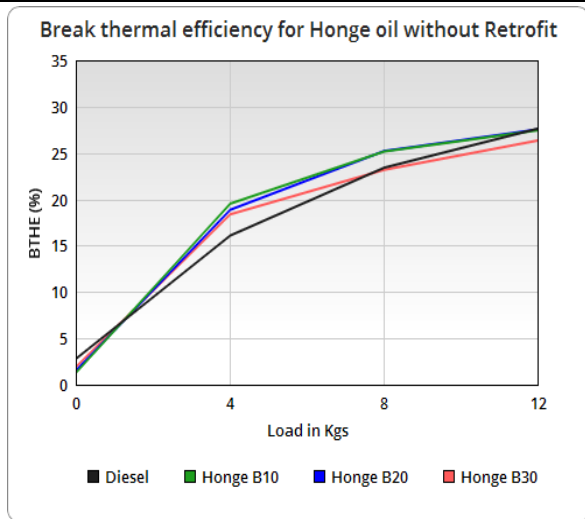


Fig: BTHE for Honge with and without Retrofit

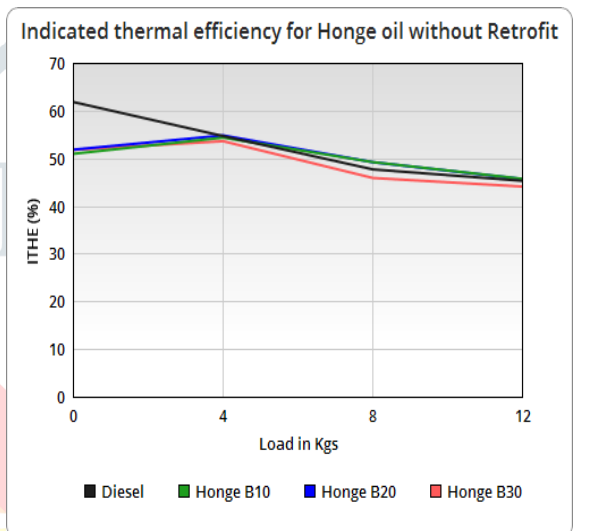
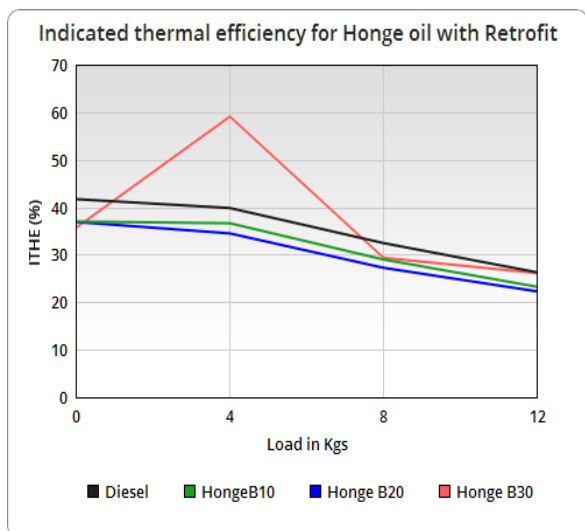


Fig: ITHE for Honge with and without Retrofit

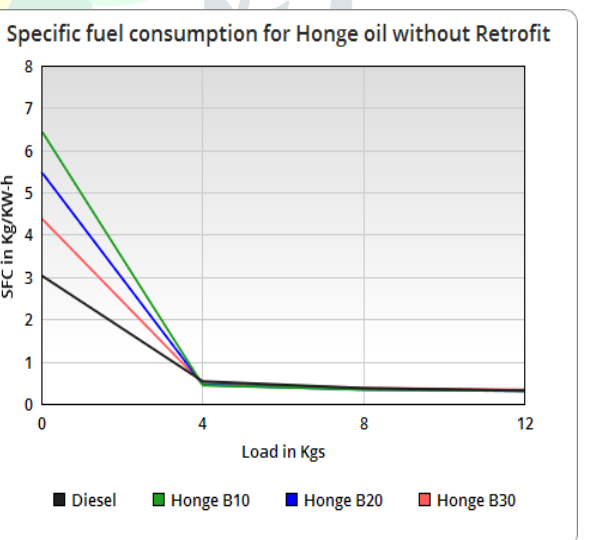
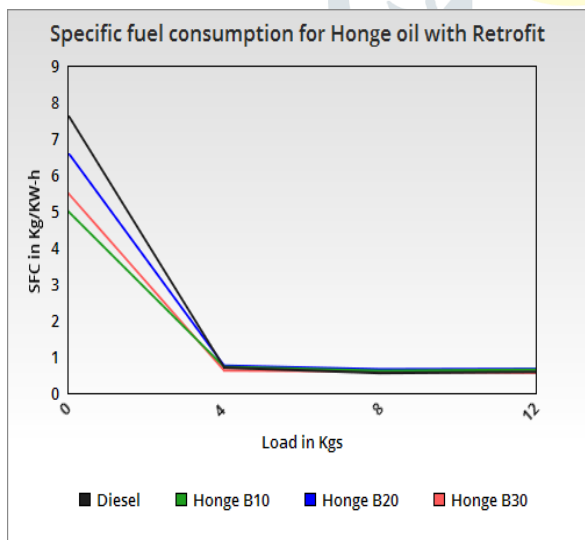
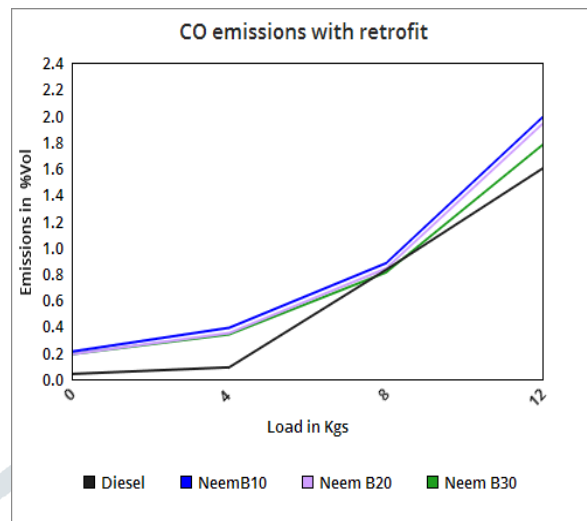
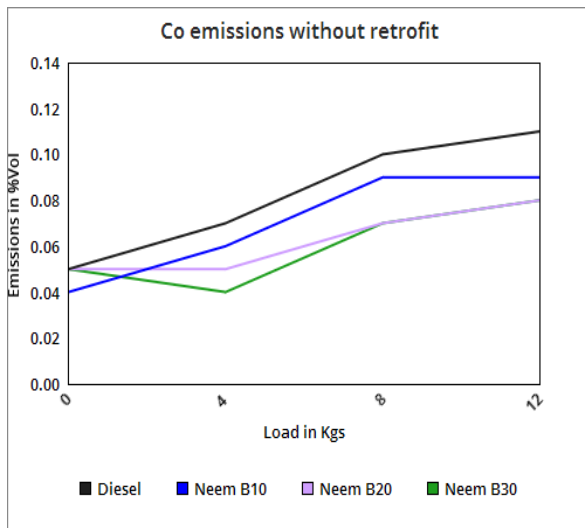


Fig: SFC for Honge with and without Retrofit

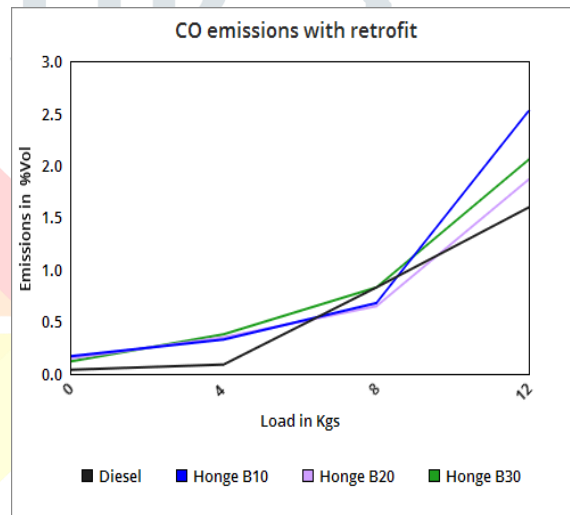
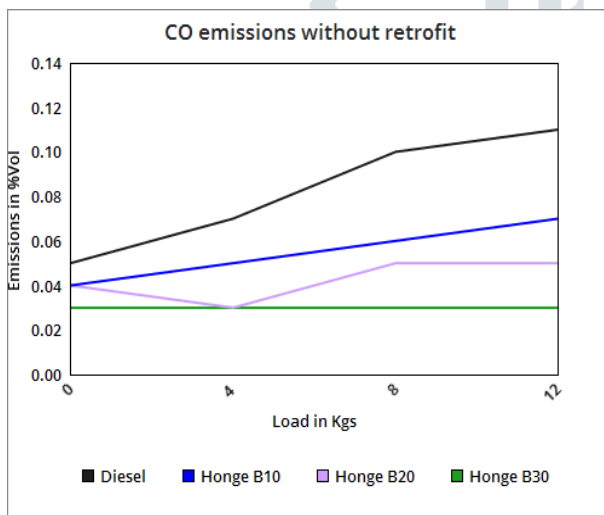
6.3. EMISSION RESULTS

(Here in results are compare to the Basic fuel which is Diesel)

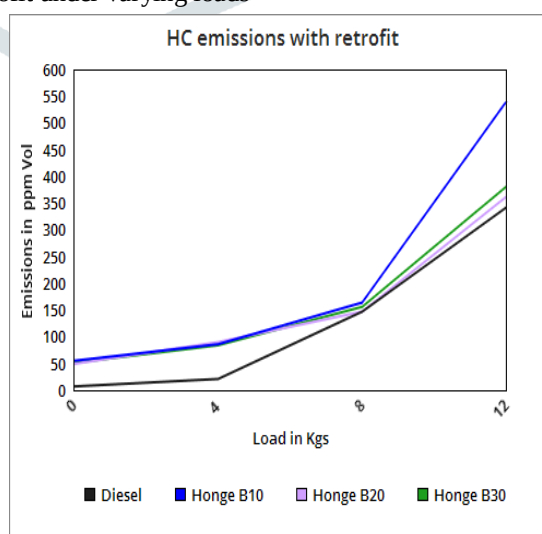
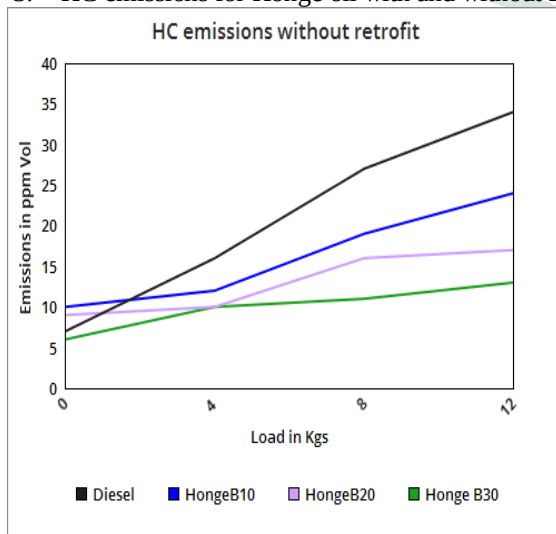
1. CO emissions for Neem Oil with and without Retrofit under varying loads.



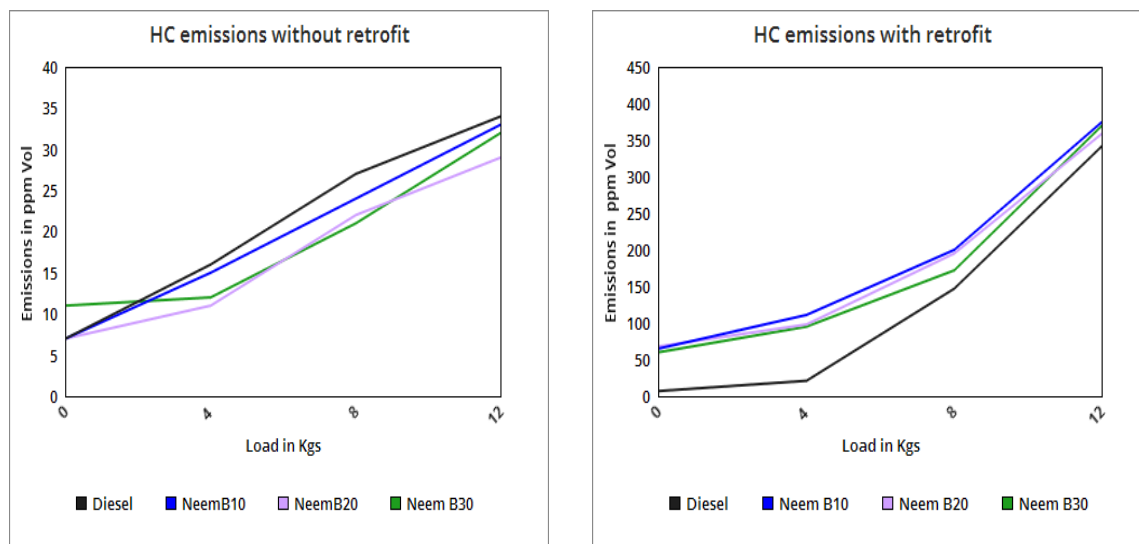
2. CO emissions for Honge oil with and without Retrofit under varying load



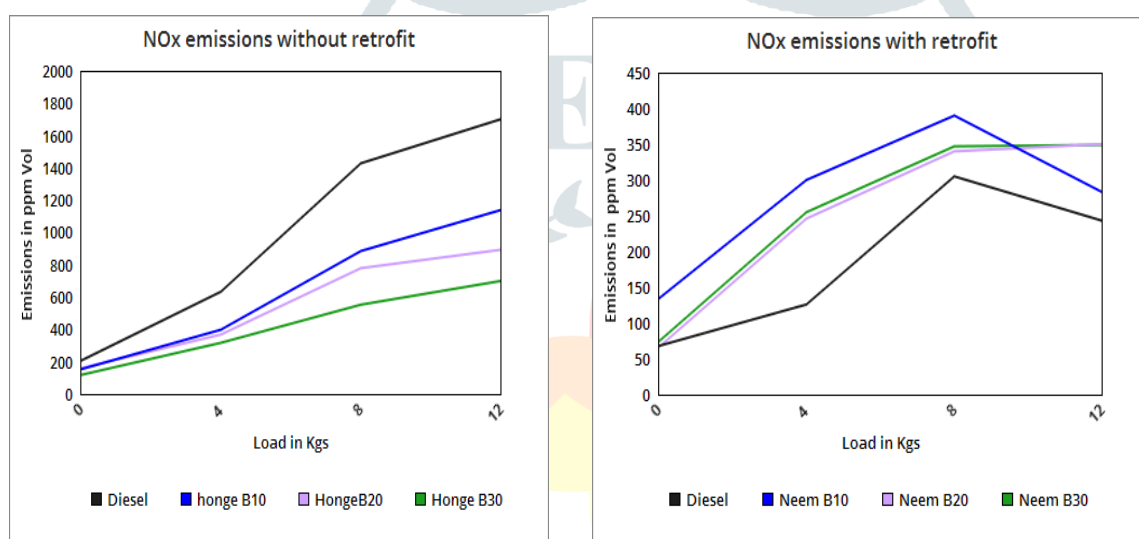
3. HC emissions for Honge oil with and without Retrofit under varying loads



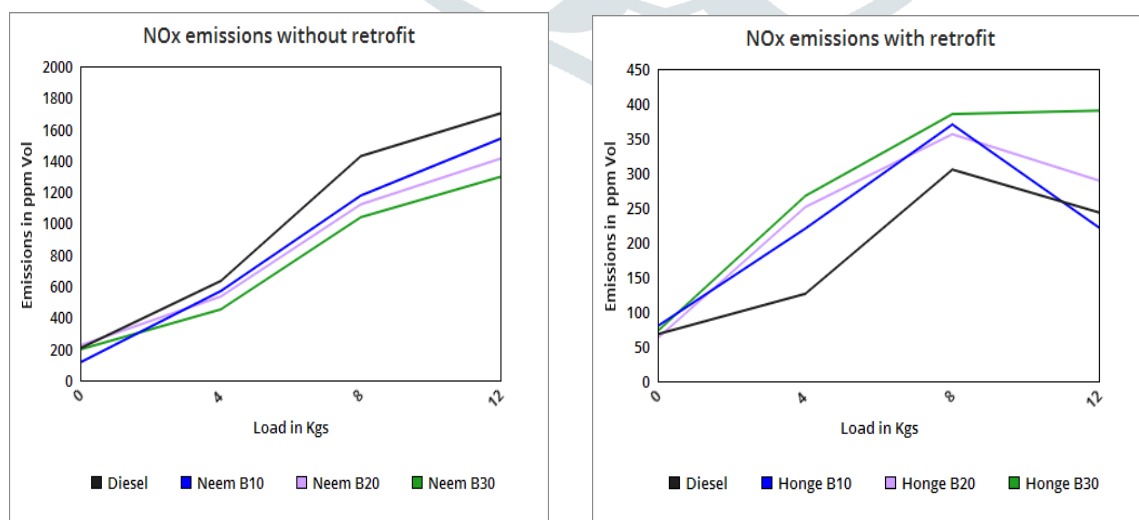
4. HC emissions for Neem oil with and without Retrofit under varying loads



5. NOx emissions for Honge oil with and without Retrofit under varying loads.



6. NOx emissions for Neem oil with and without Retrofit under varying loads.

7. CONCLUSION

As it comes to validating our work it has to undergo testing inside the engine which gave us some different results from that of expected results, though the slits (gap) between for sufficient spray-out of fuel that gap was not sufficient enough to avoid the carbon deposits there by during the initial testing the emission were within the permissible range as the test yield satisfactory results.



Fig: Carbon deposits on Retrofit after the performance tests

Further as the test was carried out for different oils and its blends the emissions were not within the permissible range and the smoke obesity was increasing vigorously and the main reason for the increase in smoke obesity and the emission was the bio-fuel (oils) were not Trans-esterified as the oils used for testing were crude oils and more over the slit gaps in between each triangular pyramids were not sufficient to avoid the carbon deposits inside the engine cylinder which resulted in the marginal decrease of the performance and increase in the smoke obesity and also the CO and HC emissions.

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