PERFORMANCE STUDY OF WASTE TRANSFORMER OIL IN DIESEL ENGINE

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ABSTRACT

This work intents to use Waste Transformer Oil(WTO) as a renewable source of fuel in diesel engine with a reduced cost due to reuse. The usage of WTO as such proved to be ineffective due to its high viscosity and lesser possibility in diesel engine applications. However, their blends with diesel in diesel engine proved to be more effective. This work discusses the experimental investigation of trans-esterfied WTO – diesel blends in diesel engine, performance and combustion characteristics which tends to notably improved. The results also shows the increase of Break thermal efficiency(BTE), Peak heat release rate(PHRR) for transesterified WTO 50 by 7.4% and 13.4% respectively than that of diesel at full load conditions. Emission rate for smoke, Hydrocarbon(HC), Carbon monoxide(CO) were tends to be reduced with increase in NOx emission.

I. INTRODUCTION

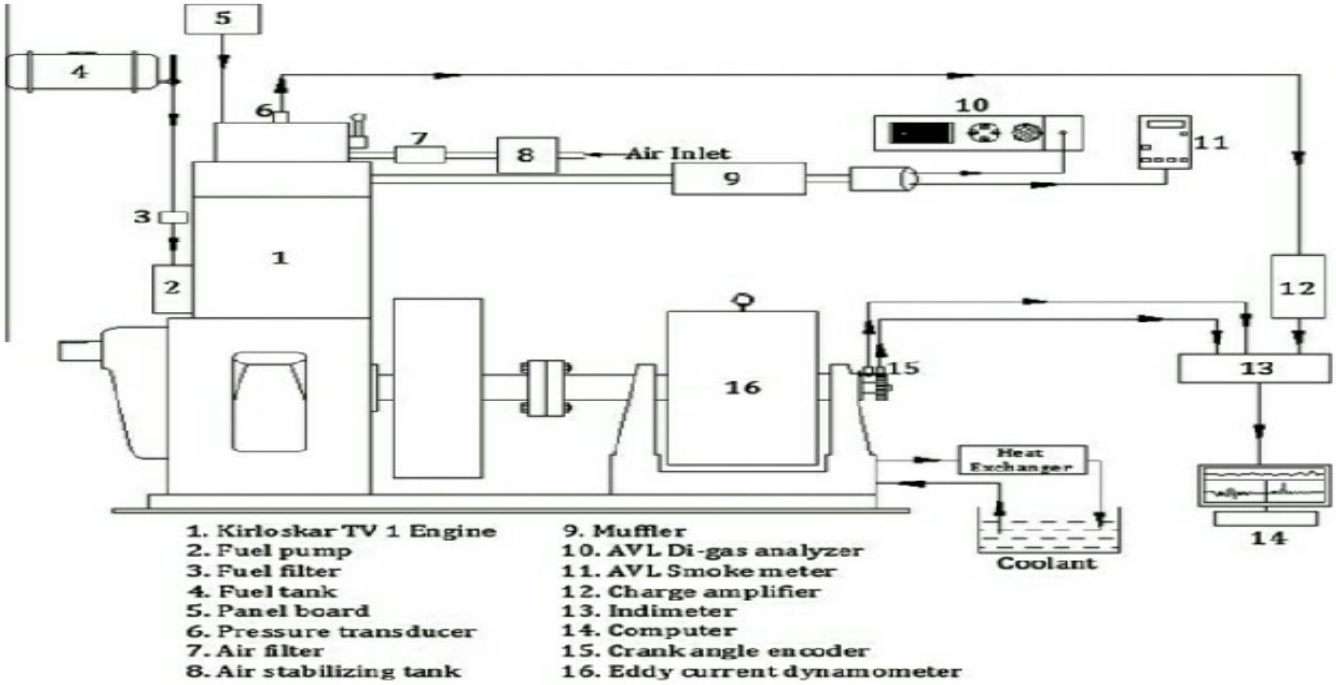
The search for renewable fuel sources is being made universally and this includes alternative fuels for internal combustion engines. Over the past few decades there has been alarming threat of fossil fuels and the demand grows larger than supply. In the current scenario researchers have identified a variety of biomass based liquid fuels, vegetable oil , Unfortunately availability of feedstock, effect of feedstock on the overall production cost of biodiesel and advancement in the production of biodiesel are recognized as potential reasons for the evolution of a new alternate oil. This throws the light on the view of reusing the Waste Transformer Oil(WTO) as a source of alternate fuel for diesel engines. Characteristically the physical and thermal properties of the WTO are little bit different and hence to make them use in diesel engine certain modifications are to made.

Over a period of time, petroleum based oils are being used as insulating and cooling oil for transformers which looses its characteristics after a certain period of time and needed to be changed often. Thus, the proper disposal of the WTO from huge number of transformers located all over our place tends to be complex since it contaminates soil and spills are hazardous. So, we have deemed to reuse the waste transformer oil after processing it using trans-esterification process which tends to give better results compared to diesel while performing the performance analysis and emissions test of WTO – diesel blend oil in diesel engine. The results based on these tests are discussed on this work.

II. EXPERIMENTAL SET- UP OF ENGINE

The compression ignition engine used for the current study was Kirloskar TV-I, single cylinder, four stroke, constant speed, vertical, water cooled and direct injection diesel engine, and the detailed specifications of it are given in Table. The engine was coupled with an eddy current dynamometer to apply different engine loads and the experimental setup and arrangements have been shown in Fig. Measurement of combustion chamber pressure was obtained by installing a water-cooled piezoelectric pressure transducer in the cylinder head with the sensitivity 16:11 pC/bar. An AVL 3057 charge amplifier and analog to digital converter transforms the charge yielded by the piezoelectric transducer into proportional electric signals, which are intercepted through a personal computer (PC) interfaced with an AVL 619 Indimeter hardware and Indwin – software version 2.2 data acquisition system. Finally, in-cylinder pressure, recorded over 100 cycles, was collected and heat release rate was computed from it.

Make	Kirloskar- TV 1 Four stroke, compression ignition, constant speed, vertical, water cooled, direct injection
Number of Cylinders	one
Bore	87.5mm
Stroke	110mm
Compression ratio	17.5:1
Rated speed	1500rpm
Rated output	5.2kw
Injection pressure	220 bar
Lubricating oil	SAE 40



Schematic layout of test engine.

The Chromel Alumel (k-type) thermocouples were installed at inlet and outlet ducts to measure the respective gas temperatures.The engine speed was measured by in-house designed magnetic pickup sensor connected to frequency meter. The smoke intensity was measured by an AVL 437 smoke meter and other emissions such as NOX (nitrous oxides), CO (carbon monoxide), HC (hydrocarbon) and CO2 (carbon dioxide) were measured by an AVL 444 di gas analyzer. The fuel consumption, exhaust gas temperature and exhaust emissions such as NOX, CO, HC and smoke were measured and recorded for different engine loading conditions. The fuel consumption was measured on manual basis using a burette and stopwatch. The tests were repeated for three times and finally, the average value of the three readings was taken for the calculation to authenticate the accuracy of the measured readings. For every test with different blend fuels, the combustion parameters were also captured and stored in the personal computer for post processing. Initially, the engine was made to attain warm up condition by confirming the temperature of engine coolant and lubricating oil to be 70 C, after running the engine with diesel for 30 min. All measurement and readings were recorded when the engine has attained steady state condition. The uncertainties and errors can arise from instrument selection, environmental condition, calibration, testing, observation and
while taking readings. In this work, an uncertainty analysis was performed using the method described by Holman.

III. RESULTS AND DISCUSSION

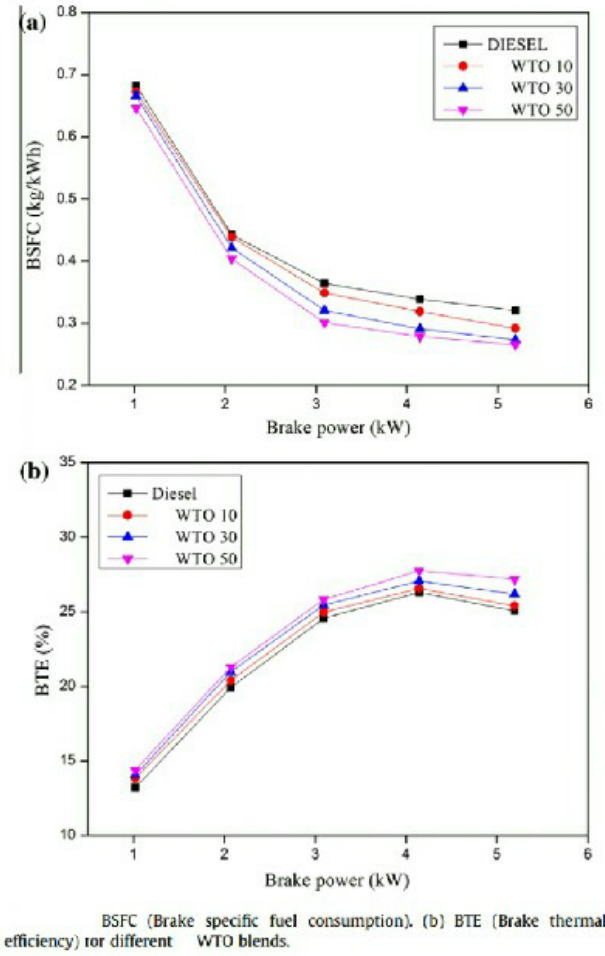
i. Combustion analysis:-

The combustion analysis in compression ignition engine is influenced by various factors such as fuel properties, combustion chamber design, fuel injection timing and engine operating conditions. The heat release rate and in-cylinder pressure are the 2 major combustion characteristics which play a prime role in determining the combustion characteristics. With the increase in proportion of TEWTO in the diesel blend, peak in-cylinder pressure increases and is noted to be higher for TEWTO-50, followed by TEWTO-30, TEWTO-10 and diesel. It is also observed that the maximum heat release rate is maximum for TEWTO-50 blend, followed by TEWTO-30 and TEWTO-10 and diesel. Since TEWTO possess comparable calorific value with diesel, there is no compromise in the amount of energy being released and therefore, they are reported to be higher than diesel. In a comparison with diesel, the peak heat release rate of TEWTO-50 was found to be 13.2 % higher than diesel at full load condition.

ii. Performance analysis:-

We know that the performance of engine relies on fuel consumption and calorific value of fuel. Therefore, it is important to study the impact of them and other fuel properties of TEWTO on BTE and BSFC of the engine at various loading conditions. It is noted that due to comparable calorific value of TEWTO with diesel, the engine is not prone to any increase in fuel consumption, which is rather comprehensible. In further introspection, viscosity of TEWTO – diesel blends are brought closer to diesel as the trans- esterification process

has improved the fuel viscosity besides the calorific value of the fuel. Therefore, fuel atomization, air/fuel mixing and subsequent combustion process are improved so as to decrease the BSFC. Remarkably, a 5.8% and 14.7% reduction in BSFC was perceivable from the figure for TEWTO- 50 than diesel at low and full load condition, respectively.

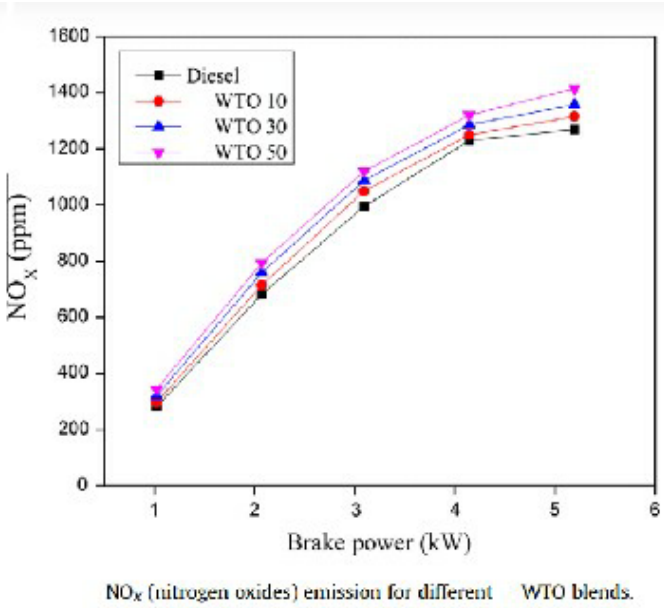


BSFC (Brake specific fuel consumption). (b) BTE (Brake thermal efficiency) for different WTO blends.

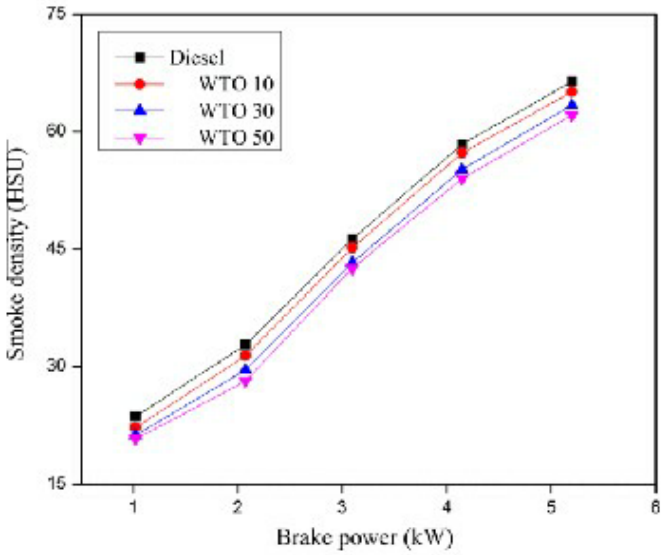
The reduced fuel consumption for TEWTO- diesel blends, due to the above mentioned reasons, clearly reflects improvement in BTE of the engine. Substantially, the comparable flash point of TEWTO- diesel blends with diesel has improved fuel evaporation and the ensuing air/ fuel mixing process so as to enhance the combustion.

iii. Emission analysis:-

NO_x emission significantly depends on the factors such as in-cylinder gas temperature, prevalence of excess oxygen in the combustion chamber. At all loading conditions, a higher NO_x, emission was found for TEWTO- diesel blends than diesel due high in-cylinder temperature, caused by the improved combustion. Substantially, heat release curve, as described above, also exhibits a higher magnitude of premixed combustion phase, supporting the cause of increased in-cylinder temperature.



NO_x (nitrogen oxides) emission for different WTO blends.

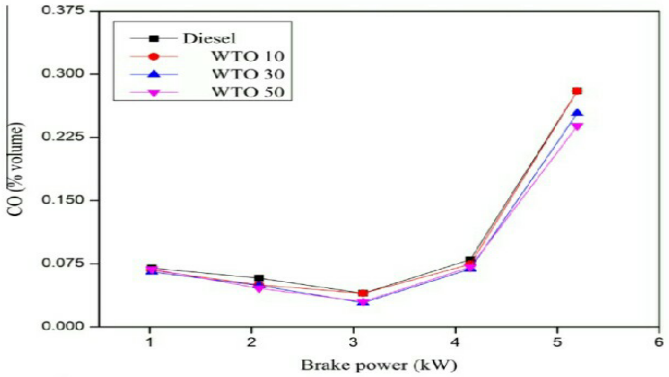


Smoke emission for different WTO blends

Conceptually, increase in NO_x emission is expected to decrease smoke emission with respect to widely reported NO_x-smoke trade off in a diesel engine and this has been observed in the current study too. The decrease in smoke emission for TEWTO- diesel blends is believed to have been due to proper oxidation of soot in the flame region, supported by the improvement in fuel properties in fuel properties of TEWTO after Trans- Esterification process.

Compression ignition engine are capable of converting the air fuel mixture into end products of combustion by 98% when compared to spark ignited engines. With such high fuel conversion efficiency obtained for conventional diesel fuel, it would be interesting to study the effect of TEWTO on incomplete products of combustion such as HC and CO. Diesel engine generally produce lower emissions of CO as they are designated as lean burn engines, which favorably

promotes oxidation of it at desired temperature of the combustion zone.



CO (carbon monoxide) emission for different WTO blends.

IV. CONCLUSION

From the above experimental investigation, we can conclude that the tran esterified WTO can be used as an alternative fuel which also finds a source way for the disposal of WTO. The trans-esterification process had been made inorder to bring the characteristics of WTO similar to diesel... The treated WTO has been tested in the four stroke, single cylinder diesel engine (with above specifications) and the results absorbed shows that the Break thermal efficiency and heat release rate were found to be increased with the reduction in the emission of smoke, HC, CO.

The performance, combustion and emission characteristics of the diesel engine are summarized as follows,

i. *BTE for WTO 50 blend is increased by 10.1% and 7.4% than* diesel at low and full load condition, respectively.

ii. The maximum heat release rate was found to be increased by 13.2% with WTO 50 blend when compared with diesel at full load condition.

iii. The exhaust emissions such as Smoke, HC and CO have been reduced by 7.7%, 4.9% and 14.8% at full load condition, while

iv. NO_x emission was increased by 9.4%, respectively.

In future, it turns out that we would endeavor to perform certain modifications on Engine and to do some fundamental studies on fuel spray, evaporation and and flame characteristics of trans esterified WTO diesel blend. The above study will be continued to implement the alternative fuel and Modified engine in real life

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