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An Experimental Investigation on the Emission Parameter using WTO-Diesel blend with Additive (PPDA-P-Phenylenediamine) in a Diesel Engine

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Abstract- **Pollution from the petroleum oil increases day by day in terms of CO2, CO, NOX, PM and many other gases and particles. Price difference and economy leads people toward the use of alternative fuels. Waste to energy is the recent trend in the selection of alternate fuels. One such fuel is WTO, which can be obtained from waste as an alternative fuel. By using WTO as a replacement of Diesel, both the above stated problems can be solved at great extent. Group compound of WTO and Diesel were identified by FTIR also various properties obtained Diethyl-Ether and p-phenylenediamine Additives were selected for experimental work.**

Five blends were prepared for the experimental investigations are WT10, WT10+200ppm PPDA, WT10+500pp PPDA, WT10DE05, WT10DE10.Prime objective of this project is to find out an alternative fuel that can be used as a replacement of diesel and analyses the performance and reduce emission parameters. To fulfill the prime objective, Diesel engine, fuelled with Waste transformer Oil (WTO) - Diesel blends with Additive should be used to be operated at different blend ration with different concentration of Additives.

Index Terms- **WTO, Additives, Performance, and Emissions.**

1. INTRODUCTION

Over the last two decades in India, there has been a tremendous increase in the number of automobiles. Currently, the motor vehicles population in India is about 180 million. Even though the transport sector plats a pivotal role for the economic development of country, it brings an unavoidable spectre of environmental deterioration along with it. This is specially a huge problem for a developing country like India. Combustion of fossil fuels in mobile sources for transportation has led to increase of pollutants such as CO, HC, NOx, SPM, and many other harmful compounds in the environment, and the resulting air quality deterioration and health effects especially in urbanized areas. Hence, an integrated approach for reducing emission from mobile sources is the most desirable in urban transportation. In this regards, alternative fuels and alternative drivetrains play a major role in emission mitigation. The major factors for need of alternative fuel are listed below.

- Greenhouse Gas Emissions
- Air Quality
- Depletion of Fossil Fuels
- National Security

Waste to energy is the recent trend in the selection of alternate fuels. Previously studies have been carried out on the utilization of Waste oil such as Waste cooking oil, Waste lubricating oil, Waste plastic oil and Waste transformer oil shows the promising new alternative feedstock to run diesel engine [13]-[18]. One such fuel is WTO, which can be obtained from waste as an alternative fuel. By using WTO as a replacement of Diesel, both the above stated problems can be solved at great extent. WTO blend with diesel used as alternative fuel without any engine modification and FTIR shows the similar group compounds of WTO and Diesel .Physical and chemical properties also comparable with Diesel [16],[17]. The HC and CO emissions for the UTO and its diesel blends are marginally higher than those of diesel operation at full load. The NOx emission is higher for the UTO–diesel blends than diesel at full load [17]. By varying the injection timing with Transesterified WTO the performance and emission parameters are improved [17].

Fuels additives have become essential tool not only improve the performance and also produce lower emissions (NOx) of diesel engines. A variety of additives (metal based, oxygenated, antioxidants, lubricity improvers, cetane number improvers, and cold flow improvers) are used in biodiesel fuel to meet the international emission standards [20]-[23].The objective of the work is to study the influence of Additives on the performance, emission parameters of a DI diesel engine using WTO as a fuel. For that FTIR of WTO and Diesel analysed. Various properties WTO-Diesel blend with Additives also were obtained.

2. WTO (WASTE TRANSFORMER OIL)

Transformer oil in an electrical power transformer is usually known as Insulating oil. It is normally obtained from fractional distillation and subsequent dealing of crude petroleum. Transformer oil mainly assists two purposes for liquid insulation in electrical power transformer and to drive away heat of the transformer acts as coolant. When a transformer is subjected to thermal and electrical stresses in oxidizing surroundings, it step by step loses its balance and becomes decomposed and oxidized, its acidity increases, and finally, it starts to produce mud, Figure 1 shows the Waste Transformer oil which is the waste product.

Figure1 Waste Transformer Oil

2.1 Group Compound of WTO

Table 1 represents the family, bond types for the diesel fuel and WTO. In case of Diesel, the strong absorbance frequencies 2924.62 cm-1 and 2729.63 cm-1 represent C–H stretching. The absorbance peaks 1459.43 cm-1 represented the C–H bending which indicates the presence of alkanes. For WTO strong absorbance peaks 2924.61 cm-1 and 2854.35 cm-1 represent the C–H stretching.

Table -1 FTIR group Compound

Diesel			WTO		
Frequency range (cm^{-1})	Bond types	Family	Frequency range (cm^{-1})	Bond types	Family
2924.62 – 2729.63	C-H stretching	Alkanes	2924.61 - 2728.75	C-H stretching	Alkanes
1459.43	C-H bending	Alkanes	1462.79	C-H bending	Alkanes
1377.52	C-X	Fluoride	1377.34	C-X	Fluoride
722.60	C-H bend	Alkanes	722.76	C-H bend	Alkanes

The absorbance peaks 1462.79 cm-1 and 722.76 cm-1 represented the C–H bending and C–H out of plane bend respectively indicating the presence of alkanes. From the FTIR graph analysis it is seen that major transmittance spectrums peaks both of the fuels are alkanes. From based on the above discussion it is clear that both oil is saturated hydrocarbon. The presence of hydrocarbon groups C–H indicates that the WTO has a potential to be used as fuels. Similar FTIR results for transformer oil have been reported by [16], [18]. The FTIR of WTO and Diesel were conducted at Centre of Excellence Laboratory, GIDC VAPI.

2.2 Properties of WTO and Diesel

For testing any alternate fuel in a diesel engine, detailed analysis of its physical and thermal properties is compulsory, and therefore, in this study, WTO fuel was investigated for its fuel properties. In this investigation, thermal properties of WTO fuel, such as specific gravity, density, flash point, gross calorific value, Sulphur contents, Moisture Contents were estimated by standard methods and compared to that of diesel, as shown in Table 2. The properties of WTO and Diesel were tested at Centre of Excellence Laboratory, GIDC VAPI.

Table 2 Properties of WTO and Diesel

PROPERTIES	WTO	DIESEL
Gross Calorific Value (cal/gm)	11357.05	13054.38
Specific Gravity	0.862	0.825
Density (kg/m^3)	862	825
viscosity[Cp]	20.0@24.5^{0}C	6.99@25.8^{0}C
Flash point [^{0} C]	150	47
Sulphur Contents [ppm]	208	103
Moisture Contents [%]	0.6588	0.0145
Fire point [^{0} C]*	145	95
Cetane number*	42	48

3. MATERIAL AND METHOD

For the experimental investigation, the WTO was blended with diesel in proportions on a volume of 10%. The blend was denoted as the WT, followed by the numerical value, which represents the percentage of the WT in the blend. For example, the numerical value in the blend WT10 indicates 10% of WTO. For getting the homogeneous stable mixture the blend was agitated well with the help of a mechanical agitator. The diethyl ether is blended with the biodiesel in the proportion of 5% and10% by volume which is called as WT10DE05, WT10DE10. The PPDA is blended with the biodiesel in the proportion of 200ppm and 500ppm which is called as WT10+200ppmPPDA, WT10+500ppmPPDA.

Table 3 Properties of Various blends

Blends	Calorific value (MJ/kg)	Kinematic Viscosity at 40^0C(mm^2/s)	Density (kg/m^3)	Cetane index
WT10	43.62	3.42	835.2	47.5
WT10+200ppm PPDA	43.46	3.76	841	46
WT10+500ppm PPDA	43.52	4.02	847.3	47.2

Table 3shows the properties of WTO-Diesel blends with Diethyl ether and PPDA (p-phenylenediamine). For comparing the diesel fuel shows marginal increase in the values of Density, kinematic viscosity and decrease in calorific value. Due to higher cetane index of Diethyl ether, blends with it show the higher value than other. The important properties of various blends were obtained at Akshar Analytical Laboratory & Research Center, Ahmedabad. The experimental work were carry out on Single cylinder, Water cooled, 3.7 kW, 1500 rpm, Diesel engine test rig to study the performance and emissions Parameters. The specifications of engine shown in Table 4.

Table 4 Engine Specifications

Engine name	Kirloskar
Engine no.	10.1012/1100662
Cylinder number	1
rpm	1500
BHP	5
kW	3.7
Fuel injection system	DI
Valve no.	2/cylinder
Bore X stroke	80mm X 110mm
Displacement	550cc
Specific fuel consumptions	245 g/kWh
Compression Ratio	16.5:1
Dynamometer	AC Electrical

4. RESULT AND DISCUSSIONS

4.1 Emission parameters

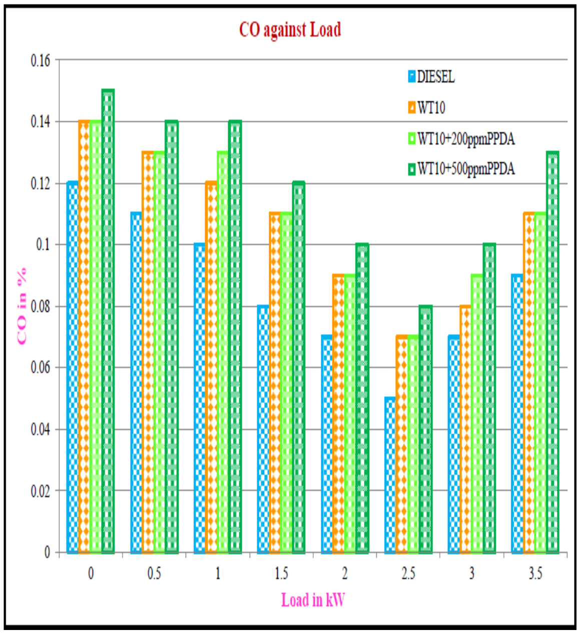

Figure 1Effect on Carbon Monoxide against Load for PPDA Blends

Due to incomplete combustion of fuels CO formed during the intermediate stages of fuels. If combustion proceeds to completion, CO is converted to CO2. If the combustion is incomplete due to shortage of air or low gas temperature, CO will be formed. The variation of the carbon monoxide emission for the Diesel and WT10 blend with additives for different engine loads is shown in Figure1. The CO emission first decreases and at higher load its increases. CO emitted from Diesel varies from 0.12% at zero load and 0.09% at full load. For WT10 it varies from 0.14% at zero load and 0.11% at full load. For WD10+200ppmPPDA it varies from 0.14% at zero load and 0.11% at full load. For WD10+500ppmPPDA it varies from 0.15% at zero load and 0.13% at full load.

Due to High viscosity, density and lower calorific value of PPDA blend and tits reactions reduce the OH radicals which are convert the CO to CO2, this are the main reasons for higher CO emissions for PPDA blends than other.

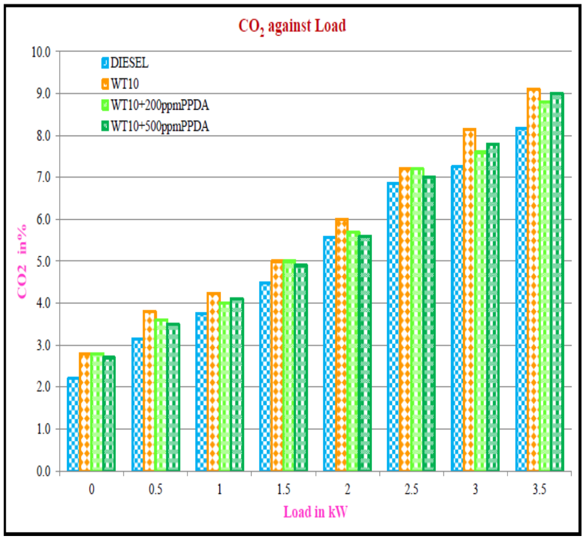

Figure 2 Effect on Carbon Dioxide against Load for PPDA Blends

The variation of the carbon dioxide emission for all blends for different engine loads is shown in Figure 2. The CO2 emission increases as load increases from zero to maximum load. For Diesel, varies from 2.2% at zero load to 8.17% at full load. For WT10, varies from 2.8% at zero load to 9.1% at full load. For WT10+200ppmPPDA, varies from 2.8% at zero load to 8.8% at full load. For WT10+500ppmPPDA, varies from 2.7% at zero load to 9% at full load. More amount of CO2 in exhaust emission indicates the complete combustion of fuel. This increasing trend of CO2 emissions is due to increase in volumetric fuel consumption.

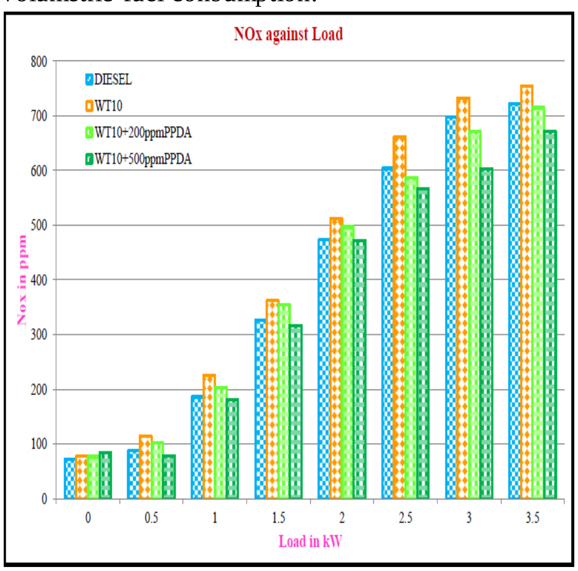

Figure 3 Effect on Nitrogen Oxide against Load for PPDA Blends

The variation of the Nitrogen oxide emission for the Diesel and WT10 blends with DE and PPDA for different engine loads is shown in Figure3. The NOx emission linearly increases as load increases from zero to maximum load. The NOx varies from 71 ppm to 722 ppm for Diesel fuel whereas WT10 it varies from 78 ppm to 755 ppm. WT10 shows the higher NOx emissions than Diesel fuel due to its higher combustion temperature.

For WT10+200ppmPPDA it varies from 77 ppm to 175 ppm.For WT10+500ppmPPDA it varies from 84 ppm to 672 ppm. During combustion process the free radicals formation take place at higher temperature which are prompt NOx production. PPDA antioxidants reduce free radical formation which reduce the NOx emissions. PPDA with 500ppm concentration are effective then 200ppm to reduce the NOx emission.

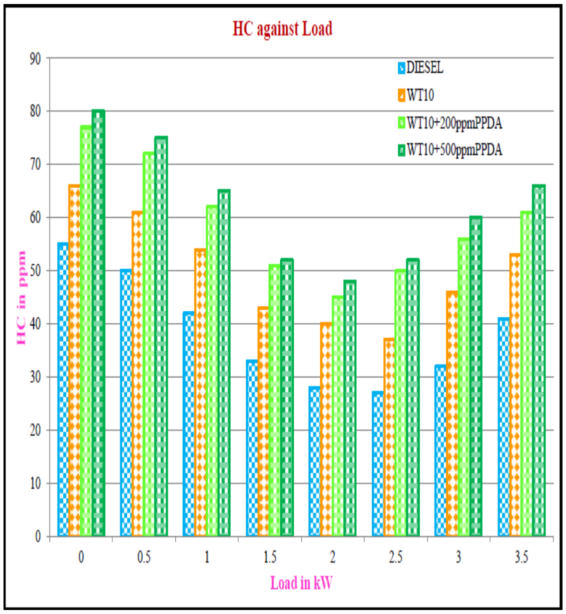

Figure 4 Effect on Hydro-Carbon against Load for PPDA Blends

Fuel that is incompletely burned result in Unburned hydrocarbon. Its organic compounds in the gaseous state and solid HC are the particulate matter. Unburned HC emissions are caused by incomplete combustion of air-fuel mixture. The variation of the Hydro carbon emission for the Diesel and WT10 blends with PPDA for different engine loads is shown in Figure4. The HC emission decreases as load increases from zero to 2.5 kW load, At higher load HC trend increases for all blends. For Diesel it varies from 55 ppm to 27 ppm. For WT10 it varies from 55 ppm to 37 ppm. For WT10+200ppmPPDA it varies from 55 ppm to 37 ppm.For WT10+500ppmPPDA it varies from 80 ppm to 48 ppm. At high engine load cause high HC emission due to less oxygen available for the reaction when more fuel is injected into the engine cylinder. The lower calorific value and the higher viscosity of WTO result in the highest HC emissions. The reason for higher level of HC at 0 kW power output is attributed to the flame quenching and cooled layer of the charge near the cylinder wall during the cold start.

5. CONCLUSION

- WTO can be used as alternative fuel because it has similar group compound to that of Diesel and its properties are comparable with Diesel fuel. The optimum blend selected for this work is WT10.The properties of WTO improved with using additives.
- CO emissions found higher for PPDA blends then Diesel and WT10.
- HC emissions found increase for all blends than Diesel. WT10 with PPDA additives show higher HC emissions.
- PPDA additives found lower NOx emission, 500ppmPPDA reduce more NOx than 200ppmPPDA.

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