EXPERIMENTAL ANALYSIS OF DIESEL ENGINE USING WASTE TRANSFORMER OIL WITH IPA IGNITION IMPROVER

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Abstract - Bio diesel it is a name of clean burning alternative fuel produced from domestic and renewable sources. Biodiesel contains no petroleum but it can be blended at any level with diesel. It is a biodegradable, Non toxic, and essentially free from sulphur. This is reliable, and renewable. Therefore in the present investigation the oil taken is the waste transformer oil .The transformer oil is produced from wax-free naphthenic oils. Entire experimental investigation is carried out on 4 strokes – twin cylinder water cooled diesel engine. For this purpose preparing blends of transformer oil with diesel like T10, T20, T30, and T40 and comparing its performance parameters with conventional diesel. Among these blends selecting optimum blend and adding ignition improver in a different proportions and finding optimum blend. By comparing performance parameters of the optimum blend with conventional diesel fuel. Here use Isopropyl alcohol is as ignition improver for optimum blend. Based on the earlier finding the current experimental investigation investigated the possibility of using waste transformer oil is a diesel substitute.

Key Words: Waste transformer oil, fuel properties, *CI engine, alternative fuel, Ignition improver.*

1 INTRODUCTION

The internal combustion engine is an engine in which the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine the expansion of the high temperature and pressure gases, which are produced by the combustion, directly applies force to a movable component of the engine such as the pistons or turbine blades and by moving it over a distance, generate useful mechanical energy. The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four stroke and two stroke piston engines along with variants, such as the winkle rotary engine. The Diesel internal combustion engine differs from the gasoline powered Otto cycle by using highly compressed hot air to ignite the fuel rather than using a spark plug. In the Diesel Engine only air is initially introduced into the combustion chamber .the air is then compressed with a compression ratio typically between 15 and 22 resulting into a 40 bar pressure compared to 8 to 14 bar in the petrol engine. This high compression heats the air to 550^0c. At about this moment fuel is injected directly in to the compressed air in the combustion chamber. This may be into a void in the top of the piston or a prechamber depending upon the design of the engine. The fuel injector ensures that the fuel is broken down into small droplets, and that the fuel is distributed evenly. The heat of the compressed air vaporizes from their surfaces and burn getting smaller, until all the fuel in the droplets has been burn. Alternative fuels known as nonconventional or advanced fuels ,are any materials or substances that can be used as fuels other than conventional fuels .conventional fuels include fossil fuels (petroleum ,coal, propane ,and natural gas)as well as nuclear materials such as uranium and thorium ,as well as artificial radioisotope fuels that are made in nuclear reactors ,and store their energy ,some well known alternative include biodiesel, bio-alcohol (methanol,ethanol,butanol,). chemically stored electricity (batteries, and fuel cells, hydrogen ,non fossil methane, non fossil natural gas and other biomass sources. Bio-diesel is a name of a clean burning alternative fuel, produced from domestic, renewable resources. Bio-diesel contains no petroleum, but it can be blended at any level with conventional diesel to create a bio-diesel blend. It can be used in compression ignition diesel engine with little or no modifications. Bio-diesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. Due to problems encountered in the use of neat vegetable oil, Bio-diesel is now referred to as the mono alkyl esters of long chain fatty acids derived from vegetable oils for use in compression ignition (diesel) engines. Methyl ester is usually made from 80-90% vegetable oil, 10-20% alcohol and 0.35—1.5% catalyst. Bio-diesel fuel is reliable, renewable, biodegradable and nontoxic. It is less harmful to the environment for it contains practically no sulfur and substantially reduces emissions of un-burnt hydrocarbons (HC), carbon mono-oxide (CO), sulfates, and polycyclic aromatic HC (PAH) and particulate matter. It has fuel properties comparable to mineral diesel and because of great similarity; it can be mixed with mineral oil and used in standard diesel engine with minor or no modifications at all. Bio-diesel works well with new technologies such as catalyst (which can reduce soluble fraction of diesel but not the solid carbon fraction), particulate traps an exhaust gas circulation. It can be produced from any kind of oil both vegetable and animal source. Used frying oil can also be used and, therefore, be very promising alternative for waste treatment. It can strengthen economy by creating more jobs and create independence from the imported depleting commodity, petroleum. It can also be used as a way of stimulating and supporting agriculture.

1.1 PREPERATION OF BLENDS WITH DIESEL

The obtained Bio- Diesel is blended for conducting the performance test, the Transformer oil seed Bio- Diesel is mixed in proper proportions.

3.8.1 Procedure for Preparation of Blends with Diesel

- The Bio- Diesel is first filtered form impurities.
- Required amount of fuel and Bio- Diesel is taken into the measuring jar and mixed thoroughly the amount of proportions shown in table 3.1.
- Obtained TOME fuel properties are find out and these values are tabulated

Notation	Fuel Quantity	Bio-Diesel Quantity	Diesel Quantity
RWTO 10	1000 ml fuel	100ml	900 ml
RWTO 20	1000ml fuel	200 ml	800 ml
RWTO 30	1000ml fuel	300 ml	700ml
RWTO 40	1000ml fuel	400 ml	600 ml
D100	1000ml fuel	0 ml	1000ml

Table: 3.1 Blending Percentage of Fuel

Fig 3.3 Process of separation

Fig: 3.4 Transformer Oil Methyl Esters Blends T10 T20 T30 T40

The blends of transformer oil with diesel in a particular proportion are shown in figure 3.4 after that conducting performance test and selecting the best blend.

4.3.3 Determination of Flash and Fire Point Apparatus required

- All's closed cup flash and fire point set up
- Thermometer

Flash and fire point are obtained by using pen sky test. The apparatus consists of a brass cup and cover fitted with shutter mechanism without shutter mechanism (open cup), test flame arrangement, hand stirrer (closed cup), thermometer socket, etc., heated with energy regulator, a thermometer socket made of copper.

4.3.4 Experimental Procedure

The cup and its accessories are well cleaned and dried before the test is started. Now the cup is filled with oil, up to the mark and covered with a lid. The cup is now set in the stove supply and thermometer inserted. Heating rate is maintained with the help of a rheostat at 5-6volts per minute and stirring rate at one or two revolution per second. Once the heating is started, the test flame is applied with the help of small sticks after reach 5⁰C rise of temperature up to temperature of 40⁰C. Now the rheostat is adjusted some that heating rate maintained at 1-2⁰C per minute and the test flame is applied after each 5⁰C rise of temperature. Operating the shutter makes the application of the test flame. The temperature at which flame application cause a flash in the interior of the cup is recorded as flash point. The heating further continued and the temperature at which the vapours will burn for at least 5 seconds is heated as fire points.

Fig: 4.1 Pensky martin flashpoint apparatus

4.4 SPECIFIC GRAVITY

Specific gravity is the relative measure of the density of a substance. It is defined as the ratio of the density of the substance, ρ, to a reference density. With the help of digital balance to find out specific gravity it is shown in fig 4.2. The specific gravity of conventional diesel fuel is t 0.835 .It is dimensional less quantity.

Fig: 4.2 Digital Balance

- Take weight of empty vessel weight after take 100 ml quantity of transformer oil in it and again measure its weight.
- Then after subtract the empty vessel weight from it. Then we got weight of 100ml oil. The process is same for all blends .the specific gravity of all blends and diesel is tabulated in table 4.2
- Specific gravity of water is unity. For this purpose we use digital balance.

4.4.1 Specific Gravity- Results for Transformer Methyl Ester Blends with Diesel T10, T20, T30, T40

S.no	Oil	Percentage	Specific Gravity
1	Diesel	D100	0.835
2.	Waste Transformer Oil	T100	0.82
3	Blends of Transformer Oil With Diesel	T10	0.83
		T20	0.838
		T30	0.84
		T40	0.8414

Table: 4.1Results of Specific Gravity for TOME and Diesel

4.5 CALORIFIC VALUE

The calorific value of a fuel is the thermal energy released per unit quantity of fuel when the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture. It measures the energy content in a fuel. This is an important property of biodiesel that determines the suitability of the material as alternative to diesel fuels. Calorific value of each of the transformer oil blends is taken as follows.

Calorific value of transformer oil methyl ester blends = (Percentage of (%) transformer oil blend) x (calorific value of refined transformer oil) + (percentage of (%) Diesel)X (calorific value of Diesel value).

4.6 VISCOSITY

The resistance to flow, exhibited by fuel blends, is expressed in various units of viscosity. It is a major factor of consequence in exhibiting their suitability for mass transfer and metering requirements of engine operation. High value of viscosity reduces volatility and gives poor atomization of oil during injection of the CI engine. This results in incomplete combustion and ultimately carbon deposits on the injector nozzle as well as in the combustion chamber.

1 stokes = 100 centistokes = 1 $cm^2.s^{-1}$ = 0.0001 $m^2.s^{-1}$.

4.5.1 Experimental Results of Calorific Value in kj/kg for Transformer methyl esters blends and Diesel

OIL	T10	T20	T30	T40
Blends of Transformer oil With Diesel	44431.3	44362.6	44293.9	44225.2
Diesel	44500	44500	44500	44500

Table: 4.2 Results of Calorific value for TOME and Diesel

4.6.1 Determination of Viscosity

Viscosity is measured by using Engler's viscometer. By using stop watch Take time for collecting every 200 ml quantity of fuel at different temperature intervals. The process is same for water. Time taken by oil to the time taken by water gives Engler's degree. Then we get viscosity in centistokes.

Figure 4.3 Engler's Viscometer and Oil collecting flask

4.6.2 Procedure for finding viscosity

The apparatus is prepared first by cleaning and then leveling by screws provided for this purpose. The cylindrical heating vessel is filled with water up to the tip of the vanes. The test sample is poured into the oil cup to the pointer and is closed with a cover. Two thermometers are inserted, one in oil cup and the other in water bath and heated uniformly with the help of regulator. The cleaned, dry 50 ml flask is placed centrally below the jet properly. The bath is heated to a few degrees above the desired temperature; the ball valve is lifted and stop watch started simultaneously. The valve is not removed completely but kept immersed in the oil by supporting it by the hook provided for the purpose. The receiving flask is located so that the oil strikes the flared mouth and does not drop directly into the opening, which would cause foaming. The stopwatch is stopped when the level of the oil reaches 50ml mark in the neck of the flask. Same procedure for finding the viscosities at various temperatures.

Table: 4.3 Results of Viscosity in centistokes for TOME blends and Diesel at 40⁰C

4.6.3 Fuel Properties of Waste Transformer Oil, Refined Transformer Oil and Diesel fuel

Table shows that fuel properties of waste transformer oil and refined transformer oil along with diesel for different properties such as density, kinetic viscosity, flash point, fire points and gross calorific values, cetane numbers ec

Properties	WTO	RWTO	DF
Density[kg/m^3]	895	874	830
Kinematic viscosity[cSt]	10.1	6.2	3.08
Flash point [^{0}C]	140	125	60
Fire point [^{0}C]	145	132	65
Gross calorific value[kJ/kg]	41775	43813	44500
Cetane number	42	50	48

Table 4.4 Properties of WTO and RWTO with Diesel

4.6.4 EXPERIMENTAL OBSERVATIONS

The engine was first operated on diesel fuel with no load for few minutes at rated speed of 1500 rpm until the cooling water and lubricating oil temperatures comes to certain temperature. The same temperatures were maintained throughout the experiments with all the fuel modes. The base line parameters were obtained at the rated speed by varying 0 to 100% of load on the engine. The diesel fuel was replaced with the transformer oil biodiesel (RWTO 10) and test was conducted with the blend of 90% diesel and 10% biodiesel by varying 0 to 100% of load on the engine with an increment of 25%. After the transformer oil biodiesel, the test was conducted with the blend of 80% diesel and 20% biodiesel (RWTO 20). After the transformer oil biodiesel, the test was conducted with the blend of 70% diesel and 30% biodiesel (RWTO30). The directly blended fuel does not require any modifications to diesel engines. After the transformer oil biodiesel, the test was conducted with the blend of 60%

S.No	Oil	Symbol	Kinematic Viscosity (CST)
1	Diesel	D100	3.74
2	Waste transformer oil	T100	10.1
3.	Transformer Oil Methyl Ester Blends With Bio-Diesel	T10	6.2
		T 20	5.5
		T30	4.25
		T40	4.15

diesel and 40% biodiesel (RWTO 40). Hence direct blending method was used in this test. The tests were conducted with these four blends by varying the load on the engine. The mass of the fuel consumption was measured by using a fuel tank fitted with a burette and a stop watch. The brake thermal efficiency and brake specific fuel consumption were calculated from the observed values.

The results from the engine with a blend of diesel and biodiesel and compared with the base line parameters obtained during engine fuelled with diesel fuel at rated speed of 1500 rpm. Out of these four blends best blend is obtained on the basis of performance parameters. In this experiment RWTO 40 shows the best results. Then RWTO 40 is added with 5ml, 10ml of IPA (Ignition improver) and evaluates performance parameters. The results from the engine with a blend of RWTO 40 and IPA biodiesel and compared with the base line parameters obtained during engine fuelled with diesel fuel at rated speed of 1500 rpm .Experiments were conducted on the specified diesel engine at constant speed using diesel and note down the observation at zero load, voltmeter reading, and ammeter reading speed, time taken for 20cc of fuel consumption and the manometer readings and tabulated in the form of tables. By varying loads steps 1/4, 1/2, 3/4 and full loads note down all the readings for the diesel engine. Taking all the readings at constant engine speed of 1500 rpm. While doing experiments fill the fuel into the tank mounted on panel frame, on engine check the lubricating oil in the engine sump with help of dip stick and set optimum flow rate of water in Rota meter.

Fig.6.6 Variation of Brake Thermal Efficiency with Load using optimum blends

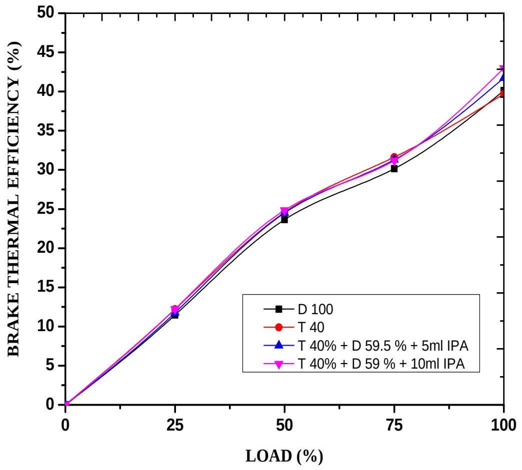

Fig.6.6 Variation of Brake Thermal Efficiency with Load using optimum blend T40 with ignition improver Isopropyle alcohol.

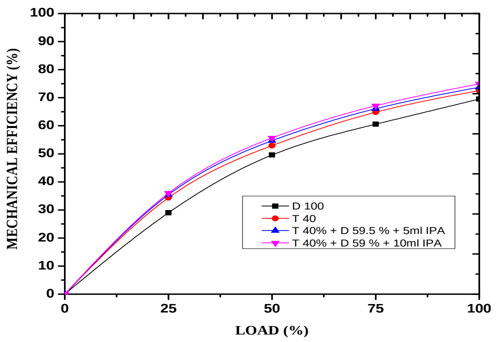

Fig 6.7 Variation of Mechanical Efficiency with Load using optimum blend T40 with ignition improver Isopropyle alcohol

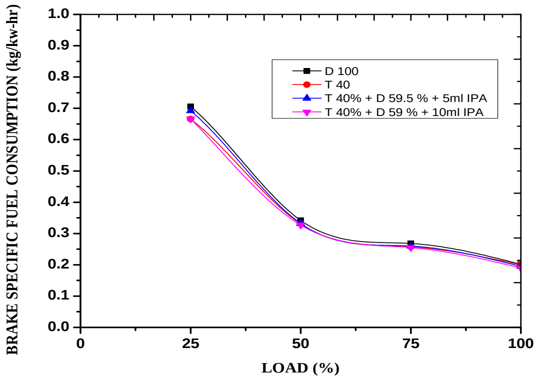

Fig.6.8 Variation of Brakespecific fuel consumption with Load using optimum blend T40 with ignition improver Isopropyle alcohol

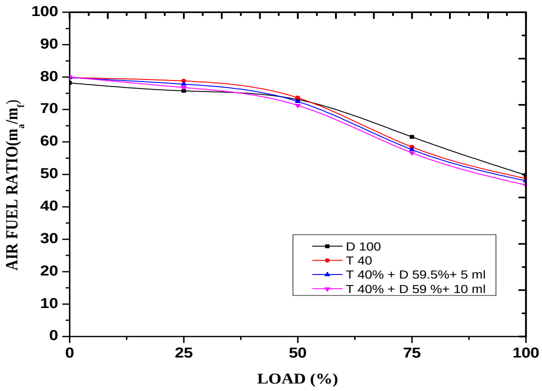

Fig 6.10 Variation of Air fuel ratio with Load using optimum blend T40 with ignition improver Isopropyle alcohol

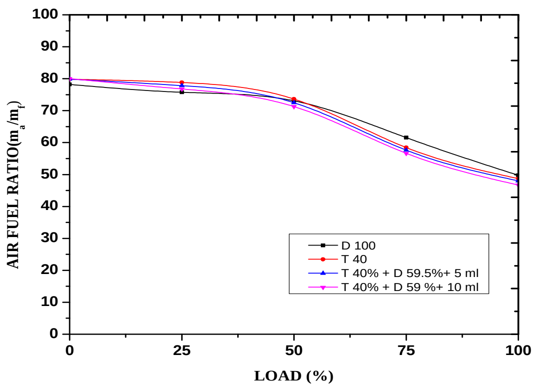

Fig 6.10 Variation of Air fuel ratio with Load using optimum blend T40 with ignition improver Isopropyle alcohol

CONCLUSIONS

The main objective of this experiment is to use waste transformer oil as an alternative fuel for compression ignition engine. The pure diesel was used as base fuel for comparing properties and performance parameters. The entire experimental investigation is conducted on a 4 stroke twin cylinder water-cooled diesel engine at a constant speed of 1500rpm and comparing its performance parameters with conventional diesel. The results of the current investigation may be summarized as follows.

7.1 PERFORMANCE ANALYSIS USING DIESEL AND TOME BLENDS

1.The flash and fire points of transformer oil were 140^{o} c, and 145^{o} c while for diesel flash and fire points were 90^{o}c and 95^{o}c respectively. This shows transformer oil is safer for
stroge. The cetane number was 42.

2. The viscosity of transformer oil is 10.1 centistokes. Mean while viscosity of diesel is 3.08 centistokes. The high viscosity gives poor atomization when at the time of fuel is injecting in the engine cylinder. For this purpose transformer oil is transesterified by transesterification process. The calorific value of diesel was higher than transformer oil.

3. The brake thermal efficiency increases with increase bio diesel percentage. The brake thermal efficiency for each blend was found to be high because of proper combustion.

4. The brake thermal efficiency for T10, T20, T30, T40 were found to be 35.87%, 39.1726%, 39.374%, 41.6%. Out of all the blends T40 shows best performance parameters when compared to diesel. The maximum brake thermal efficiency obtained is 41.63% with T40 blend.

4.The brake specific fuel consumption for T10, T20, T30, T40 were found to be0.2354 kg/kw-hr,0.21490 kg/kw-hr,.0.21315 kg/kw-hr, 0.2003 kg/kw-hr .out of all the blends T40 having low specific fuel consumption when compared to diesel fuel.

5. Since T40 blend reduces the environmental pollution, high in thermal efficiency when compared with diesel it will be a promising renewable energy source for sustaining the energy.

7.2 PERFORMANCE ANALYSIS USING DIESEL AND OPTIMUM BLEND WITH IGNITION IMPROVER

In further stage the investigations were carried out on the 4 stroke twin cylinder water cooled Diesel engine with addition of Isopropyl Alcohol (ignition improver) 5%, 10% volume ratios to optimum blend T40 (T40D59.5IPA5, T40D59IPA10) find out performance parameters and compared with optimum blend and Diesel base line data. Out of this 10% volume addition of ignition improver (T40D59IPA10) shows best and give high brake thermal efficiency and low specific fuel consumption at full load conditions. The conclusions of this investigation are compared with optimum blend T40 and Diesel base line data at full load as follows:

1 .The brake thermal efficiency increases with increase ignition improver by volume percentages in blends

2. The brake thermal efficiency at full load condition for Diesel it is 40.12% while for blend T40D59.5IPA5ml it is 41.739% and for blend T40D59IPA10ml it is 43.776%.

3. Mechanical efficiency for Diesel fuel is 72.54% and for T40D59.5IPA5ml it is 73.1% and for T40D59IPA10ml it is 73.649%.The maximum brake thermal efficiency is obtained by T40D59IPA10ml

4.Brake specific fuel consumption for Diesel is 0.201 kg/kw-hr mean while for blend T40D59.5IPA5ml it is 0.1950 kg/kw-hr & blend T40D59.5IPA10ml it is 0.1911 kg/kwhr

5. The value of volumetric efficiency is at full load condition for T40 is 83.82% for diesel is 83.81%mean while volumetric efficiency for blend T40D59.5IPA5ml is 83.83%. Mean while the Blend T40D59IPA10ml it is 83.89%.

6. The value of air fuel ratio is at full load condition for T40 is 48.72 for diesel it is 49.75. Mean while air fuel ratio for blend T40D59.5IPA5ml is 48.7 and blend T40D59IPA10ml it is 48.67.

All these tests for characterization of bio diesel demonstrated that almost all the important properties of bio diesel are very close agreement with the Diesel making it a potential candidate for the application in CI engines. An attempt made to use Transformer oil methyl esters as a fuel in the C.I engine is very effective and can be used as an alternative fuel. From all these discussion it can be concluded that Diesel engine can perform satisfactorily on bio-Diesel blends T40 with addition of ignition improver with 10ml without any engine design modification.

Based on this investigation, it is observed that a time will be reached in the future when demand for non-polluting and efficient energy sources will be met by other sources than fossil fuel globally. It is concluded that in order to overcome the energy crisis in future, mega cultivation of this species may be carried out for Bio Diesel production at large-scale. Based on the findings, WTO, and RWTO are suggested to be alternative fuel for compression ignition engine.

7.3 SCOPE OF FUTURE WORK

In the present investigation the performance parameters are evaluated with constant speed, constant pressure, compression ratio and injection timing. In the future work the experiment can be carried out by varying the operating parameters like injection pressure, compression ratio and crank angle by using waste transformer oil.

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