INTRODUCTION: The depleting fossil fuel resources, increases the price of fuel continuously. At one point of time the whole resources may come to end. Keeping this in view many researchers identified various alternative fuels and tested successfully. In the present investigation the Analysis and emission characteristics of single cylinder four stroke direct injection diesel engine using Pongamia pinnata seed oil i.e., as Straight Vegetable Oil (SVO) by avoiding Transesterification process as an alternate fuel is evaluated.

High viscosity is one important difference between Pongamia seed oil and commercial diesel fuel. So, Here Pongamia pinnata seed oil is blended with Petrol at various proportions and finally reached the desired viscosity as that of diesel. The experimental data for various parameters such as Viscosity, Density, Flash and Fire Points, SFC are analyzed before and after blending to desired Percentages. A single cylinder, four stroke, constant speed, air cooled, direct injection diesel engine is used for the experiment.

The Analysis of the engine is done through Visual Inspection, as this engine is tested for 100hrs of running without change in any engine condition, blending ratio or modification in it. and the emissions such as CO, HC, O_2, CO_2, K, HU is measured using exhaust gas analyzer for initial diesel and blend for every 25hrs of running. Acceptable Viscosity and other parameters were obtained with blends containing 20% of Petrol in Pongamia pinnata seed oil on mass basis.

The pongamia pinnata seed cultivation in India is abundantly done and the availability of pongamia pinnata seeds is also high. The oil obtained by crushing these seeds can be used as an alternate fuel and they are also non edible. pongamia pinnata seed oil is used directly by avoiding Transesterification process i.e. SVO and it is blended with appropriate percentage of petrol in order to meet the properties of diesel fuel, as a substitute fuel for CI engines. The engine Analysis and emission characteristics are acceptable. Also due to the high availability of pongamia seed oil the impact of fossil fuel on Indian economy can be minimized. If mass production of oil is done, it will favour the agricultural sector of our
Alternate fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engines operational condition [2]. For the developing countries, fuels of bio-origin provide a feasible solution to the twin crises of fossil fuel depletion and environmental degradation. Now bio-fuels are getting a renewed attention because of global stress on reduction of greenhouse gases (GHGs) and clean development mechanism (CDM). The fuels of bio-origin may be alcohol, vegetable oils, biomass and bio gas. Some of the fuels can be used directly while others need to be formulated to bring the relevant properties close to the conventional fuels. For diesel engines, a significant research has been directed towards using vegetable oils and their derivatives as fuels [3]. Diesel engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long-term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India’s demand for diesel fuel is roughly six times of gasoline hence seeking alternative to mineral diesel is a natural choice. Pongamia seed oils have comparable energy density, cetane number, heat of vaporization and stoichiometric air / fuel ratio with mineral diesel. In addition they are bio degradable, non-toxic and have a potential to significantly reduce pollution. Pongamia seed oil and its derivatives in diesel engines, lead to substantial reductions in emissions of sulfur dioxides, hydrocarbons (HC), Harridge unit (HU), light absorption coefficient (K), carbon monoxide (CO), poly aromatic hydrocarbon (PAH), smoke, particulate matter (PM) and noise. Furthermore, contribution of bio fuels to greenhouse effect is insignificant, since carbon dioxide (CO$_2$) emitted during combustion is recycled in photosynthesis process in plants [4].

Bio fuel are produce locally, which decreases the nation’s dependence upon foreign energy and can employ hundreds or thousands of workers, creating new jobs in rural areas and crop cultivation of biodiesel plants will boost the rural Economy.

**Objectives of the project:**

- **Engine Analysis And Emission Testing**
- Analyzing the CI engine and its components on using SVO blended with petrol.
- Running the engine for 100 hrs using 80% of SVO +20% petrol on mass basis.
- Experimenting on CI engine by use of straight vegetable oil blended with petrol in order to know the emission is increased or reduced after usage of fuel.
- In order to reduce emission Percentage.
EXPERIMENTAL METHODOLOGY

Block diagram

Pongamia pinnata

Pongamia pinnata

Sedimentation and filtration

Testing the Pongamia oil properties, such as viscosity, density, flash and fire points.

Blending the petrol to the pongamia seed oil till it meets the viscosity and other values that of diesel

Dis-assemble the CI engine and analysing the components, parts of CI engine

Assemble the CI engine and running the engine with (80% pongamia seed oil + 20% petrol) by mass basis.

Running the engine for 100hrs by using (80% pongamia seed oil + 20% petrol) by mass basis

Emission test is done at initial for diesel and for blend at every 25 hrs

Engine Analysis is done after running 100 hrs.

Fuel property testing

Viscosity and density measurement formula

- Viscosity is the property of the fluid which measures the resistance to flow.
- Unit: Dynamic viscosity – poise and Kinematic viscosity - centistokes.
- Kinematic Viscosity is the ratio of absolute viscosity to the density and the calculation of the Diesel, SVO and (SVO+PETROL) for various blends are
determined by using the Redwoods viscometer. Viscosity of the fluids varies with the temperature.

Formula: Kinematic viscosity: $0.247t - (50/t)$ Cst ($t>100$sec)

$$0.26t - (179/t) \text{ Cst (} t<100 \text{sec)}$$

“t” denotes redwood second

- **DENSITY**: It is the ratio of mass per volume.

  Formula: Mass/volume gm/cc

  Weight of the empty 50cc flask, W1 in gm.
  
  Weight of the (flask with oil), W2 in gm.
  
  Net weight $W = (W2 - W1)/50$ gm/cc.

---

**For 5 Litre Blend** (Mass Basis)

<table>
<thead>
<tr>
<th>SVO: 4,290.45ml</th>
<th>Petrol: 1,366ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>----------------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,656.5ml</strong></td>
</tr>
</tbody>
</table>

---

**Experimental values of various blends represents the viscosity of various SVO with Petrol blends**

<table>
<thead>
<tr>
<th>sl.no</th>
<th>Substance at Room temp</th>
<th>Redwood sec</th>
<th>Kinematic Viscosity cst</th>
<th>Density gm/cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Petrol</td>
<td></td>
<td></td>
<td>0.73</td>
</tr>
<tr>
<td>2</td>
<td>Diesel</td>
<td>35</td>
<td>3.98</td>
<td>0.82</td>
</tr>
<tr>
<td>3</td>
<td>SVO</td>
<td>202</td>
<td>49.73</td>
<td>0.93</td>
</tr>
<tr>
<td>4</td>
<td>SVO+Petrol (97+3%)</td>
<td>142</td>
<td>34.72</td>
<td>0.93</td>
</tr>
<tr>
<td>5</td>
<td>SVO+Petrol (95+5%)</td>
<td>121</td>
<td>29.47</td>
<td>0.91</td>
</tr>
<tr>
<td>6</td>
<td>SVO+Petrol(90+10%)</td>
<td>88</td>
<td>20.42</td>
<td>0.90</td>
</tr>
<tr>
<td>7</td>
<td>SVO+Petro (85+15%)</td>
<td>69</td>
<td>15.35</td>
<td>0.91</td>
</tr>
<tr>
<td>8</td>
<td>SVO+Petro (80+20%)</td>
<td>54</td>
<td>10.73</td>
<td>0.89</td>
</tr>
<tr>
<td>9</td>
<td>SVO+Petro(75+25%)</td>
<td>44</td>
<td>7.01</td>
<td></td>
</tr>
</tbody>
</table>
Above graph indicates kinematic viscosity v/s blend % (SVO + Petrol). As observed in the Fig. 3.9, viscosity of the blend decreases with increase in the percentage of petrol in the blend. 25 % petrol blend shows a viscosity value of 7cst. However, the 25% mix would have higher chances of back fire in the engine. Hence, 20% petrol blend with SVO was used for further testing.

**Engine Experimental Setup**

Nearly all agricultural tractors pump sets, farm machinery, and transport vehicles use direct injection diesel engines. Keeping the specific features of diesel engines in mind, a typical engine system widely used in the agricultural sector in developing countries has been selected for present experimental investigations. Here present study was carried out to investigate the analysis and emission test of Pongamia oil blended with petrol in a stationary single cylinder diesel engine and to compare it with diesel fuel. The test were conducted on a four stroke, air cooled, direct injection diesel engine having rated power of 7.5kw at a constant speed of 1500rpm (Fig. 4.1). The engine was coupled with water load pump. The specifications of the engine are given in Table 4.1
**Engine Specification**

**Valve Timing Operation**

<table>
<thead>
<tr>
<th>Engine Type</th>
<th>Strokes, Single Cylinder, direct injection Diesel Engine, air cooled.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore Diameter</td>
<td>102 mm</td>
</tr>
<tr>
<td>Engine Power</td>
<td>10 hp</td>
</tr>
<tr>
<td>RPM</td>
<td>1500 rpm</td>
</tr>
<tr>
<td>Type Of Starting</td>
<td>Crank Starting</td>
</tr>
<tr>
<td>Load Type</td>
<td>Water pump</td>
</tr>
<tr>
<td>No of cylinder</td>
<td>01</td>
</tr>
</tbody>
</table>

- Length of the flywheel =124.5cm
- \[1\text{cm} - \frac{360}{124.5} = 2.89^\circ\]

**Valve Timing Measurements Values**

<table>
<thead>
<tr>
<th>Sl no</th>
<th>VALVE OPERATION</th>
<th>ANGLE IN DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IVO (BTDC)</td>
<td>4.046</td>
</tr>
<tr>
<td>2</td>
<td>IVC (ABDC)</td>
<td>30.63</td>
</tr>
<tr>
<td>3</td>
<td>EVO (BBDC)</td>
<td>29.478</td>
</tr>
<tr>
<td>4</td>
<td>EVO (BTDC)</td>
<td>2.89</td>
</tr>
</tbody>
</table>

Valve timing operation is conducted to know the inlet and outlet valve operations during the running period of the engine. The table 4.2 shows the valve opening and closing at certain angle.

**EXHAUST GAS ANALYZER**

Emission testing process is carried out to compare the emission norms of blended fuel (SVO+PETROL) with that of diesel.

The exhaust gas composition was measured using exhaust gas analyzer (I3SIS) as shown in (Fig 5.1)

It measures various gas emissions like carbon dioxide, carbon monoxide, oxygen, Hydrocarbons, and the oxides of nitrogen concentration in the exhaust gas.
ENDURANCE TEST

In the long-term endurance test, the effect of use of (SVO+PETROL blend) and their blends on various engine parts v/s mineral diesel fuel were studied. For this purpose, diesel engines were subjected to constant operating conditions with same blend fuels. The assessment of wear of various parts of diesel-fuelled engines was done in long-term endurance test after dismantling various parts of the engine.

After the completion of Preliminary running in and fuel consumption test, the engines were dismantled completely and examined physically for the conditions of the various critical parts before endurance test was commenced. After physical examination, the dimensions of various moving, vital parts were recorded e.g. cylinder head, cylinder bore/ cylinder liner, piston, piston-rings, gudgeon pin, valves (inlet and exhaust), valve seats (inserts), valve guide, valve springs, big-end bearing, small-end bush, camshaft etc. The engines were re-assembled and mounted on suitable test beds and again run-in for 100 hours. This test was carried out to take care of any misalignments occurring during dismantling and re-assembling of the engine. This test continues until the completion of 100hrs. During the running-in period, none of the critical components listed above were replaced.

Emission test cycle is a protocol contained in an emission standard to allow repeatable and comparable measurement of exhaust emissions for different engines or vehicles. Test cycles specify the specific conditions under which the engine or vehicle is operated during the emission test. There are many different test cycles issued by various national and international governments and working groups. Specified parameters in a test cycle include

<table>
<thead>
<tr>
<th>Measuring quantity</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0-10%</td>
</tr>
<tr>
<td>CO₂</td>
<td>0-20%</td>
</tr>
<tr>
<td>HC</td>
<td>0-20000PPM</td>
</tr>
<tr>
<td>O₂</td>
<td>0-22%</td>
</tr>
<tr>
<td>NOₓ</td>
<td>0-5000PPM</td>
</tr>
</tbody>
</table>
a range of operating temperature, speed, and load. Ideally these are specified so as to accurately and realistically represent the range of conditions under which the vehicle or engine will be operated in actual use. Because it is impractical to test an engine or vehicle under every possible combination of speed, load, and temperature, this may not actually be the case. Vehicle and engine manufacturers may exploit the limited number of test conditions in the cycle by programming their engine management systems to control emissions to regulated levels at the specific test points contained in the cycle, but create a great deal more pollution under conditions experienced in real operation but not represented in the test cycle. This results in real emissions higher than the standards are supposed to allow, undermining the standards and public health.

**Disassembled engine after the endurance test**

After the completion of the long term endurance test, the engine parts are disassembled and it is shown in (Fig 6.1) to check the certain engine parts such as cylinder head, valve seating, piston, fuel injector through visual inspection method to know the changes in the engine parts and to compare with initial condition.

### 6.2 Results And Discussions

**Fig 6.2. Cylinder Head before endurance Test**

**Fig 6.3 Cylinder head after endurance Test**

**Fig 6.2** shows the photograph of cylinder head before start endurance test. The cylinder head is subjected to initial service to remove the particles adhere to the head.

**Fig 6.3** shows the photograph of cylinder head after completing the 100 hours test. It has been observed that carbon deposition occurs on the cylinder head due to incomplete combustion. It is observed that, around the valve seat of the cylinder head, higher amount of carbon is deposited.
Valve Seating

Fig 6.4 Valve seating before endurance test  Fig 6.5 Valve seating after endurance test

Fig 6.4 shows the photograph of valve seating of the testing engine before endurance test. Upper and inner surface of the seating’s are cleaned before subjecting to the experiment. Fig 6.5 shows the photograph of valve seating of the engine after the endurance test. By observing the photograph through visual inspection the carbon content deposition is more on the valve seating. Due to which the valve operation may be blocked or changed.

Piston Rings

Fig 6.6 Piston rings before endurance test  Fig 6.7 Piston rings after endurance test

Fig 6.6 shows the photograph of pistons rings before endurance test. It consists of 3 compression rings and 2 oil rings. During the new pistons rings are subjected to experiment. Surface of the rings are clean.

Fig 6.7 represents the photograph of piston rings after the endurance test. By observing the photo of piston rings carbon deposition on the rings is lesser compared to other elements. Rings do not undergo any type of the wear.

Head Gasket

Fig 6.8 Head Gasket before endurance test  Fig 6.9 Head Gasket after endurance test

Fig 6.8 represents the photograph of head gasket before endurance test. The surface of the material is flat and does not contain any type of deposition.
**Fig 6.9** represents the photograph of head gasket after the endurance test. The surface of the gasket contains black carbon patches. The surface does not have any type of wear or damage during the experiment.

**Piston**

**Fig 6.10** shows the photographs of side view of cleaned piston before the endurance test. Later after 100 hrs endurance test **Fig 6.11** shows the photograph of side view of piston observed that some slightly ware on surface, and no carbon deposited on surface of piston.

**Piston Top view**

**Fig 6.12** shows the photographs of top view of piston before endurance test. The top surface contain little black marks observed before subjected to experiment.

**Fig 6.13** shows the photograph of top view of piston after the 100 hrs endurance test. Observed that whole top surface of piston covered by carbon deposition due to incomplete fuel combustion.

**Engine Inlet and Outlet Valves**

**Fig 6.14** Engine Inlet and Outlet Valves before endurance test
Fig 6.15  Engine Inlet and Outlet Valves after endurance test

Fig 6.14 shows the photograph of inlet and outlet valve before endurance test. Valves are operated by cam action. Bottom and top surface of the valves free from

Fig 6.15 shows the photograph of inlet and outlet valve after the 100 hrs endurance test. From the figure, we can observe that more carbon deposition occurs on the bottom and middle portion of the valves. This may lead to change in valve movements.

Fuel Injector

Fig 6.16 Fuel Injector before Endurance test  Fig 6.17 Fuel Injector after Endurance test

Fig 6.16 shows the photographs of fuel injector before endurance test. The injector contains three nozzles to atomize the blended fuel during the combustion period. The surface is clean and does not contain any type of deposition layer before subjecting to the experiment. The tip of the nozzle made up of brass material.

Fig 6.17 shows the photographs of fuel injector after the 100 hrs endurance test. As observed that little oil grease substance adhere to the tip of the outer surface of the nozzle, due to thickness of SVO but the tip of nozzle did not blocked.

Emission Test Results And Discussions
Emission Test Results

<table>
<thead>
<tr>
<th>Emission norms</th>
<th>DIESEL</th>
<th>BLEND (25 hrs)</th>
<th>BLEND (50 hrs)</th>
<th>BLEND (75 hrs)</th>
<th>BLEND (100 hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HU (%) (Harridge unit)</td>
<td>99.99%</td>
<td>47.83</td>
<td>37.32</td>
<td>31.03</td>
<td>25.74</td>
</tr>
<tr>
<td>K (light absorption co-efficient)</td>
<td>21.43</td>
<td>1.514</td>
<td>1.63</td>
<td>1.32</td>
<td>0.692</td>
</tr>
<tr>
<td>CO₂(%)</td>
<td>2.07</td>
<td>3.60</td>
<td>3.53</td>
<td>3.72</td>
<td></td>
</tr>
<tr>
<td>HC (ppm)</td>
<td>373</td>
<td>250</td>
<td>50.23</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>CO(%)</td>
<td>2.07</td>
<td>1.09</td>
<td>0.54</td>
<td>0.316</td>
<td></td>
</tr>
<tr>
<td>O₂(%)</td>
<td>2.07</td>
<td>15.88</td>
<td>16.77</td>
<td>15.10</td>
<td></td>
</tr>
</tbody>
</table>

represents the emission test results of diesel at initial condition and blended fuel (SVO+PETROL) for very 25hrs.
From the table we can observed that blended fuel emission norms are lower compared to diesel fuel because of the lower content of carbon and hydrogen of the blended fuel.

The smoke density parameters such as HU, k units of the blend are lowered when compared to diesel due to uniform combustion rate of the fuel. The HC unit is goes on decreasing due to lower content of carbon and hydrogen.
Higher the viscosity of the SVO affects the atomization process resulting in localized rich mixtures of the blend. This should result in higher CO formation. But the oxygen content in the fuel in addition to the air supplied during combustion helps to reduce CO formation.
Hence by the above readings the emission percentages are reduced, when compared to the diesel emission reading at initial condition.

**OBSERVATION**

1. After running for 100hrs, the carbon deposition on the engine parts are visually inspected and carbon deposition is extracted by physically, and amount of carbon content on the engine parts is determined by electronic weighing machine.
Electronic Weighing Machine

- Piston head - 2.39 gms
- Outlet valve – 0.44gms
- Inlet valve - 0.49gms
- Valve seatings - 1.52gms

**Expected Outcome of the project:**
The outcome of project is useful in deciding
- Use of SVO in CI engines.
- Engine durability can be studied.
- Optimum blend of SVO and petrol with reference to emission levels.
- Effect of using SVO in engine for longer duration.
- Promotion of usage SVO to farmers in their diesel pump sets.
- Emission characteristics
- Economic viability

**APPLICATION OF THE PROJECT**

- Generators in Small scale industries and institutes can use direct SVO has fuel source
- Domestic usage
- Farmers – use of tiller, water pump set, tractor, which are run by diesel, so by use of the (SVO) they can effectively utilize this.
- About 80% of Indian railways are running with the diesel, hence we can utilize there in large quantity.

**Scope for future work:** By this project work, we can say that pongamia pinnata oil which is used in blending with petrol in the form of straight vegetable oil, i.e transesterification process is avoided. Hence in future this will help in developing the bio-fuel engines in automobiles in large scale. And also emission is reduce by using SVO.

- It will be very useful to country like ours , because we dependent mostly on railways,
- Then here usage of diesel is more, hence by using these fuels instead of diesel, the country economy increases, and our country will be in top. As these are eco-friendly and non-harmful to humans.
CONCLUSION

The main aim of the present investigation was to reduce the viscosity of Pongamia seed oil (SVO) close to that of conventional fuel to make it suitable for use in single cylinder, air cooled, vertical and direct injection diesel engine and to evaluate the Emission testing of the engine with modified Pongamia seed oil. Significant reduction in viscosity was achieved by blending with Petrol on mass basis. The bio-fuel from SVO is blended with Petrol at varying proportions. It is observed that 20% of petrol blend with SVO blended fuel properties is nearer to that of diesel fuel properties. Emissions from the blends were also acceptable. Bio-fuel use could preserve the environmental air quality by decreasing harmful emissions released by regular diesel fuel. Bio fuel are produce locally, which decreases the nation’s dependence upon foreign energy and can employ hundreds or thousands of workers, creating new jobs in rural areas and crop cultivation of biodiesel plants will boost the rural Economy. Hence they can be used as alternate fuel without any modification, operational difficulties in existing diesel engine.

* ~ * ~ *