# EMISSION CONTROL AND PERFORMANCE STUDIES OF DIESEL JSVO AND THEIR BLENDS WITH EGR

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**BACHELOR OF TECHNOLOGY**

**(Automotive Design Engineering)**

*Harnessing Energy through Knowledge*

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# CERTIFICATE

This is to certify that the work content in the report on "**EMISSION CONTROL AND PERFORMANCE STUDIES OF DIESEL JSVO AND THEIR BLENDS WITH EGR**" by Ms.Ankita Sehgal, Mr.Gaurav Bali, Mr.Himanshu Sharma, Ms.Monika Deo in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology is an original work carried out by them under my supervision and guidance. It is certified that the work has not been submitted anywhere else for the award of any other degree of this or any other University.

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# ABSTRACT

The gradual depletion of world petroleum reserves and the enormous increase in environmental pollution which is due to increasing exhaust emissions ,requires humankind to explore for suitable alternative fuels which can be used in diesel engines. In the present investigation of our project, jatropha oil, a non-edible vegetable oil has been considered as a potential alternative fuel for C.I. engines.It has been chosen to find out its suitability for use as fuel oil

The project involves the study of the performance and emission characteristics of Jatropha oil and its blends in a diesel engine fitted with EGR.A single cylinder,indirect injection engine was used to carry out the experiment. Various blends of jatropha oil were prepared in varying proportions.B100,B80 and B60 blends of jatropha with diesel have been used. Thereafter they were compared with diesel.

Firstly,the baseline data was taken without EGR for diesel and jatropha and its blends. Thereafter data with EGR at 5 to 40% in steps of 5 EGR rates was taken. NOx ,CO,CO2,Smoke ,HC emissions were recorded. Various engine performance parameters were also evaluated. Graphs were plotted to show the comparison of various performance parameters and emissions of diesel fuel versus the jatropha biodiesel blends. The main aim of this dissertation is to find out the most suitable blend of jatropha biodiesel which would give out least NOx emissions using a EGR system. Also the aim is to find which blend would reduce emissions and give improved performance parameters.

The NOX emissions of various JSVO blends was found to be higher than diesel. The result showed that with EGR at 15% EGR diesel, , B 60 at 20% EGR, B 80 at40% EGR, and B 100 at 5% EGR, the NOx emissions were effectively reduced by 10.1%, ,15.26%,19.81%, and 24.82% respectively. CO, HC and Smoke emission were found to be lesser in Jatropha biodiesel and its blends as compared to diesel fuel.Brake thermal efficiency was found to be higher for diesel and Specific fuel consumption was higher for jatropha biodiesel and its blends.

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# LIST OF ABBREVIATIONS

- **EGR:** Exhaust Gas Recirculation
- **IDI**: In-Direct Injection
- **JSVO:** Jatropha Straight Vegetable Oil
- **BTE:** Brake Thermal Efficiency
- **BSFC:** Brake Specific Fuel Consumption
- **C.I:**Compression Ignition
- **PPM:**Parts per million
- **CO**: Carbon Monoxide
- **CO2** :Carbon Dioxide

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# 1. INTRODUCTION

## 1.1 MOTIVATION:

The gradual depletion of world petroleum reserves and the enormous increase in environmental pollution which is due to increasing exhaust emissions and requires humankind to explore for the suitable alternative fuels which can be used in diesel engines. In aspect of this, vegetable oil is a calling alternative because it has got several advantages like it is renewable and also environment friendly and can be cultivated easily in the rural areas, where there is an intense need for advanced forms of energy .Therefore, in recent years, a lot of efforts have been made by many research workers to use vegetable oils as fuel in engines. Evidently, the use of non-edible vegetable oils as compared to edible oils is more significant because of the huge demand for edible oils to be used as food and also they are far too expensive to be used as fuel nowadays.

From earlier studies, it is observable that there are many problems related with vegetable oils being used as fuel in compression ignition engines, the one of the main problem is their high viscosity. The reason for high viscosity is because of their large molecular mass and the chemical structure of vegetable oils which in turn heads to problems in combustion, pumping and atomization in the injector system of the diesel engine. Because of the high viscosity, in long time working, vegetable oils will introduce the development of ring sticking, the formation of injector deposits, gumming and also inconsistency with conventional lubricating oils . That is why, a decrease in viscosity is very important to make vegetable oils a desirable alternative fuel for diesel engines. The problem of high viscosity of the vegetable oils has been gone about in several ways, such as trans-esterification, blending with other fuels, pre heating of oil and thermal cracking.

In the present investigation of our project, jatropha oil, a non-edible vegetable oil has been considered as a potential alternative fuel for C.I. engines.It has been chosen to find out its suitability for use as fuel oil. Jatropha curcas is a large shrub commonly found and utilized in most of the tropical and subtropical regions of the world. Many properties of this plant like its hardness, rapid growth, easy propagation and also its wide range usefulness have resulted in its spread. The jatropha oil is a slow-drying oil that is odourless and colourless when it is fresh but it becomes yellow on keeping. The oil content of jatropha seed ranges from 30 to 50% by weight .The fatty acid composition of jatropha classifies it as a linoleic and oleic type, which are known as unsaturated fatty acids. The composition of jatropha oil consists of palmitic, oleic and linoleic acids toxic due to the presence. However, from the properties of the oil it is seen that the oil will be suitable as a fuel oil. But there is a great difference between jatropha oil and diesel oil and that is in viscosity. The high viscosity of jatropha oil will contribute to the formation of the carbon deposits in the engines, incomplete combustion of fuel and it also results in reducing the life of an engine, we have observed the effect of the heating on reduction in viscosities of the blends and to evaluate the engine performance using the prepared blends as fuel.

Over the recent years, a strict emission legislations has been enforced on NOx, particulate emission(PM) and smoke which is emitted from automotive diesel engines. Diesel engines are characterized by very low fuel consumption and low CO emissions. But, it is seen that the NOx emissions from diesel engines still remain very high. So, in order to meet environmental legislations, it is desirable to reduce the amount of NOx in the exhaust gas. Because of their low fuel consumption, they have been increasingly used for small lorries and also passenger cars. But a higher NOx emissions from the diesel engine has always remained a major problem in the pollution aspect.

However, the technologies like exhaust gas recirculation and exhaust gas after treatment are essential to cater to challenges posed by the increasingly strict environmental emission laws.

## 1.2 OBJECTIVE:

- To use jatropha biodiesel as a blend with diesel to find the optimum blend which would reduce NOx emissions.
- To study the effect of EGR on NOx emission formation of IDI diesel engine when diesel, JSVO and their blends is fuelled in it at 100% load.
- To measure the emissions in an IC engine operating with Jatropha based biodiesel and diesel blends without EGR.
- To check for the Break Thermal Efficiency and Break Specific Fuel Consumption of Jatropha blends and the corresponding emissions using Exhaust Gas Recirculation (EGR) Systems.

# 2. LITERATURE REVIEW

As civilization is increasing, transport has become an essential part of our life. The biggest problem due to growing civilization is the growing population & depletion of fossil fuel. About many years ago, the major source of energy shifted from solar to the fossil fuel (hydrocarbons). Advance technology has generally led to a higher use of the hydrocarbon fuels, making the civilization threatened to a decrease in supply. Therefore, this demands for the search for alternative of oil as energy source.

## 2.1 BIODIESEL:

Biodiesel is meant to be used in the standard diesel engines and are thus different from the vegetable and waste oils which are used to fuel diesel engines. Biodiesel can be used alone or also blended with petro diesel. Biodiesel is considered as an alternative fuel for the diesel engine.The esters of vegetable oils and animal fats are known collectively as biodiesel. It is a domestic, renewable fuel for the diesel engine which is derived from natural oil like jatropha oil,karanja oil etc. The energy content of biodiesel is about 12% less than that of petroleum based diesel fuel on a mass basis. Its molecular weight, viscosity and flash point are higher than that of diesel fuel. Biodiesel is feasible substitute for petroleum based diesel fuel. Its advantages are improved lubricity, cleaner emision,high cetane no. and reduced global warming. Jatropha has potential as an alternative energy source. But, this oil alone will not solve our dependence on foreign oil. Use of this source and other alternative energy sources can contribute to a large stable supply of energy to us. Major production centers on the level of modern petroleum refineries have not been developed. The economics of biodiesel fuels when compared with traditional petroleum resources are in borderline, public policy are needed to be revised to encourage their development. The increased Jatropha oil production would also require a significant dedication of resources. The land for production are needed to be contracted and biodiesel production plants needs to be built and their distribution and storage facilities should be constructed, and the monitoring of its use for detection of problem in large scale use are all needed to be done to encourage development of this industry. Also to meet the challenges of the excessive import of it, our oilseed sector need to be strengthened by laying special emphasis on harnessing the existing and researching future potential source of green fuel. The organized plantation of jatropha oil and its systematic collection, being biodiesel substitutes will reduce the import burden of crude petroleum. The emphasis are made to invest in agriculture sector for exploitation of existing potential by establishing a model seed centers and also by installing preprocessing and processing facilities,transesterification etc. There is also a need to increase the future potential by investing largely on the organized plantation of Jatropha on the available wastelands. This will enable the country to become independent in the fuel sector by adopting and promoting biodiesel as an alternative to the petroleum fuels. It is proved that there are new work opportunities in the Jatropha cultivation and biodiesel production sectors and the industry can be grown in such a manner that favors many prosperous independent farmers and other farming communities.

## 2.2 JATROPHA

Jatropha is an unusual among tree crops which is a renewable non edible plant. Jatropha oil can be extracted from jatropha seeds.Jatropha oil has similar properties as that of diesel. But some of the properties such as kinematic viscosity, flash point , solidifying point and ignition point is very high in the jatropha oil. Hence by some chemical reactions, Jatropha oil is converted into biodiesel. Some of the benefits of jatropha oil are:

(i) Its oil is being extensively used for making soap in some of the countries as it has very high soaponification value.

(ii) The oil is also used an illuminants because it burns without emitting smoke.

(iii) The latex of the jatropha curcas contains an alkaloid known as jatrophine which have anti cancerous properties.

(iv) From bark of jatropha curcas a dark blue dye can be produced which is used for coloring cloth etc.

(v) The byproduct of jatropha seeds contain high content of nitrogen, phosphorous and potassium which is used for fish foods, domestic animals food and in lands it is used as fertilizer.

Cultivation of jatropha is simple. Jatropha grows in tropical and subtropical regions. This plant can also grow in wastelands and grows on almost any type of terrain, also on gravelly, saline and sandy soils. It can flourish in poor and stony soils.Its complete germination can be achieved within 9 days. Addition of manure during the time of germination has negative effects, but it is favorable if applied after germination is achieved. It can be propagated by the cuttings, which yields faster results than multiplication by the seeds.

Jatropha curcas thrives on mere 250 mm (10 in) of rain per year, and only during its first two years it is need to be watered in the closing days of dry season. Ploughing and planting are not needed regularly since this shrub has a life expectancy of approximately of forty years. Since the plant has pesticidal and fungicidal properties it is not necessary to use pesticides . Jatropha starts yielding from 9 to12 months time, but the best yields are obtained only after 2 to 3 years time. If it is planted in hedges, then reported productivity of Jatropha is from 0.8 kg. to 1.0 kg. of seed per meter. The seed production is around 3.5 tons / hectare .The seed production ranges from about 0.4 tons per hectare in first year to over 5 tons per hectare after 3 years.

Jatropha curcas has very limited natural vegetative propagation and is usually propagated by the seed. Propagation through seed leads to genetic variability in terms of growth ,biomass, seed yield and oil content. However, the clonal techniques can help a lot in overcoming these problems that hinder mass propagation of this tree borne oilseed species.The vegetative propagation has been achieved by the stem cuttings, budding,grafting as well as by air layering techniques.

## 2.3TRANSESTERIFICATION

It is the process by which we produce biodiesel. In this process an ester reacts with an alcohol to form another ester and another alcohol. The catalyst for this reaction is KOH. In the reaction three mol of methanols react with one mol triglyceride which give mixture of fatty esters and glycerin. In industries the processes for transesterification of the vegetable oils were developed in the early 1940s to improve the method of separation of glycerin during soap production. The oil is assumed as primary input oil that has previously been extracted from jatropha oilseed. To perform the transesterification reaction , methanol and oil and catalyst are mixed together in the stirred reactor. Temperature of 50 °-60 ° C will cause this reaction to reach the equilibrium state more rapidly.Mostly the temperature is kept below normal boiling point of the methanol (60°C) so that reactor does not need get pressurized. In practice, most producers will use at least 100% excess methanol to force reaction equilibrium towards a complete conversion of the oil to biodiesel. The reaction is slowed by the mass transfer limitations since at start of the action the methanol is slightly soluble in the oil and later on, the glycerin is not soluble in methyl esters. The catalyst can become unavailable for reaction without agitation since it tends to concentrate in the glycerin. An approach to overcome this issue is to conduct the transesterification in the two stages. First, the oil is combined with 60% to 90% of the methanol and catalyst and this mixture is allowed to react to the equilibrium. Then, the glycerin that has been formed is separated by gravity separation and the remaining 10% to 30% of the methanol and catalyst is added for the second reaction period. At conclusion of the second reaction period, the remaining glycerin is separated from it and the biodiesel is ready for its further processing. The steps for separation of glycerin are usually accomplished by the gravity settling. After the biodiesel has been separated from the glycerol, it contains 3% to 6% methanol and usually some of the soap. If the soap level is low (300 to 400 ppm), the methanol can be removed by the vaporization and this methanol will be dry enough to directly recycle it back to the reaction. Methanol acts as a co-solvent for the soap present in the biodiesel. As a result at higher soap levels the soap will precipitate as a viscous sludge when we remove the methanol. After the methanol is removed, the biodiesel is washed to remove residual free glycerin, soaps, catalyst. This is done mostly by using liquid liquid extraction that is done by mixing water with the biodiesel and then gently agitating them to promote transfer of the contaminants to the water without creating emulsion that will be difficult to break. The washing process is done multiple times until the wash water no longer picks up soap. Although the gray water from the later washes can be used as supply water for the previous wash steps, the total amount of water will typically be one to two times the volume flow rate of biodiesel. Sometimes, to reduce the amount of water required, producers will add acid to wash water. Weaker organic acids, such as citric acid, will neutralize catalyst and will produce a soluble salt. The final product of the biodiesel from Jatropha oil is used as an alternative fuel to operate the diesel engine.

## 2.4 FUEL PROPERTIES

The important chemical and physical properties of the jatropha oil were determined by the standard methods and compared with the diesel. The results shows that heating value of the vegetable oil is comparable to diesel oil and the cetane no. is slightly lower than diesel fuel. But, the kinematic viscosity and the flash point of jatropha curcas oil are several times higher than diesel oil.

| Properties | Jatropha Oil | Diesel |
|---|---|---|
| Density [g/cm3) | 0.93292 | 0.836–0.850 |
| Kinematic viscosity at 30c | 55 | 4.0 |
| Calorific value [MJ/kg] | 39.5 | 45 |
| Cetane number | 43 | 47 |
| Boiling point ºC | 286 | 248 |

Table 2.1:Properties of Jatropha oil and diesel

## 2.5 BLENDS

The blends of the biodiesel and conventional hydrocarbon based diesel are the products which are most commonly distributed for use in the retail diesel fuel marketplace. Most of the world uses a system known as "B" factor to state amount of the biodiesel in any fuel mix:

- A 100% biodiesel is referred to as **B100**.
- A 80% biodiesel, 20% petrodiesel is referred as **B80.**
- A 60% biodiesel, 40% petrodiesel is referred as **B60.**

In the project B100,B80 and B60 blends of JSVO with diesel have been used. Blends of 20% biodiesel and also lower can be used in diesel equipment with no or minor modifications, although some manufacturers do not extend warranty coverage if the equipment is damaged by these blends. Blending B100 with petroleum diesel may be done by:

- Mixing both the biodiesel and petroleum diesel in tanks at the manufacturing point prior to the delivery to tanker truck
- Splash mixing in tanker truck (adding specific percentages of biodiesel and petroleum diesel)
- In line mixing, the two components arrive at the tanker truck simultaneously.

- In metered pump mixing, petroleum diesel and biodiesel meters are set to the X total volume, the transfer pump pulls from the two points and mixes complete on leaving pump.
- 

In Diesel engines, the NOx formation is highly temperature dependent phenomenon and it takes place when the temperature in the combustion chamber exceeds 2000 K. Therefore, in order to reduce the NOx emissions in the exhaust, it is necessary to keep the peak combustion temperatures under control.

One of the simplest way of reducing the NOx emission of the diesel engine is by late injection of fuel into the combustion chamber. This technique is effective but the drawback is that it increases fuel consumption by 5–15%, which necessitates the use of more effective NOx reduction techniques like exhaust gas recirculation (EGR). Re-circulating part of exhaust gas helps in reducing the NOx, but appreciable particulate emissions are observed at the high loads, hence there is a trade-off between NOx and smoke emission. In order to get maximum benefit from this trade-off, a particulate trap can be used to reduce the amount of unburnt particulates in the EGR, which in turn also reduce the particulate emission.

**2.6 EGR**

EGR is a useful technique for reducing NOx formation in the combustion chamber. Exhaust consists of $CO_2$;$N_2$ and water vapours mainly.The recirculated gas in the engine cylinder acts as diluent to the combusting mixture. This reduces the oxygen concentration inside the combustion chamber.Since the specific heat of the EGR is much higher than that of fresh air, EGR increases the heat capacity (specific heat) of the intake charge.This decreases the temperature rise for the same heat release in the combustion chamber.

The EGR system reduces NOx production by recirculation of small amount of exhaust gases into the intake manifold where it mixes with the incoming air. As a result the air mixture dilutes under these conditions which reduces the peak combustion temperature and pressure, finally resulting in an overall reduction of the NOx output.

The EGR system consists of the below mentioned items:

1. EGR control valve.
2. Exhaust control valve.
3. EGR cooler.
4. Exhaust cooler.
5. Digital manometer

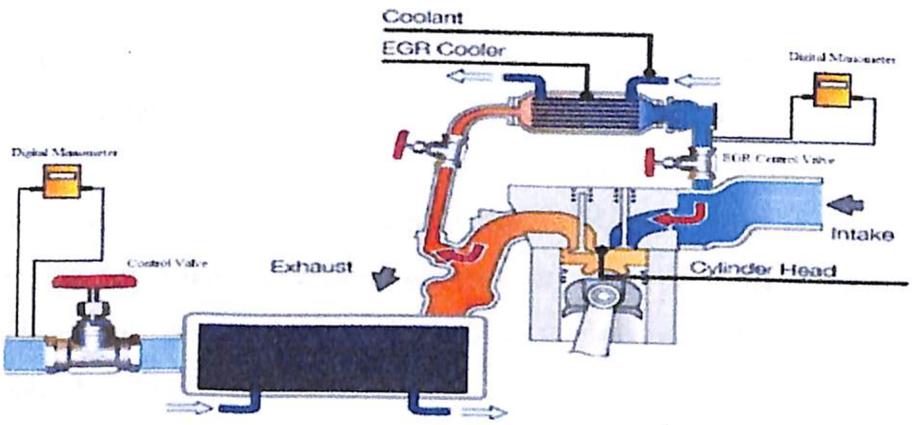


Figure 2.1: EGR system

Description:

In the present system the exhaust gas coming out of the engine is passes to an EC (exhaust cooler).

The exhaust gases from the EC after cooling are passed via a valve and digital manometer. The digital manometer is provided in order to find the total amount of exhaust gas low and valve or controlling the flow. The digital manometer operates with the temperature range of 10-50 degree celcius; this is the reason for cooling the exhaust after the EGR system.

In the main exhaust line of tapping is provided for EGR system, The exhaust gas passes from the tapping through a valve and is passed to the EGR cooler ,where the exhaust gas is cooled before sending it to the engine. At the inlet manifold of the engine a digital manometer is provided in order to know the flow of exhaust gas to the engine.

To allow desired percentage of EGR into the engine,the first step we should find the total flow of exhaust gas with the digital manometer provided with the EC.If the flow is supposing40mm,therfore 40 mm is the 100% at some particular load.If we wise to pass 10% EGR,now the EGR Control valve is slowly opened until we reach 4mm reading in the digital manometer provided at the intake manifold of the engine.

Three popular explanations for the effect of the EGR on NOx reduction are increased ignition delay, dilution of intake charge with inert gas and high heating capacity. The ignition delay hypothesis verifies that as EGR causes an increase in ignition delay, it has same effect as retardation of injection timing. The heat capacity states that addition of the inert exhaust gas into intake increases the heat capacity (specific heat) of nonreacting matter which is present during the combustion. It is seen that the increased heat capacity has the effect of lowering peak combustion temperature. According to dilution theory, the effect of EGR on NOx is caused by the increased amounts of inert gases in the mixture, which reduces the adiabatic temperature.

At very high loads, it is difficult to employ the EGR due to reduction in diffusion combustion and this might result in an excessive increase in the smoke and particulate emissions (PM). At very low loads, the unburnt hydrocarbons contained in EGR would reburn in the mixture, which will lead to a lower unburnt fuel in the exhaust and thus will have improved brake thermal efficiency. Also apart from this, hot EGR would raise intake charge temperature, which will influence the combustion and exhaust emissions.

With use of EGR, there will be a trade-off between reduction in the NOx and increase in the soot, unburnt hydrocarbons and CO. A large number of studies have been done to research this. It is seen that for more than 50% EGR, particulate emissions(PM) increase significantly, and therefore use of particulate trap will be recommended. The change in the oxygen concentration will cause a change in structure of flame and hence will change the duration of combustion. It is seen that the flame temperature reduction is the most important factor which influence NOx formation.

When engine components come into contact with the high velocity soot particulates, then the particulate abrasion might occur. Condensed water and sulphuric acid in EGR also cause corrosion. Some of the studies have detected damages on cylinder walls due to the reduced oil's lubrication capacity .This necessitates use of an efficient particular trap which is efficient .Studies have shown ,EGR which is coupled with high collection efficiency particulate trap, controls smoke, Nox emission and unburnt HC simultaneously. The particulate trap, needs to be regenerated with time as its pores get clogged by trapped soot particles. These soot traps increase backpressure to engine exhaust, and thus will affect engine performance also. These traps need to be regenerated after some days using thermal or aerodynamic regeneration techniques.The other methods of reducing the particulate emission from diesel engines are multiple injections, supercharging etc. Now a days the highest attention is currently being paid to two regenerating systems which are: fuel additive support regeneration by using cerium additives, and continuous regeneration trap using sulphur free diesel fuel

**Classification of EGR systems**

On the basis of EGR temperature ,configuration and pressure various EGR systems have been classified,

1. Classification based on temperature:

(i) Hot EGR: In this Exhaust gas is recirculated without being cooled ,which results in increased inletcharge temperature.

(ii) Fully cooled EGR: Exhaust gas is first fully cooled before mixing it with fresh in take air using a water-cooled heat exchanger. In this case, the moisture which is present in the exhaust gas will condense and the resulting water droplets will cause an undesirable effects inside the engine cylinder.

(iii) Partly cooled EGR: In this to avoid the condensation of water,the temperature of the exhaust gas is kept just above its dew point temperature.

2. Classification based on configuration

(i) Long route system (LR): In this system the pressure drop across the air intake and the stagnation pressure in the exhaust gas makes EGR possible. A small stagnation pressure is created by the exhaust gas velocity,which gives rise to the pressure difference in combination with low pressure after the intake air in order to accomplish EGR across the entire torque and speed of the engine.

(ii) Short route system (SR): This system differs in the method used to set up a positive pressure difference across the circuit of EGR. Using a variable nozzle turbine is another method to control the EGR rate. Most of the systems have single entrance.Such systems reduce the efficiency of the system by exhaust pulse separation.

3. Classification based on pressure

Two different routes for EGR, namely low-pressure and high-pressure route systems may be used :

(i) Low pressure route system: The passage for EGR is provided from downstream of the turbine to the upstream side of the compressor and it is found that by using this method, EGR can be used in a high load region, with NOx reducing significantly. However, some problems occur, which influence durability, high compressor outlet temperature and intercooler clogging.

(ii) High pressure route system: The EGR is passed from upstream of the turbine to downstream of the compressor. In this method, it is seen that although EGR is possible in the high load regions, fuel consumption increases greatly and there is a decrease in the air- fuel ratio.

# 3. METHODOLOGY

## 3.1 EXPERIMENTAL SETUP

In order to carry out the experiment a single cylinder, water cooled IDI diesel engine.The table below shows the engine specifications.

| S.No | Particulars | Specifications |
|---|---|---|
| 1 | Make | Field marshal Diesel engine |
| 2 | Rated Brake Power (BHP) | 10 |
| 3 | Rated speed (rpm) | 1000 |
| 4 | Number of cylinder | 1 |
| 5 | Compression ratio | 17:18 |
| 6 | Cooling System | Water Cooled |
| 7 | Sump Capacity | 4.5 Litre |

Table 3.1: Engine specifications

Figure 3.1: Field marshal Diesel engine

Figure 3.2:Fuel inlet and controller

Figure 3.3:EGR

**The blends have been used in the following proportion:**

| Jatropha oil IN % | DIESEL IN % |
|---|---|
| 100 | 0 |
| 80 | 20 |
| 60 | 40 |

Table 3.1:Jatropha and diesel blends used

## 3.2 BIODIESEL PREPARATION

The process adopted for biodiesel preparation is transesterification.The process is carried out so as to reduce the viscosity of JSVO.This s done by removing the fatty acid present in JSVO.For this purpose 100ml mixture of NAOH and methanol is added to jatropha oil . The temperature is maintained between 50°C - 60°C as beyond this temperature there are chances of the oil catching fire.This is because methanol ignites at very low temperature

The above mixture of NAOH,methanol and jatropha oil is allowed to settle for 10hrs in the container. After this it will be seen that there is clear separation on glycerol and the ester which is the required oil (jatropha biodiesel).

The end result is golden colored jatropha biodiesel final.The golden colour testifies that the oil has undergone good transesterification .Also there should be no smell of the alcohol used in process.

## 3.3 EXPERIMENTAL PROCEDURE:

The bio-diesel test in the testing lab was done according to the following steps:

- The engine was started by cranking it with hand. The engine attains a constant speed in a less time as it is constant speed engine.
- Fuel was filled in the fuel tank and flows automatically to the calibrated tube. This tube helps in calculating the time taken for the consumption of 50 ml of the fuel.
- Electrical loading is applied and gets power from the engine.
- Sensors are attached and gives the following temperature readings

  T1 = Air inlet temperature

  T2 = Water outlet temperature

  T3 = Exhaust temperature

  T4 = Lubricant oil temperature

Inlet temperature can be considered as ambient temperature which is approximately 19 C.

- Tacometer is used to measure the rpm (revolutions per minute) of the engine at a particular load.
- The pipe of the gas analyzer is connected to the smoke outlet manifold.
- The emission readings are obtained from the smoke meter and gas analyzer. Three sets of readings are taken to take the average value of the three.
- The experiment was done for diesel B 60, B 80 and B 100 fuels..
- The baseline data was recorded, i.e. all parameters for both diesel and jatropha biodiesel and its blends without EGR'
- Then the above data was recorded with EGR .
- All the readings were taken at 100% load and the fuel consumption observations were made for 50cc consumption of fuel.
- The EGR rates were varied at 5 to 40% in steps of 5.

- The various readings were recorded and the discussions have been made upon the results obtained.
- Graphs have been plotted to show the comparison of various emission and performance parameters of diesel and jatropha biodiesel and its blends with EGR.

# 4. THEORETICAL CONSIDERATIONS

After recording the various test parameters, calculations were done using the following formulas:

## 4.1 MEASUREMENT OF RATE OF FUEL CONSUMPTION:

Let time taken in consuming 50cm^3 fuel=t sec

Vol. fuel consumed in one second $= \frac{50cm^3}{t}$

Mass fuel consumed per second

$= \frac{50*10^{-6}*\text{density of fuel}}{t}$

**1.For diesel fuel** $= \frac{50\times10^{-6}\times817}{t}$ kg/sec

**2.For JSVO** $= \frac{50\times10^{-6}\times910}{t}$ kg/sec

## 4.2 MEASUREMENT OF BRAKE POWER OUTPUT

$$\text{Power(P)} = \frac{\text{Voltage} \times \text{Current}}{1000 \times \text{efficiency of generator}} \text{ kw}$$

## 4.3 MEASUREMENT OF BRAKE SPECIFIC FUEL CONSUMPTION(BSFC):

$$\text{BSFC} = \frac{\text{rate of fuel consumption}}{\text{Brake Power output}}$$

$$= \frac{50 \times 10^{-6} \times \text{density of fuel/time}}{\frac{\text{Voltage} \times \text{Current}}{1000 \times \text{efficiency of generator}}}$$

1. **For Diesel Fuel:**

$$\text{BSFC} = \frac{50 \times 10^{-6} \times 817/\text{time}}{\frac{\text{Voltage} \times \text{Current}}{1000 \times \text{efficiency of generator}}}$$

$$= \frac{40.85 \times 3600 \times \text{generator efficiency}}{\text{voltage} \times \text{current} \times \text{time}} \text{ kg/kWh}$$

$$= \frac{1.47060 \times 10^{5} \times \text{generator efficiency}}{\text{voltage} \times \text{current} \times \text{time}} \text{ kg/kWh}$$

2. **For JSVO:**

$$BSFC= \frac{50\times10^{-6}\times910/time}{\frac{Voltage \times Current}{1000\times efficiency\ of\ generator}}$$

$$=\frac{45.55\times3600\times\ generator\ efficiency}{voltage\times current\times time}\ kg/kWh$$

$$=\frac{1.638\times10^{5}\times\ generator\ efficiency}{voltage\times current\times time}\ kg/kWh$$

## 4.4 MEASUREMENT OF BRAKE THERMAL EFFICIENCY(BTE):

$$BTE = \frac{Brake\ Power\ output\times100}{Rate\ of\ fuel\ conumption\times calorific\ value}\ \%$$

1. **For Diesel Fuel:**

$$BTE= \frac{voltage\times current\times time}{1.7157\times10^{4}\times\ generator\ efficiency}$$

(Calorific value of diesel used:42000KJ/Kg)

**2.For JSVO:**

$$BTE = \frac{voltage\times current\times time}{1.7745\times10^{4}\times\ generator\ efficiency}$$

(Calorific value of JSVO used:39000KJ/Kg)

# 5. RESULTS AND DISCUSSIONS

## 5.1BTE:

It was observed that the brake thermal efficiency of diesel was higher than jatropha biodiesel and its blends may be due to the lower calorific value of biodiesel and slightly higher viscosity than diesel. Diesel shows maximum brake thermal efficiency followed by B60.The lower BTE of JSVO also indicates that the fuel combustion efficiency of JSVO is inferior to diesel.

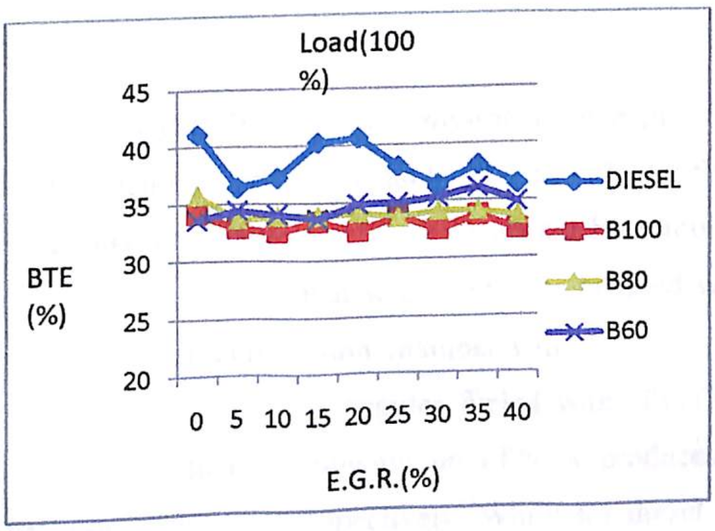


Figure 5.1:BTE(%) v/s E.G.R.(%)

## 5.2 BSFC:

The specific fuel consumption for diesel was observed to be lower than the JSVO blends.High specific fuel consumption of JSVO shows that the heat released by the combustion of fuel is lower as a result of which the brake power output reduces.Since the brake power output reduces,the BSFC becomes high.For B100 BSFC was found to be highest.

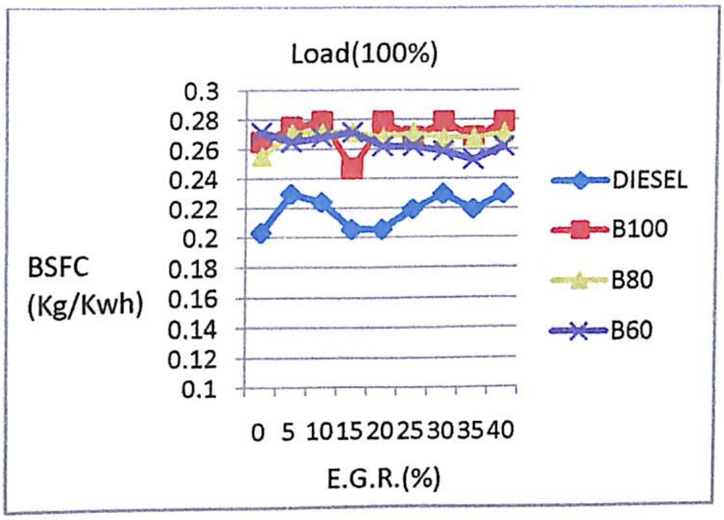


Figure 5.2:BSFC(Kg/Kwh) v/s E.G.R.(%)

### 5.3 NOx EMISSIONS:

NOx is one of the most harmful gaseous emission from engines and there are several methods by which NOx emission can be reduced. One of the method is to use EGR.The NOx emissions of various JSVO blends has been found to be higher than diesel.The reason behind it is that when JSVO is blended with diesel, the amount of oxygen present in combustion chamber will be more which leads to higher quantity of NOx formation in engines fueled with JSVO-diesel blends .For B 100, B 80 and B 60, the maximum amount of NOx produced at 100% load are 882 ppm, 848 ppm, 806 ppm),respectively. While for diesel the maximum amount of NOx produced at 100% load was 643 ppm which is much lesser than the JSVO blends with diesel.

The result showed that with EGR at 15% EGR diesel , B 60 at 20% EGR, B 80 at40% EGR, and B 100 at 5% EGR, the NOx emissions were effectively reduced by 10.1%, ,15.26%,19.81%, and 24.82% respectively.

| | DIESEL | B100 | B80 | B60 |
|---|---|---|---|---|
| NOx(ppm)(without EGR) | 643 | 882 | 848 | 806 |
| NOx(ppm)(with EGR) | 578(at15%) | 663(at5%) | 680(40%) | 683(20%) |
| % reduction with EGR | 10.1 | 24.82 | 19.81 | 15.26 |

Table 5.1:NOx with and without EGR and its % reduction with EGR

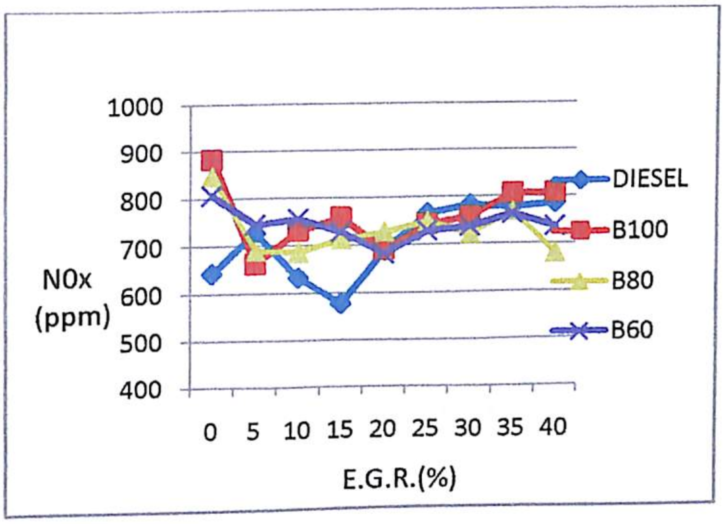


Figure 5.3 :NOx(ppm) v/s E.G.R.(%)

## 5.4 CO EMISSIONS:

CO emission is lesser in Jatropha biodiesel and its blends as compared to diesel fuel.It was observed that after using EGR there was an increase in CO emission.This was because of decreasing air-fuel ratio.

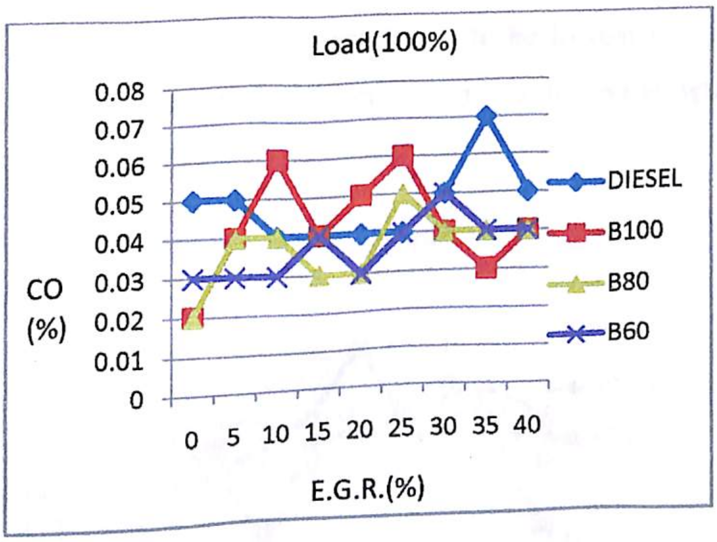


Figure 5.4 :CO(%) v/s E.G.R.(%)

### 5.5 C02 EMISSIONS:

CO2 emissions for diesel were higher with E.G.R. than without E.G.R.For B100 CO2 emissions reduced with E.G.R. than without E.G.R. by 22.63% at 20% E.G.R. rate.

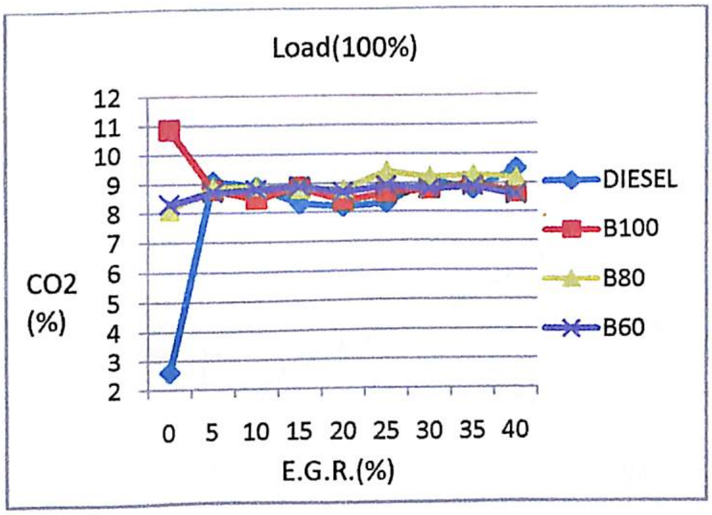


Figure 5.5 :CO2(%) v/s E.G.R.(%)

### 5.6 HC EMISSIONS:

It was observed that the HC emissions were higher in case of diesel as compared to jatropha biodiesel. HC emissions were found to be lowest for B100 with 15% EGR providing 50 % reduction in HC emissions compared to without EGR for B100.

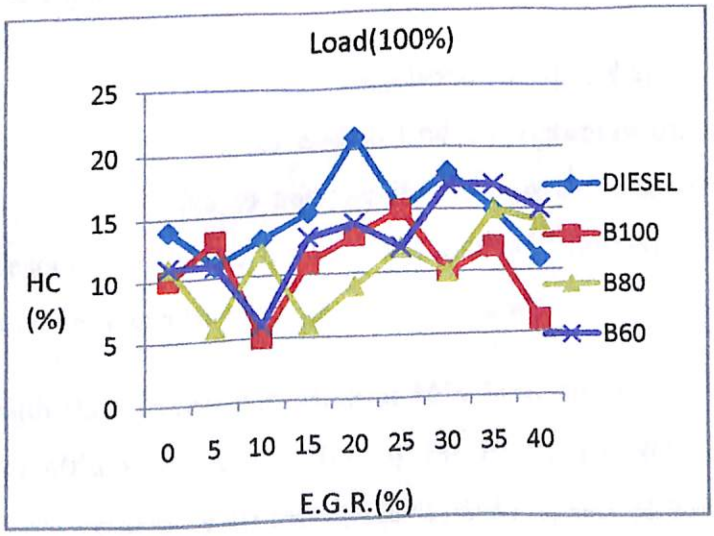


Figure 5.6 :HC(%) v/s E.G.R.(%)

### 5.7 SMOKE OPACITY:

It was observed that the smoke opacity was higher when the engine was operated with EGR as compared to when the engine was operated without EGR in both the case of diesel and JSVO blends. The reason being that EGR lowers the concentration of oxygen for the combustion of fuel

On comparing diesel and JSVO blends with EGR, Smoke opacity was found to be lower for JSVO blends as it contains molecular oxygen. It is also observed that B100 gave lowest smoke opacity at 5% EGR rate.

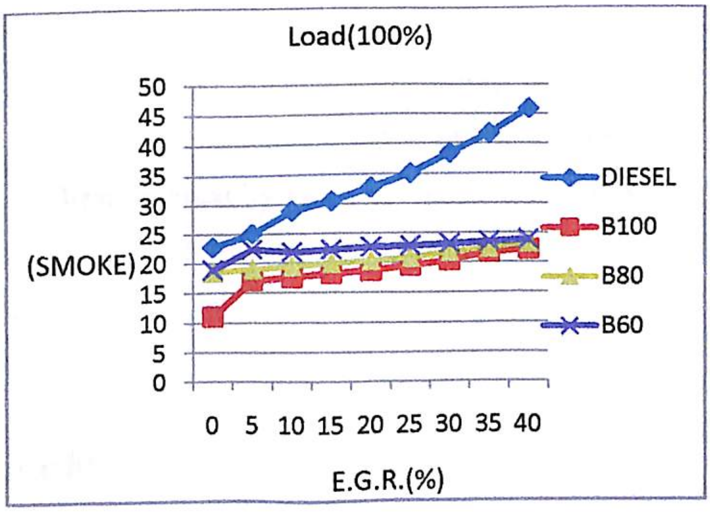


Figure 5.7 :Smoke v/s E.G.R.(%)

### 5.8 CONCLUSIONS:

The objective of this dissertation is to use jatropha biodiesel as a blend with diesel in order to improve its properties and to find the optimum blend which would reduce NOx emissions. Also to analyze the various exhausts of JSVO and its blends with diesel at 100% load.It was found that EGR proved to be successful in reducing NOx percentages by varying the EGR rates.

- The result showed that with EGR at 15% EGR diesel, , B 60 at 20% EGR, B 80 at 40% EGR, and B 100 at 5% EGR, the NOx emissions were effectively reduced by 10.1%, ,15.26%,19.81%, and 24.82% respectively.

- The brake thermal efficiency of diesel was found to be higher than JSVO and its blends with diesel, which may due to higher calorific value of diesel and its slightly lower viscosity.
- The exhaust gas temperature of JSVO and its blends with diesel was found to be lower than that of diesel fuel.
- CO, Smoke and HC emissions were found to be lower in JSVO and its blends with diesel as compared to diesel.
- The specific fuel consumption for diesel was observed to be lower than the JSVO blends.High specific fuel consumption of JSVO shows that the heat released by the combustion of fuel is lower as a result of which the brake power output reduces.Since the brake power output reduces,the BSFC becomes high

## 5.9 FUTURE SCOPE:

EGR has many advantages but still there are some limitations. These limitations can be resolved by modifications in the future. In future long term assessment of engine durability when biodiesel is used in long term with EGR needs to be studies. Then the effect of biodiesel fuelled engine with EGR on the lubricating oil needs to be examined. Another field of research for the future is the development of a sophisticated EGR valve which would give response when the engine is in dynamic mode of operation.

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