IJIRIS: International Journal of Innovative Research in Information Security E-ISSN: 2349-7017
Volume 09, Issue 03, June 2023 P-ISSN: 2349-7009
https://www.ijiris.com/archives

ALTERNATE FUEL BIODIESEL

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Abstract:
The rapid growth of industrialization and transportation has led to a significant increase in greenhouse gas emissions and environmental degradation. To mitigate these challenges, there is an urgent need for sustainable energy solutions that can reduce dependence on fossil fuels and minimize environmental impact. Bio-diesel, a renewable and cleaner-burning fuel derived from organic sources, has emerged as a promising alternative to traditional petroleum-based diesel. This abstract provides an overview of bio-diesel, its production process, properties, and its environmental benefits. Bio-diesel is typically produced from feedstocks such as vegetable oils, animal fats, and waste cooking oils through a transesterification process that converts triglycerides into esters. The resulting bio-diesel exhibits similar properties to petroleum diesel, making it compatible with existing diesel engines and infrastructure. One of the significant advantages of bio-diesel is its reduced carbon footprint. It has a significantly lower lifecycle greenhouse gas emissions compared to petroleum diesel, primarily due to the absorption of carbon dioxide during the growth of the feedstock plants. Bio-diesel also contributes to a reduction in air pollutants, such as sulfur oxides and particulate matter, resulting in improved air quality and human health benefits. Additionally, bio-diesel offers economic benefits by promoting local agriculture and creating new job opportunities in the biofuel industry. The utilization of waste cooking oils and animal fats as feedstocks also contributes to waste reduction and efficient resource utilization. Despite its numerous benefits, challenges remain in the widespread adoption of bio-diesel. These challenges include feedstock availability, land use competition with food production, and the need for consistent quality standards. Ongoing research and development efforts are focused on optimizing the production process, exploring alternative feedstocks, and improving the overall sustainability of bio-diesel production. In conclusion, bio-diesel holds great potential as a sustainable alternative to petroleum diesel, offering environmental, economic, and societal benefits. Its reduced carbon footprint and compatibility with existing infrastructure make it a viable option for transitioning towards a greener future. Further advancements in technology and policies supporting bio-diesel production and utilization will play a crucial role in realizing its full potential and achieving a more sustainable energy landscape

INTRODUCTION

Nowadays, people have come with new discovered source of fuel for the diesel engine named biodiesel. Biodiesel is an alternative choice of fuel to replace the crude oil from the industry. Biodiesel fuel offers a potential reduction of carbon dioxides (CO_2) and hydrocarbon (HC) emissions due to its higher content of oxygen (O_2). Many studies of biodiesel engine have found that exhaust from biodiesel fuel has higher nitrogen oxide (NOx) emissions while HC and lower particulate matter (PM) than conventional diesel fuel. EGR is used to solve the problem of excessive NOx emission from the biodiesel exhaust. EGR is operated by re-circulating the gas produced by the diesel engine exhaust back to the engine cylinder, so that the exhaust gas which is re-circulating replaces some of the excess O_2 in the pre-combustion mixture. At higher temperature which is about 1371C, the formation of NOx will be faster. Chemical gases are formed from the chemical reaction between nitrogen (N_2) and O_2 in the combustion chamber. When these gases react with HC with the presence of sunlight, a black haze will appear in the skies known as smog. The EGR reduces the amount of NOx in the exhaust gas emission by re-circulating it into the intake manifold where it mixes with air-fuel-ratio charge. The result of the mixing of inlet air with re-circulated gas is that peak combustion temperature and pressure are reduced by diluting the mixture of air-fuel-ratio at these conditions. Generally, EGR flow is divided into three conditions. Firstly is high EGR flow. High EGR flow is necessary during cruising and mid-range acceleration and it happens when the combustion temperature is very high. Secondly is low EGR flow which is necessary at low speed and light load condition. Lastly is no EGR in which this condition occurs when EGR operation could adversely affect engine operating efficiency or vehicle drivability, such as when engine is warmed up, idling, and when the throttle is wide open. The operation of the EGR will affect the performance of the diesel engine. Theoretically, EGR system has to precisely match with the various EGR flows and to over ride flow under condition which would give the best performance to the engine. A precise combination of the amount of EGR into the intake manifold and the load change will give a good result to the engine performance. The engine performance will be reduced if the exhaust gas is too much metered into the intake manifold. While in the other hand, if too little EGR flow goes into the intake manifold, it will also give a negative effect in which the engine might suffer from knocking and thus end up not meeting strict emission standards.

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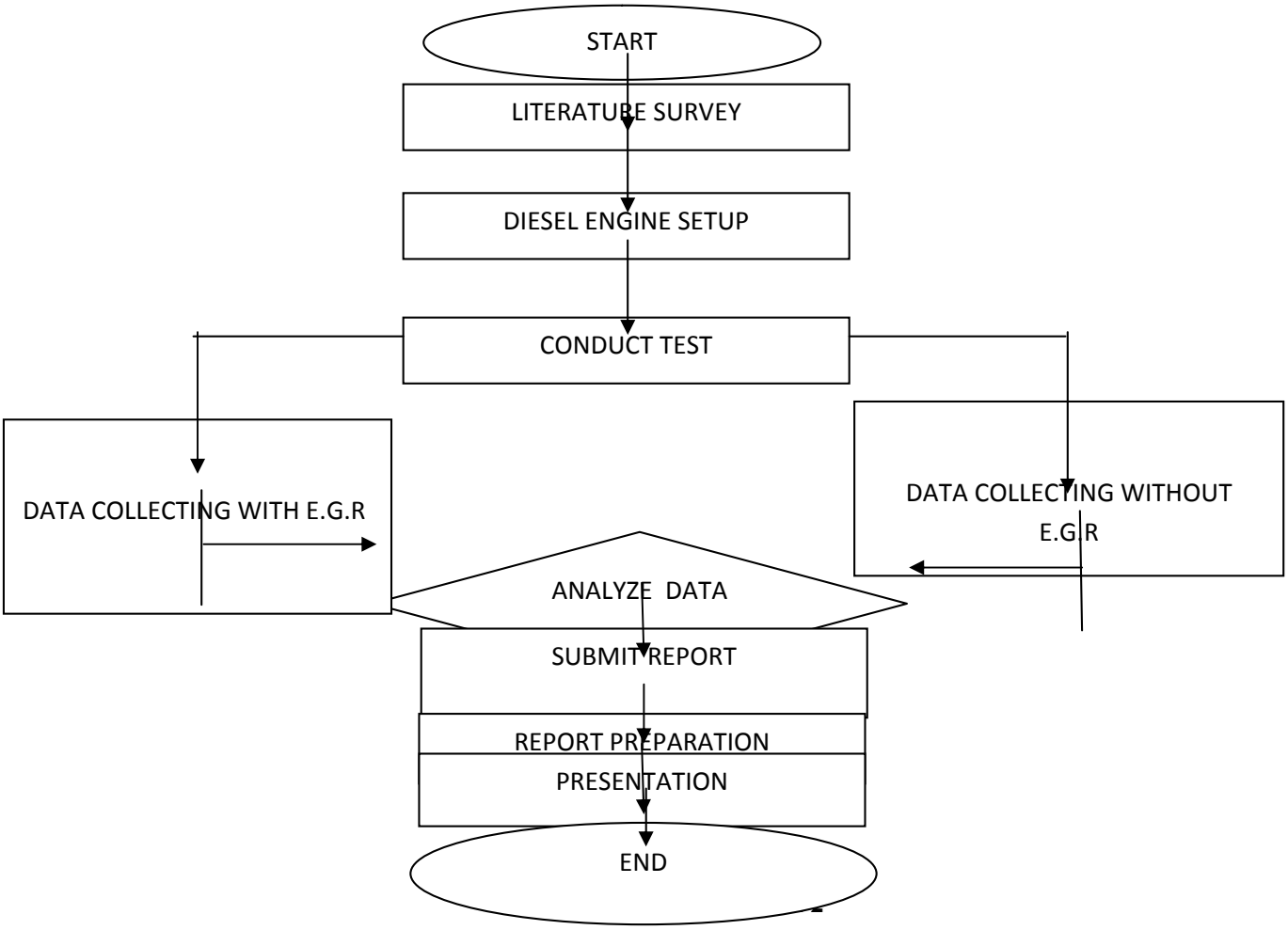
The effectiveness of EGR to reduce the emission contained in the exhaust gas depends on the flow of EGR. When the flow is too slow, it will cause detonation and emissions failure for excessive NOx, because EGR tends to reduce the vitality of the air fuel charge. Otherwise, when too much EGR, an excessive flow for driving condition will cause stumble, flat spot, hesitation, and surging. This problem happens because EGR dilutes the air-fuel charge. When the flow of EGR is too much compared to the engine demand, misfiring happens.

1.1RADISH SEED:

The seeds of the Raphanussativus species can be pressed to extract seed oil. Wild radish seeds contain up to 48% oil content, and while not suitable for human consumption the oil is a potential source of bio fuel. The oilseed radish grows well in cool climates.

PROJECT SUMMARY (FLOWCHART)



HISTORY OF BIOFUEL

There has not been much literature published on the topic of on-farm production of biodiesel. But there is a growing knowledge base on oilseed crops, their agronomics, economics, and conversion to biodiesel. Using vegetable oils for fuel in diesel engines is as old as the engine itself. In a very well known demonstration, Dr. Rudolph Diesel used peanut oil in his engine in the absence of other fuels. As petroleum prices have risen, more research has been done in the area of biodiesel from oilseed crops in search of a cheaper alternative to petroleum diesel (Ma and Hanna, 1999). However, increase in demand for biodiesel has lead to the potential for the price of vegetable oil feed stocks to increase by as much as 14% over the period of five years (Raneses et al., 1999).

The rise in vegetable oil prices has also increased the price of raw oilseeds leading many farmers to look at growing oilseed crops to sell as biodiesel feedstock.If traditional oilseed crops were grown specifically for commercial biodiesel production in India. This displacement would cause a loss of income on the farm (CAED-CAES, 2007). This is because, although vegetable oil prices are rising, crude petroleum oil prices have not reached a level high enough to allow for the more expensive vegetable oils to be converted into biodiesel (Agarwal, 2007). For example, it has been proposed that diesel prices in the US would have to exceed approximately $5.00 per gallon at the pump for biodiesel from peanut oil to reach their break even point (CAED-CAES, 2007).

Research is currently being done to reduce the cost of vegetable oil by reducing inputs required to grow oilseed crops (Branch and Fletcher, 2004). Lower prices of vegetable oil feedstock would lead to more biodiesel production. Crop rotations are used to maintain soil fertility while decreasing the reliance on fertilizers (Yunusa and Rashid, 2007). Cover crops are grown in Georgia's cool season (after major economic crops are harvested, i.e. peanuts and cotton) as a green manure to restore nutrients to the soil, aid in combating soil pathogens for the next economic crop, and to prevent erosion (Larkin and Griffin, 2007). Currently these crops are of economic importance only in the manner that they reduce the costs of fertilizer, pesticides, and erosion control on the farm; the crops are not sold in the market place as cash crops. Some oilseed crops, such as oilseed radish (Raphanussativusssp. oleiferus, in the Brassicafamily), rapeseed, and mustard, can provide many rotational and green manure benefits when grown as cover crops (Bunte et al., 1997). These crops contain comparable levels of seed oil content to the traditional oilseed crops such as soybean and peanut.

Oilseed radish contains about 40% oil in its seed (Eckey, 1954). This crop has been grown as a cool season cover crop in the US and has been shown to have favourable effects in aiding in control of plant pathogens (Lazzeri et al., 2004). Since Biodiesel has been produced on a large scale, certain favorable fuel properties have been established to evaluate potential fuels from new feedstocks (Ali and Hannah, 1995). Some of these properties include temperature and viscosity dependence and boiling point. Cold-flow properties such as cold filter plugging point (CFPP) could be added in the future. Fuel performance properties have also been established when Biodiesel fuels are used in diesel engines (Korus et al., 1985 and Goodrum et al., 1996). These properties include degree of coke deposited on fuel injectors (injector coking). Biodiesel made from cool season crops in the Brassicafamily, such as canola, have also been comparable to No.2 diesel fuel as well (Geller etal).

2.1 Biofuels

"Bio" represents as a renewable and biological source in contrast to traditional petro-diesel fuel; "diesel" refers to its use in diesel engines. As an alternative fuel, biodiesel can be used in neat form or mixed with petro-diesel. Biodiesel defined as "a substitute for, or a additive to diesel fuel that is derived from the oils and fats of plants and animals" (Ma and Hanna, 1999) or mono-alkyl esters of long chain fatty acids derived from a renewable lipid feedstock, such as vegetables oil or animal fat. Biodiesel is an alternative diesel fuel that is produced from vegetable oils and animal fats. It consists of the monoalkyl esters formed by a catalyzed reaction of the triglycerides in the oil or fat with a simple monohydric alcohol.

Biofuels are energy carriers that store the energy derived from biomass, commonly produced from plants, animals and micro-organisms and organic wastes. Biofuels may be solid, liquid or gaseous and include all kinds of biomass and derived products used for energetic purposes. Biofuels are renewable energy sources, meaning that fresh supplies can be regrown. They are a possible substitute product for fossil fuels. Compared with the latter product there are some advantages to subscribe to biofuels. Advantages and benefits of biofuels, however, depend on the categorization of the specific biofuel, type of feedstock used and technology applied to produce it.

2.2 Biodiesel

Biodiesel are non toxic, renewable which is produced from plants, algae and animal fats.

The following are the advantages

1) Biodiesel molecules are simple hydrocarbon chain, containing no sulphur or aromatic substance.
2) Biodiesel is an oxygenated fuel so it enhances the combustion process to be completed.
3) Biodiesel gives considerably lower emissions of particulate matters, carbon monoxide and Hydrocarbons without any engine modification.
4) It has higher flash and fire point so it is safer to transport.
5) It has excellent lubricity.

Among all these advantages one major disadvantage of biodiesel is that it emits higher NOx which is one of the most undesirable pollutant.

2.3 The Possible Methods of Biodiesel

The quality of feed vegetable oil particularly FFA content plays an important role in identifying the suitable technology. The important factors to be considered for a biodiesel production plant include:

i) Process ability of variety of vegetable oils without or minimum modifications
ii) Process ability of high free fatty acid (FFA) containing oils/feed-stocks
iii) Must be able to process raw both expelled and refined oil
iv) Process should be environment friendly with almost zero effluent

Certain difficulties are experienced in the engines while using straight vegetable oil (SVO) or chemically unmodified vegetable oils. One major problem is the higher viscosity of vegetable oils.. There are the various methods for processing of biodiesel as follows:

i) Pyrolysis

ii) Micro-emulsification
iii) Transesterification

2.3.1 Pyrolysis

Pyrolysis refers to a chemical change caused by application of thermal energy in absence of air or nitrogen. The liquid fractions of the thermally decomposed vegetable oil are likely to approach diesel fuels. Many investigators have studied the pyrolysis of triglycerides with the aim of obtaining products suitable for diesel engines. Thermal decomposition of tri-glycerides produces compounds of several classes, including alkanes, alkenes, alkadienes, aromatics, and carboxylicacids.

2.3.2 Microemulsification

The formation of micro-emulsions (co-solvency) is a potential solution for reducing the viscosity of vegetable oil. Micro-emulsions are defined as transparent, thermodynamically stable colloidal dispersions. The droplet in micro-emulsions ranges from 100 to 1000 Å. A micro-emulsion can be made of vegetable oils with an ester and dispersant (co-solvent), or of vegetable oils, an alcohol and a surfactant and a cetane improver, with or without diesel fuels. Water (from aqueous ethanol) may also be present in order to use lower-proof ethanol, thus increasing water tolerance of the microemulsions. The use of micro emulsions with solvents such as methanol, ethanol, and 1-butanol has also been studied as a means of solving the problem of high viscosity of vegetable oils. Micro emulsions are isotropic, clear or translucent thermodynamically stable dispersions of oil, water, a surfactant, and often a small amphiphilic molecule, called a co surfactant. Ziejewski*et al* prepared an emulsion of 53.3% (v/v) alkali-refined and winterized sunflower oil, 13.3% (v/v) 190-proof ethanol and 33.4% (v/v) 1-butanol. This non-ionic emulsion had a viscosity of 6.31 x 10-6 m^2/s at 40°C, a cetane number of 25, a sulfur content of 0.01 %, free fatty acids of 0.01 %, and an ash content of less than 0.01%. Lower viscosities and better spray patterns were obtained by increasing the amount of 1-butanol. Schwab *et al.* (Schwab, Bagby, and Freedman, 1987) reported that 2-octanol was an effective amphiphile in the micellarsolubilization of methanol in triolein and soybean oil. However, in a laboratory screening endurance test, irregular injector needle sticking, heavy carbon deposits, in complete combustion and an increase of lubricating oil viscosity were reported.

2.3.3 Transesterification

Transesterification is the process of separating the fatty acids from their glycerol backbone to form fatty acid esters (FAE) and free glycerol. Fatty acid esters commonly known as biodiesel can be produced in batches or continuously by transesterifying triglycerides such as animal fat or vegetable oil
with lower molecular weight alcohols in the presence of a base or an acid catalyst. This reaction occurs stepwise, with monoglycerides and diglycerides as intermediate products. The transesterification process of converting vegetable oils to biodiesel is shown. The "R" groups are the fatty acids, which are usually 12 to 22 carbons in length. The large vegetable oil molecule is reduced to about 1/3 its original size, lowering the viscosity making it similar to diesel fuel. The resulting fuel operates similar to diesel fuel in an engine. The reaction produces three molecules of an ester fuel from one molecule of vegetable oil.

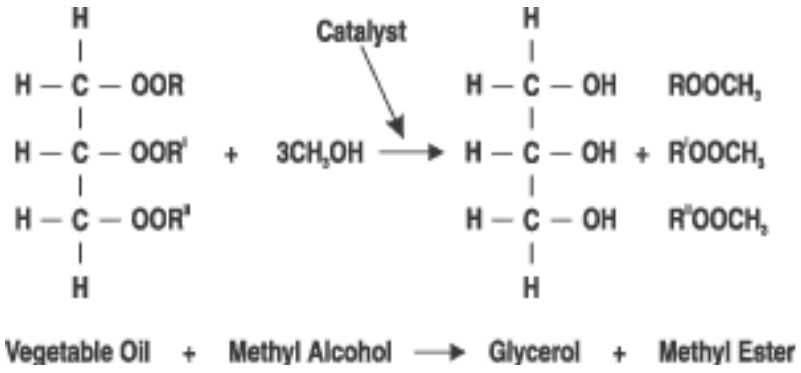


Fig. 2 Transesterfication process

In such reaction known as transesterification, a triglyceride is allowed to react with a threefold excess of an alcohol such as ethanol or methanol, and this alcohol takes the place of the ester linkage to glycerol, yielding three fatty acid esters of the new alcohol and glycerol. Above the process using methanol as shown in figure 1. Here three molecules of one alcohol are replacing glycerol, another alcohol, in the triglyceride. Vegetable oils have to undergo the process of transesterification to be usable in internal combustion engines. Biodiesel is the product of the process of transesterification. Biodiesel is biodegradable, non-toxic and essentially free from sulfur; it is renewable and can be produced from agriculture and plant resources. Biodiesel is an alternative fuel, which has a correlation with sustainable development, energy conservation, management, efficiency and environmental preservation. Transesterification is the

reaction of a fat or oil with an alcohol to form esters and glycerol. Alcohol combines with the triglycerides to form glycerol and esters. A catalyst is usually used to improve their action rate and yield. Since the reaction is reversible, excess alcohol is required to shift the equilibrium to the product side. Among the alcohols that can be used in the transesterification process are methanol, ethanol, propanol, butanol and amyl alcohol. The process of transesterification brings about drastic change in viscosity of vegetable oil. The biodiesel thus produced by this process is totally miscible with mineral diesel in anyproportion. Biodiesel viscosity comes very close to that of mineral diesel hence no problems in the existing fuel handling system. Flash point of the biodiesel gets lowered after esterification and the cetane number gets improved. Even lower concentrations of biodiesel act as cetane number improver for biodiesel blend. Calorific value of biodiesel is also found to be very close to mineral diesel. Some typical observations from the engine tests suggested that the thermal efficiency of the engine generally improves; cooling losses and exhaust gas temperature increase, smoke opacity generally gets lower for biodiesel blends.

Possible reason may be additional lubricity properties of the biodiesel; hence reduced frictional losses (FHP). The energy thus saved increases thermal efficiency, cooling losses and exhaust losses from the engine. The thermal efficiency starts reducing after a certain concentration of biodiesel. Flash point, density, pour point, cetane number, calorific value of biodiesel comes in very close range to that of mineral diesel.

.2.4 Characteristics of oils or fats affecting their suitability for use as biodiesel

• **Calorific Value, Heat of Combustion** – Heating Value or Heat of Combustion, is the amount of heating energy released by the combustion of a unit value of fuels. One of the most important determinants of heating value is moisture content. Air-dried biomass typically has about 15-20% moisture, whereas the moisture content for oven-dried biomass is negligible. Moisture content in coals varies in the range 2-30%. However, the bulk density of most biomass feedstocks is generally low, even after densification – between about 10 and 40% of the bulk density of most fossil fuels. Liquid biofuels however have bulk densities comparable to those for fossil fuels.

• **Melt Point or Pour Point** - Melt or pour point refers to the temperature at which the oil in solid form starts to melt or pour. In cases where the temperatures fall below the melt point, the entire fuel system including all fuel lines and fuel tank will need to be heated.

• **Cloud Point** - The temperature at which an oil starts to solidify is known as the cloud point. While operating an engine at temperatures below oil's cloud point, heating will be necessary in order to avoid waxing of the fuel.

• **Flash Point** - The flash point temperature of a fuel is the minimum temperature at which the fuel will ignite (flash) on application of an ignition source. Flash point varies inversely with the fuel's volatility. Minimum flash point temperatures are required for proper safety and handling of diesel fuel.

• **Iodine Value** - Iodine Value (IV) is a value of the amount of iodine, measured in grams, absorbed by 100 grams of a given oil. Iodine value (or Iodine number) is commonly used as a measure of the chemical stability properties of different biodiesel fuels against such oxidation as described above. The Iodine value is determined by measuring the number of double bonds in the mixture of fatty acid chains in the fuel by introducing iodine into 100 gram of the sample under test and measuring how many grams of that iodine are absorbed. Iodine absorption occurs at double bond positions - thus a higher IV number indicates a higher quantity of double bonds in the sample, greater potential to polymerize and hence lesser stability.

• **Viscosity** – Viscosity refers to the thickness of the oil, and is determined by
measuring the amount of time taken for a given measure of oil to pass through an orifice of a specified size. Viscosity affects injector lubrication and fuel atomization. Fuels with low viscosity may not provide sufficient lubrication for the precision fit of fuel injection pumps, resulting in leakage or increased wear. Fuel atomization is also affected by fuel viscosity. Diesel fuels with high viscosity tend to form larger droplets on injection which can cause poor combustion, increased exhaust smoke andemissions.

• **Cetane Number** - Is a relative measure of the interval between the beginning of injection and auto ignition of the fuel. The higher the cetane number, the shorter the delay interval and the greater its combustibility. Fuels with low Cetane Numbers will result in difficult starting, noise and exhaust smoke. In general, diesel engines will operate better on fuels with Cetane Numbers above 50. Cetane tests provide information on the ignition quality of a diesel fuel. Research using cetane tests will provide information on potential tailoring of vegetable oil-derived compounds and additives to enhance their fuel properties.

• **Density** – Is the weight per unit volume. Oils that are denser contain more energy. For example, petrol and diesel fuels give comparable energy by weight, but diesel is denser and hence gives more energy per liter.

The aspects listed above are the key aspects that determine the efficiency of a fuel for diesel engines. There are other aspects/characteristics which do not have a direct bearing on the performance, but are important for reasons such as environmental impact etc. These are:

• **Ash Percentage -** Ash is a measure of the amount of metals contained in the fuel. High concentrations of these materials can cause injector tip plugging, combustion deposits and injection system wear. The ash content is important for the heating value, as heating value decreases with increasing ash content.
Ash content for bio-fuels is typically lower than for most coals, and sulphur content is much lower than for many fossil fuels. Unlike coal ash, which may contain toxic metals and other trace contaminants, biomass ash may be used as a soil amendment to help replenish nutrients removed by harvest.

• **Sulphur Percentage -** The percentage by weight, of sulphur in the fuel Sulphur content is limited by law to very small percentages for diesel fuel used in on-road applications.

2.5 Diesel Engine

Diesel engine is like a gasoline engine, it is an internal combustion engine that converts chemical energy in fuel to mechanical energy which makes the piston moves up and down in the cylinders. To change the motion of the piston in the engine from linear motion to rotational motion, the pistons are connected to the crankshaft. This motion is needed to drive the vehicle's wheel.
In diesel engine operation, the fuel ignites on its own. Air heats up when it is compressed. Therefore, the spark plug and carburetor are replaced by a fuel injector in diesel engine. When the piston approaches the Top Dead Center (TDC), the fuel injection process in diesel engines will start and this process will continue during the first part of the power stroke. The combustion process in the ideal diesel cycle is approximated as a constant pressure heat addition process.

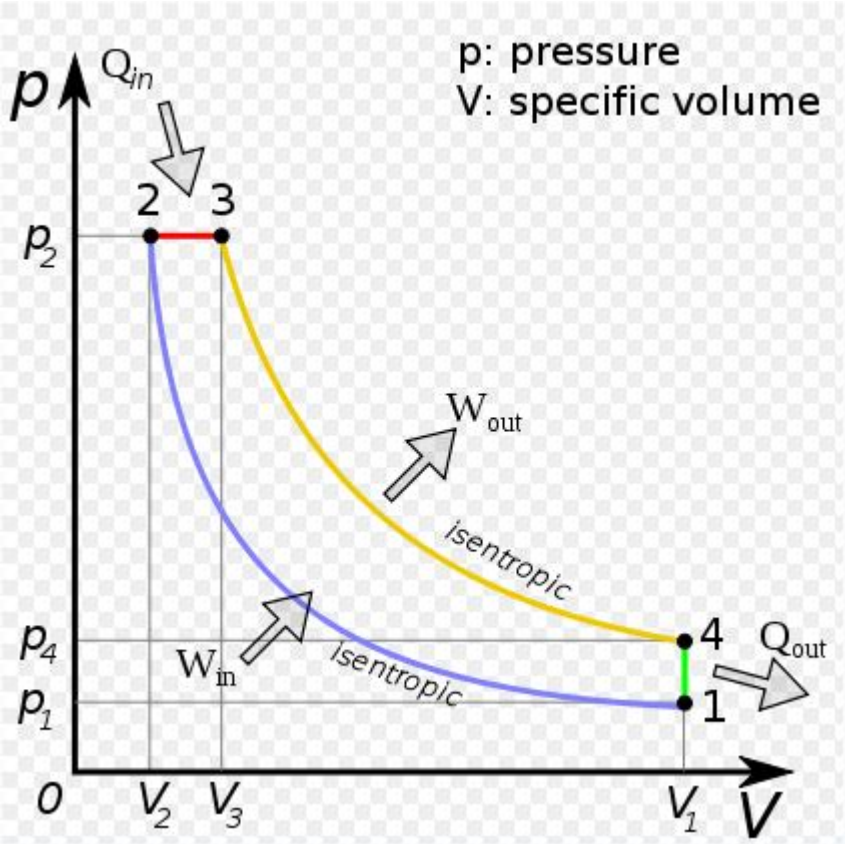


Fig.3 Standard graph of relationship between diesel compression ratio and thermal efficiency.

Process 1-2 is an isentropic compression, while 3-4 is an isentropic expansion and 4-1 is a constant heat-volume rejection (Cengel and Boles, 2007). Hence diesel engine is also known as compression ignition engine, it also has a high thermal efficiency because of its high compression ratio and fuel lean operation. To achieve the auto-ignition, high compression ratio is required as it will produce high temperature, so that the high expansion ratio will make the engine discharge less thermal energy in the exhaust. To complete and compensate the combustion for homogeneity in the fuel distribution, the extra oxygen (O2) is necessary to facilitate it.

However, locally stoichiometric air will cause the high flame temperatures predominate, so in such heterogeneous combustion process the fuel ratios will prevail (BormanGL and GaglandKW, 1998) Ideal p-v diagram for diesel cycle Source : From the thermodynamics text book – an engineering approach sixth edition (SI units), Yunus A. Cengel, 2007 P : Pressure V : Specific Volume.

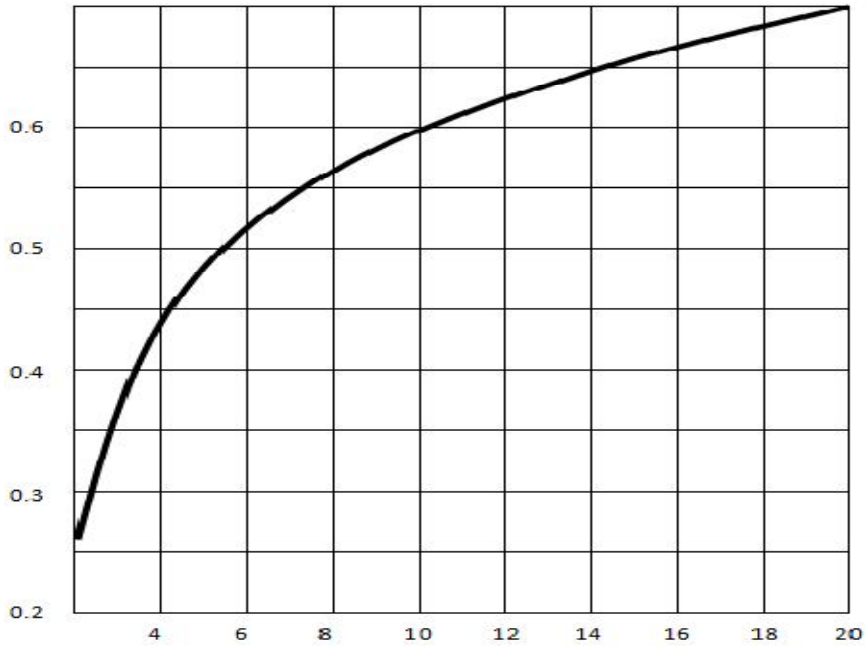


Fig.4 Schematicdiagramofdieselenginecompressionratio

2.5.1 Ignition and Combustion

The ignition in diesel engines happens rapidly with accumulated fuel burns corresponding to the temperature and pressure that increase rapidly. At the time rapid combustion happens, the injector is still receiving the fuel and thus a period of controlled combustion follows. The greater the ignition lag, the more violent the combustion as well as greater resulting noise, vibration and harshness. During the initial starting, at the time where the engine in the cold condition, the ignition lag becomes very bad. The will produce noise, white smoke, and rough combustion as known as 'diesel detonation'. This phenomenon will disappear when the engine condition is warm.

2.5.2 Two Stroke and Four Stroke Cycle

The operation of a four stroke-cycle of an engine is as shown in the Figure 4.At the first cycle, intake valve is opened and air is allowed to enter into the cylinder. Then the intake valve is closed at the second cycle as the piston at the BDC moves up to the TDC thus compressing the volume of air inside the cylinder. At the high compression and temperature, the fuel is injected for ignition. When the fuel is ignited, it drives the piston down as known as expansion cycle and this is third cycle. Then the last cycle, the exhaust valve opened and the piston rises again to reject the spent mixture of gases and fuel. This cycle called the exhaust stroke completes the cycle. However for the two cycle engine, the intake stroke and the compression stroke are combined to be one cycle. The third and fourth cycle, expansion stroke and exhaust stroke are also combined to become one cycle.

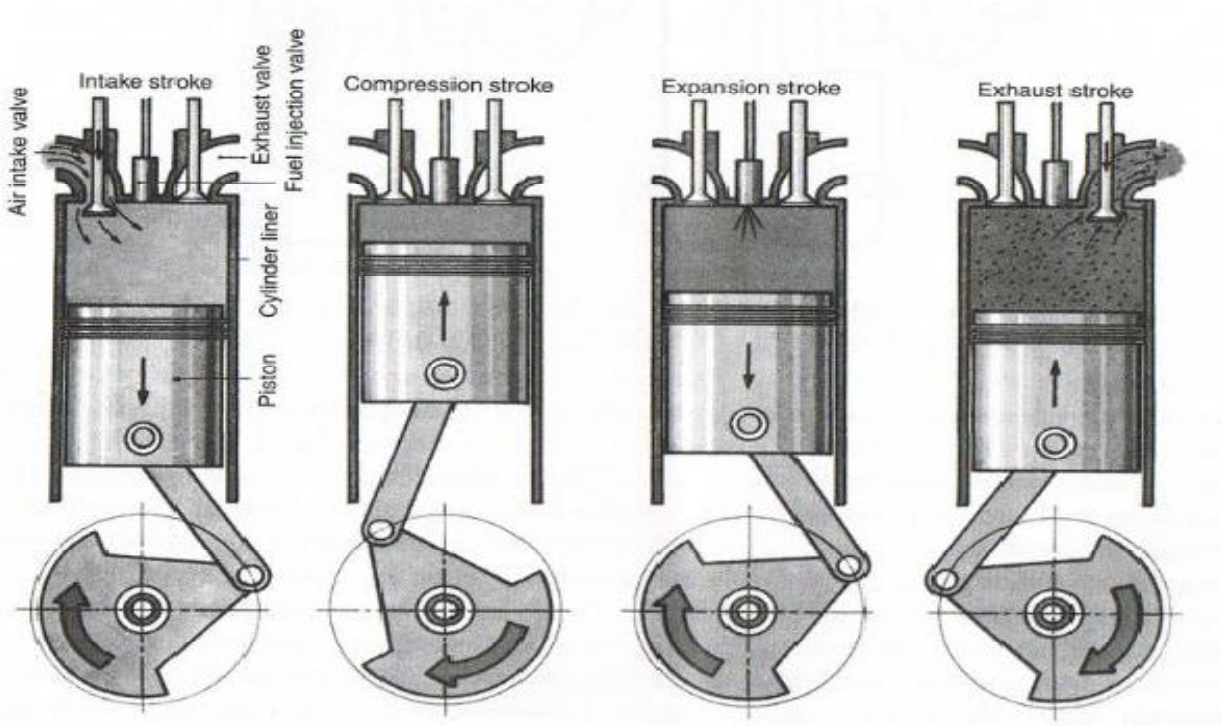


Fig. 5 Schematic diagram of Four stroke-cycle.

2.6 EGR EXHAUST GAS RECIRCULATION (E.G.R)

EGR is used to solve the problem of excessive NOx emission from the biodiesel exhaust. EGR is operated by re-circulating the gas produced by the diesel engine exhaust back to the engine cylinder, so that the exhaust gas which is re-circulating replaces some of the excess O2 in the pre-combustion mixture.

2.6.1 Basic EGR operation

The NOx forms under high pressures and temperatures commonly found in the combustion chamber, so we can control its formation by either reducing the compression or the temperature in the combustion chamber. Emission control engineers chose the latter. How is temperature controlled? By introducing a metered amount of inert gas into the cylinder to partially quench the fire, much like misting your barbecue when it flares. It doesn't put out the fire, but it slows things down a bit. The result is that the fire in the combustion chamber is less intense. EGR exhaust gas occupies space that would otherwise contain air. With EGR, the fire is more like a smoldering pile of leaves than a blast furnace. Exhaust gas was chosen because it is free and plentiful. EGR reduces the formation of NOx up to 60 percent. The cat usually cleans up much of the rest. The EGR valve opens during light throttle and warm engine cruising and channels the exhaust gases back into the engine's inlet air. It doesn't take much. EGR accounts for less than 10 percent of the total air/fuel mixture but even this small amount of non-flammable stuff is enough to quench the flame somewhat. When everything is on the money, the EGR lowers combustion temperatures to just under the 2500°F bogey.

2.6.2 Need for E.G.R

❖ If there isn't enough EGR, NOx emissions increase, but the only driveability problems are a surging at cruise, a complaint of spark knock or a failed enhanced emissions inspection due to a high NOx reading.

❖ If there is too much EGR, or EGR at the wrong time, your clues will be poor engine performance.

The symptoms include:

* poor idle
* stalling, especially when starting after cold soak
* hesitation, stumble and rough running during warm-up
* tip-in hesitation or stumble
* surge at cruise, even with warm engine
* poor acceleration
* low engine vacuum.

2.6.3 Types of E.G.R

There are currently six types of EGR systems in use. Going from theoldest (and perhaps the most familiar) they are:

- Ported (late 1960s to present)
- Positive backpressure (1970s to present)
- Negative backpressure (1970s to present)
- Pulse-width modulated (early 1980s to present)
- Digital (electronic) (late 1980-early 1990s)
- Linear (electronic) (early 1990s to present.)

➢ Two types of backpressure EGR valves are normally usedpositiveand negative. On GM cars, they are identified by the last letter of the part number stamped on the diaphragm housing on top of the valve.(Prior to 1988, they were not identified and can cause some confusion, so be careful when ordering a replacement.) The letter 'P' stands forpositive backpressure and the letter 'N' for negative backpressure. If there is no letter it operates on ported vacuum.

➢ On the positive backpressure EGR valve, a control valve located in the EGRvalve acts as a vacuum regulator valve. The control valve manages the amount of vacuum to the EGR diaphragm chamber by bleeding vacuum to the atmosphere during certain operating conditions. When the control valve receives a backpressure signal from the exhaust through the hollow shaft of EGR valve pintle, pressure on the bottom of the control valve closes it. When the control valve closes, the full vacuum signal is applied directly to the EGR valve diaphragm which opens the valve and lets the exhaust gas recirculate.

➢ On the negative backpressure EGR valve, a hose connected to the upperpart of the EGR valve supplies a vacuum signal. Manifold vacuum is also applied to the lower diaphragm through an intake port at the base of the EGR valve. When manifold vacuum in the lower chamber isn't strong enough to overcome the spring tension on the lower diaphragm, a bleed valve closes, allowing vacuum in the upper chamber to open the EGR valve. Exhaust flow opens a check valve in the pintle so that vacuum bleeds to atmosphere and the valve rises, but tries to drop again so it dithers to control EGR flow.

Fig.6 EGR System

CHAPTER 3
METHODOLOGY

3.1 Crushing of oil seed Radish

Here the Seeds were crushed using a model ZY-12C screw type oil press. Operating conditions were 150°C, 60 Hz; the oil was filtered through a metal mesh screen, andthereafter centrifuged in a centrifuge. Although heat was supplied, this is considered a cold crush; no solvents were used to extract additional oil.

3.2 Preparation of Oil seed Radish Biodiesel

Several protocols for biodiesel reactions were experimented to determine the proper protocol for the conversion of oilseed radish oil into biodiesel. These protocols varied reaction stages (one or two), number of total reactions (one or two), and washing methods. The most desirable protocol, and the one used for this paper, used 9 grams KOH per liter of oil and 200 milliliters methanol per liter of oil. Methanol and KOH were mixed prior to transesterification to produce the methoxide used in the conversion of the oil to biodiesel. The first reaction was a two stage reaction utilizing 85% of the methoxide in the first stage and the remaining 15% of the methoxide in the second stage. In each stage of the reaction the methoxide and oil were mixed at
270 rpm on a heated stir plate for one hour maintaining a temperature range of 50-60oC. The biodiesel was allowed to settle in a separatory funnel for one hour and all glycerin was removed from the biodiesel. Three washes were done using warm water at 10% of the biodiesel volume; mixing the water and biodiesel for 1.5 minutes at 170 rpm. After each wash the water was separated from the biodiesel. After the third wash the biodiesel was dried (all water removed by heat), and a second, one stage was done, using 9 g KOH per liter and 200 milliliters methanol. After glycerin was decanted, four washes were done at 10% warm water and the fuel was dried on a heated stir plate until all water was evaporated.

3.3.PROPERTIES OF RADISH OIL SEED:

No:	Name of the properties	Value
1	Specific gravity at 27/27^{0}C	0.9167
2	Kinematic viscosity 40^{0}C in Cst	51.9
3	Flash point	211^{0}C
4	Gross calorific value Kcal/kg	10,012
5	Fire point	223^{0}C
6	Cetane number	50.2
7	Acidity as mg of KOH/gm	0.47

Table1: Properties Of Radish Oil Seed

3.3.1 Purpose of Trans-esterification process

- The process is simple in operation
- The process is Eco friendly
- This process does not involve production of toxic and corrosive chemicals.
- It is less expensive.

3.4PREPARATION OF BIODIESEL:

Using trans-esterification process Bio-diesel was prepared from radish seed raw oil.

3.5 BIODIESEL BLEND WITH DIESEL:

The prepared bio-diesel was blended with diesel to produce the following samples,

1. B25 with 25% Bio-diesel and 75% Diesel
2. B50 with 50% Bio-diesel and 50% Diesel
3. B75 with 50% Bio-diesel and 25% Diesel

3.6 TEST FOR PROPERTIES:

S. No.	Name of the properties	ASTM Code	B0	B25	B50	B75	B100
1	Kinematic viscosity at 40°C in cSt	D2217	2.6	3.42	5.70	6.60	51.9
2	Gross calorific value in kJ/kg	D4809	45596	43976	43268	42523	41819
3	Flash Point in °C	-	65	76	96	117	211
4	Fire Point in °C	-	70	81	101	122	223
5	Cloud Point in °C	-	-15	4	8	11	13
6	Specific gravity	D445	0.82	0.8416	0.854	0.8702	0.9167
7	Acidity	-	0.065	0.041	0.057	0.073	0.47
8	Cetane number	-	46	51.8	51.6	51.3	50.2

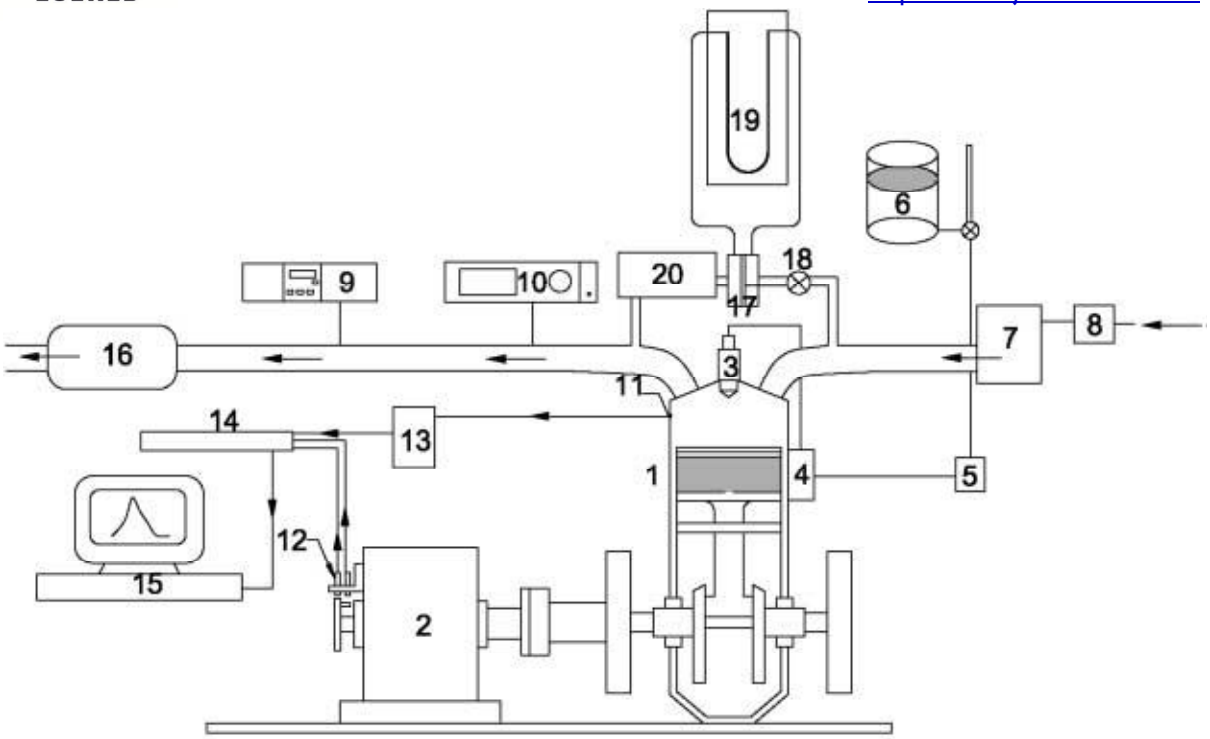
Table 2. Properties of Radish Seed oil biodiesel and its Diesel Blends

3.7EXHAUST GAS RECIRCULATION

Exhaust gas recirculation is used for controlling the NOx emissions.EGR is an effective technique of reducing NOx emissions from the diesel engine exhaust. EGR involves replacement of oxygen and nitrogen of fresh air entering in the combustion chamber with the carbon dioxide and water vapor from the engine exhaust. The recirculation of part of exhaust gases into the engine intake air increases the specific heat capacity of the mixture and reduces the oxygen concentration of the intake mixture. These two factors combined lead to significant reduction in NOx emissions. EGR (%) is defined as the mass percentage of the recirculated exhaust (MEGR) in total intake mixture (Mi).
Here in which we have to take the values with E.G.R and without E.G.R.

3.7.1 Experimental Setup

A 5.2kW four-stroke single cylinder, direct injection, water cooled, constant speed (1500 rpm),vertical cylinder, direct-injection Kirloskar TV-1 diesel engine was used in the test. The compressionratio, injection pressure and timing of test engine are 17.5, 220 bar and 23before top deadcentre (bTDC), respectively, for diesel. The injection timing for EOF and diesel blends operation was optimized and it was 25◦ bTDC. The experimental set-up is shown in Figure 1. AnAVL 3057charge amplifier converts the charge yield by the piezo-electric transducer into the proportionalelectric signals. A personal computer was interfaced with an AVL 619 indimeter hardware and medium – software version 2.2 data acquisition system to collect combustion parameter data such as heat release rate (HRR), incylinder pressure and cyclic variations. The engine speed was measured by inbuilt magnetic pick-up sensor connected to a frequency meter.AnAVL 444 Di gas analyzer was used to measure the oxides of nitrogen (NO*x*), CO and HC emissions. The smoke intensity was measured by anAVL 413 smoke meter. The exhaust gas temperature was measured with a k-type thermocouple. For exhaust gas, recirculation piping was done. The engine setup with EGR is shown in Figure 1. The amount of EGR was regulated through a control valve which is installed in the EGR loop. The amount of exhaust gas flow can be measured using orifice. An air box and diaphragm were installed before the orifice which is used to absorb the fluctuations of recirculatedexhaust.The experiments were conducted on diesel engine for various EGR rates and it is found that at 15% EGR gives maximum NOxreduction without much adverse effect on BSFC and brake thermal efficiency (BTE) (Pradeep and Sharma 2007).



1. Kirloskar TV1 Engine
2. Eddy current dynamometer
3. Injector
4. Fuel pump
5. Fuel filter
6. Fuel tank
7. Air stabilizing tank
8. Air filter
9. AVL smoke meter
10. AVL Di-gas analyser
11. Pressure transducer
12. TDC Encoder
13. Charge amplifier
14. Indimeter
15. Monitor
16. Exhaust silencer
17. EGR Orifice meter
18. EGR flow control valve
19. EGR Manometer
20. EGR stabilizing tank

Fig.8 Experimental setup

The eucalyptus oil was mixed with diesel fuel in volume basis with various concentrations ranging from 10% to 50%. And this biofuel blend was used as a fuel for conducting the experiments. In this work, the engine was run with the diesel fuel and no EGR to generate baseline data and then run with EOF blends with EGR.The data for the HC, NO*x*, CO, smoke and fuel consumption were collected. Then the engine performance, combustion and emission pattern were compared. The engine was started on neat diesel fuel and warmed up at every stage and the cold water temperature maintained at 70◦C.The optimized injection timing by the supplier (23◦ bTDC) was used for diesel fuel, and for EOF and diesel blends, the injection timing was optimized by conducting test and it was 25◦ bTDC.The test was repeated three times and each test was done for 3 h. Then the average value of three readings was taken for the calculation

3.7.2.Engine specification

SL.NO	SPECIFICATION	RATING
1	Make	Kirloskar
2	Model	TAF 1
3	Type	Direct injection,air cooled
4	Bore X Stroke (mm)	87.5 X 110
5	Compression ratio	17.5 :1
6	Cubic capacity	0.611 L
7	Rated power	4.4 kw
8	Rated speed	1500 rpm
9	Start of injection	23.4^0bTDC

Table 3 Engine specification

RESULTS AND DISCUSSIONS

4.1EGR ANALYSIS

Here we compare performance, emission and combustion characteristics engine using various EGR levels

4.1.1 PERFORMANCE&EMISSION CHARACTERISTICS

The experiment investigation is carried out by using CI engine. The engine test was conducted with five different EGR levels. They are EGR-25%,EGR-50%, EGR-75%,EGR-100%&base EGR. The optimum condition for diesel fuel operation is 23 BTDC injection timing ,205 bar injection pressure and 17.5 compression ratio. However all the test s using different EGR levels are conducted under same engine settings. The performance parameters like brake thermal efficiency, break power, specific fuel consumption etc and emission parameters like smoke and carbon monoxide were determined and analyzed.

- **FUEL CONSUMPTION**

FIG 6 shows that the graph between fuel consumption and brake power at various EGR level. From this we get clear view that fuel consumption increases with increase in brake power . At 25% EGR level we get minimum fuel consumption and at 100% EGR level we get a maximum fuel consumption compared with other EGR levels . The fuel consumption of base EGR is more than25% EGR , from this we can conclude that the low EGR level gives less fuel consumption.

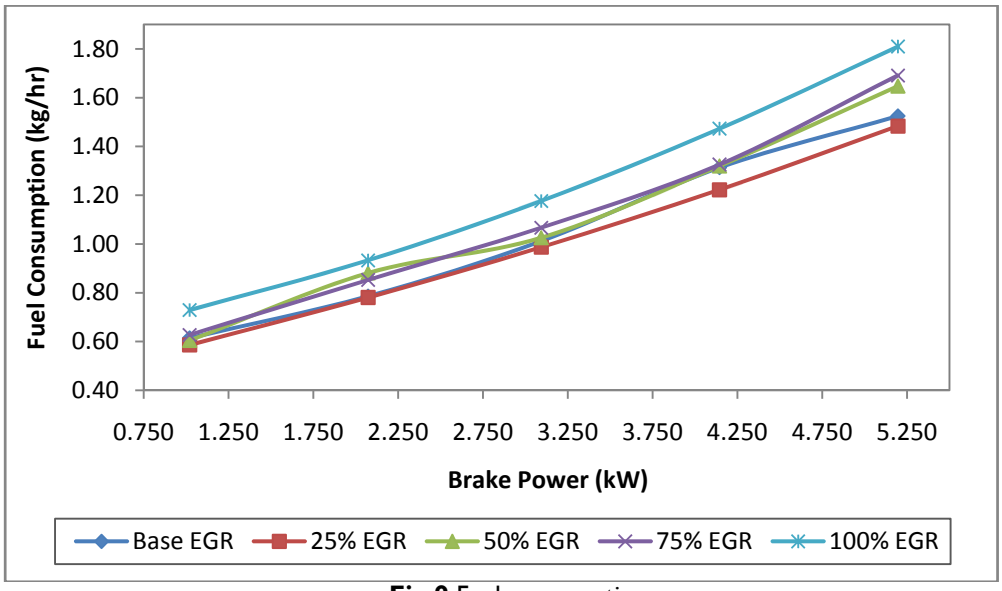


Fig.9 Fuel consumption

- **SPECIFIC FUEL CONSUMPTION**

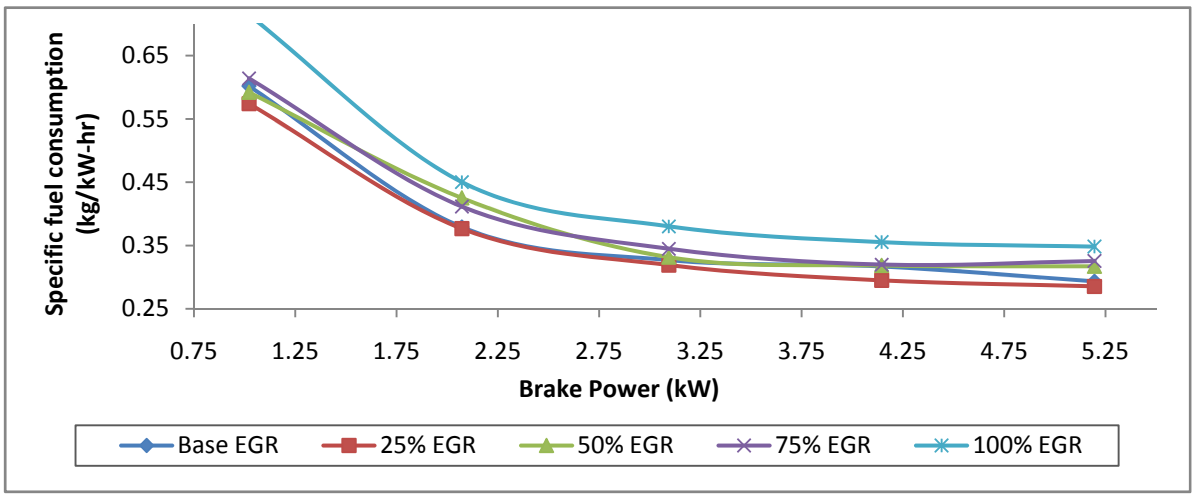


Fig. 10specific fuel consumption

EGR LEVEL

Fig10 shows that graph between specific fuel consumption and brake power at various EGR level .From this graph, it is clear that specific fuel consumption decreases with increase in brake power , 25% EGR gives minimum specific fuel consumption & 100% EGR gives maximum. Compared with other EGR levels base EGR is specific fuel consumption of base EGR is more than 25% EGR , from this we can conclude that the low EGR level gives less specific fuel consumption.

- **BRAKE THERMAL EFFICIENCY**

Fig. 11 shows that relationship between brake thermal efficiency and brake power .From this graph it is clear that brake thermal efficiency increase with increase in brake power .25% EGR gives maximum brake thermal efficiency .100% EGR gives minimum break thermal efficiency compared with other EGR levels , From this we can conclude that minimum EGR gives maximum brake thermal efficiency**.**

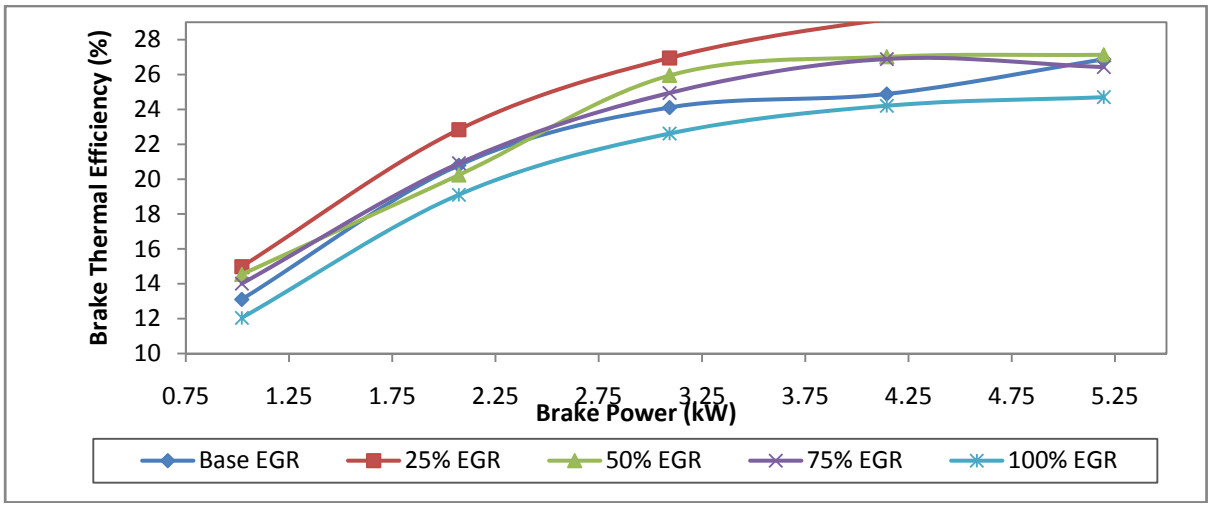


Fig. 11 Brake thermal efficiency

- **EXHAUST GAS TEMPERATURE**

Fig.12 shows that relation between exhaust gas temperature and brake power. Here exhaust gas temperature increases with increase in brake power 100% EGR gives maximum exhaust gas and 25% gives minimum compared with other EGR levels. From this grap it is clear that 25% EGR is more applicable.

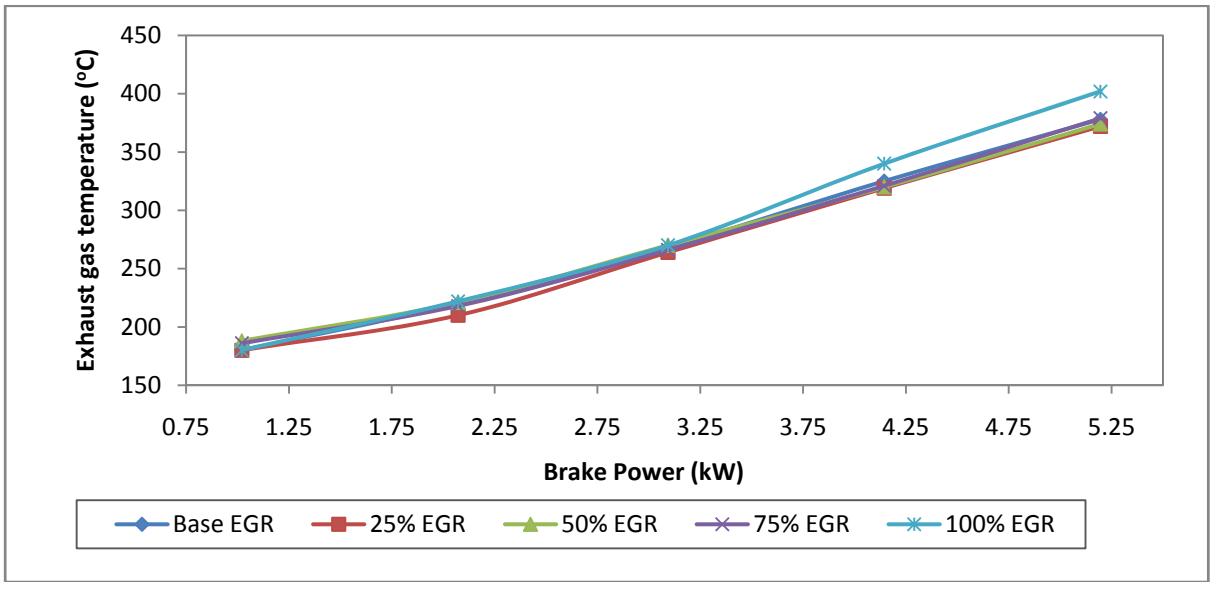


Fig.12 Exhaust gas temperature

- **SMOKE DENSITY**

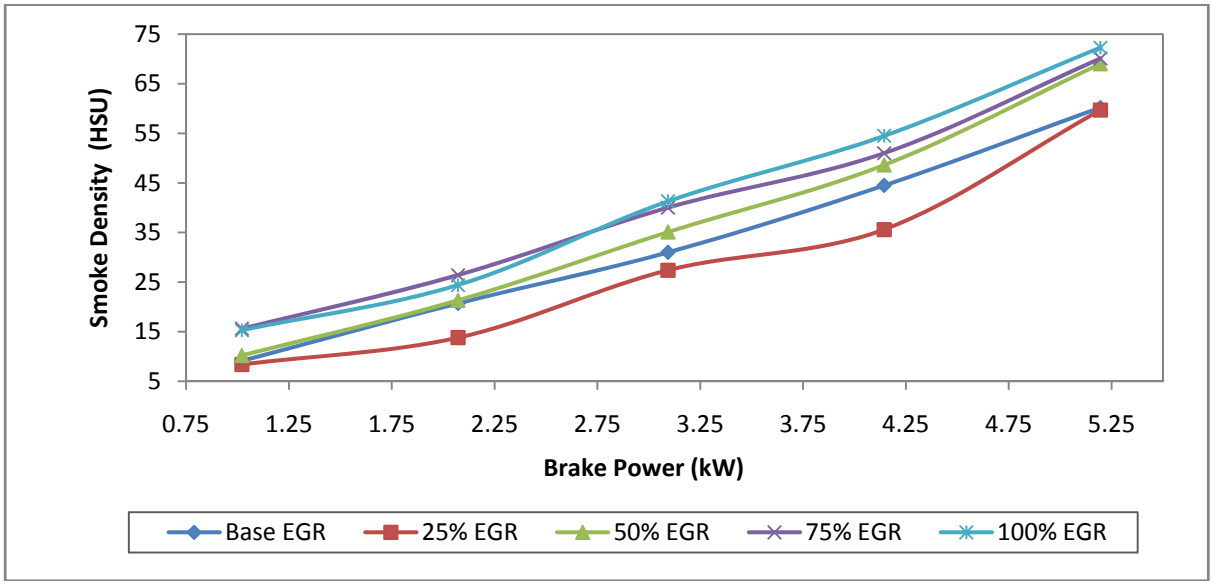


Fig.13 Smoke density

Fig. 13 gives relation between smoke density and brake power with various EGR levels, here smoke density increases with brake power. 100% EGR gives maximum smoke density&25% gives minimum amount of smoke density. Base EGR emits more smoke density than 25% EGR level. Smoke density should be decrease with increase in brake power ,therefore 25%EGR is more applicable.

- **EMISSION OF OXIDES OF NITROGEN**

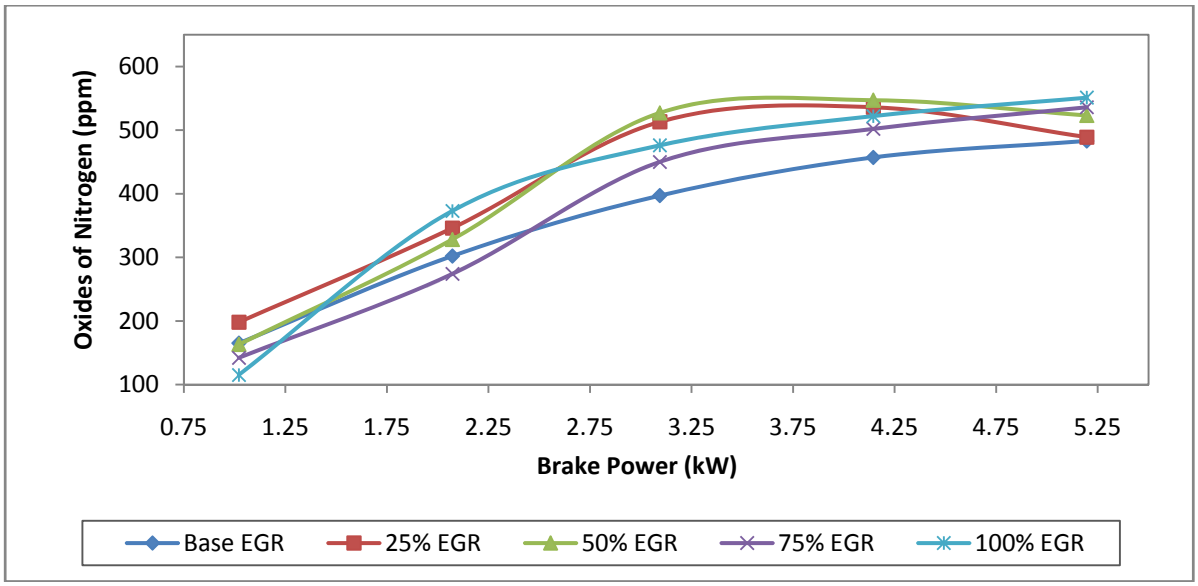


Fig.14 Emission of oxides of nitrogen

Fig.14 gives relation between oxides of nitrogen with brake power. Here emission of oxides of nitrogen increases with brake power. 100% EGR gives maximum emission of NOx and 25% EGR & base EGR gives minimum emission of NOx compared with other EGR levels .The emission of NOx should be decrease with increase in brake power, so it is clear that 25% EGR is more applicable.

- **EMISSION OF CARBON MONOXIDE**

Fig.15 shows relation between emission of CO with brake power. Here emission of CO increases with brake power.100% EGR gives maximum emission of CO & 25% EGR gives minimum emission of CO compared with other EGR levels .The emission of CO should be decrease with increase in brake power, therefore 25% EGR is more applicable.

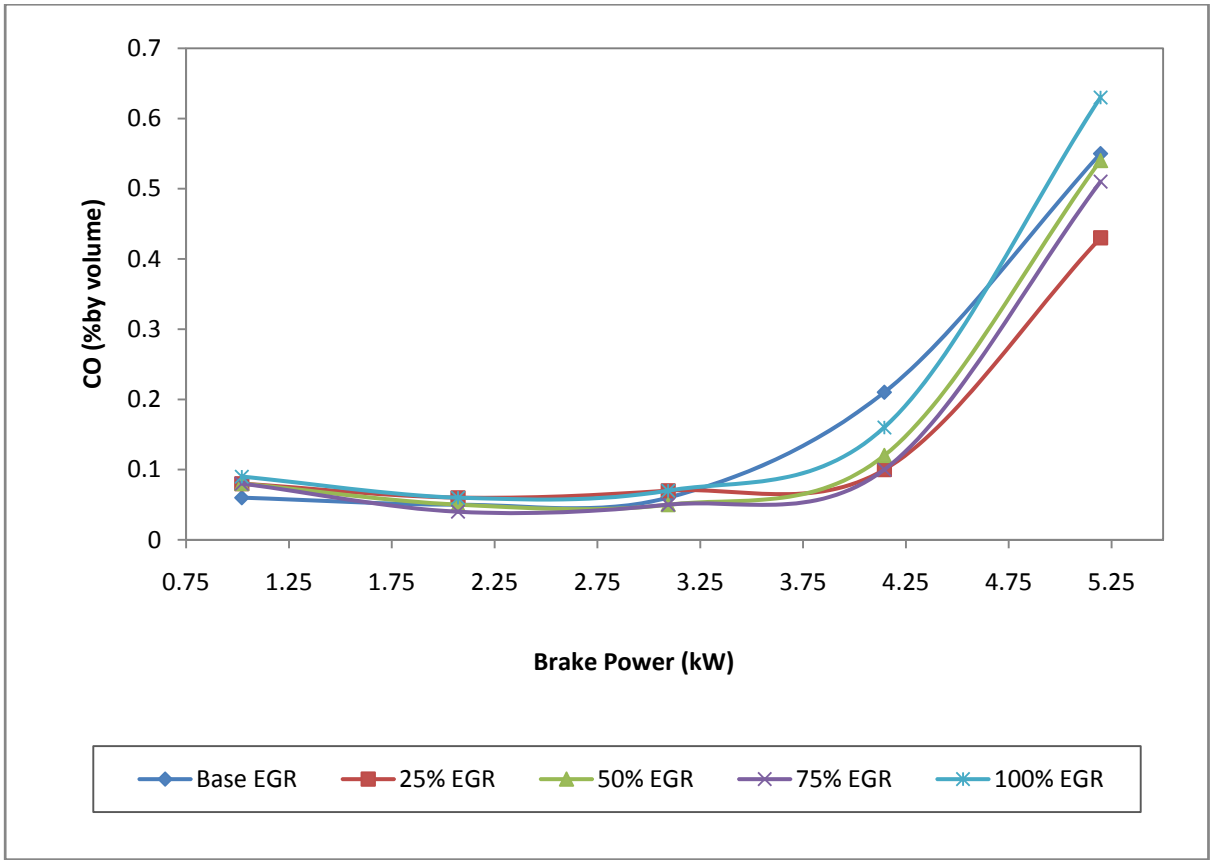


Fig. 15 Emission of carbon monoxide

Fig.15 shows relation between emission of CO with brake power. Here emission of CO increases with brake power.100% EGR gives maximum emission of CO & 25% EGR gives minimum emission of CO compared with other EGR levels. The emission of CO should be decrease with increase in brake power, therefore 25% EGR is more applicable.

- **EMISSION OF HYDRO CARBON**

Fig.16 gives relation between emission of hydro carbons with brake power. Here emission of HC increase with brake power , 100% EGR gives maximum emission of HC and 25% of EGR gives minimum emission of HC compared with other EGR levels. The emission of HC should be decrease with increase in brake power therefore 25% EGR is more applicable.

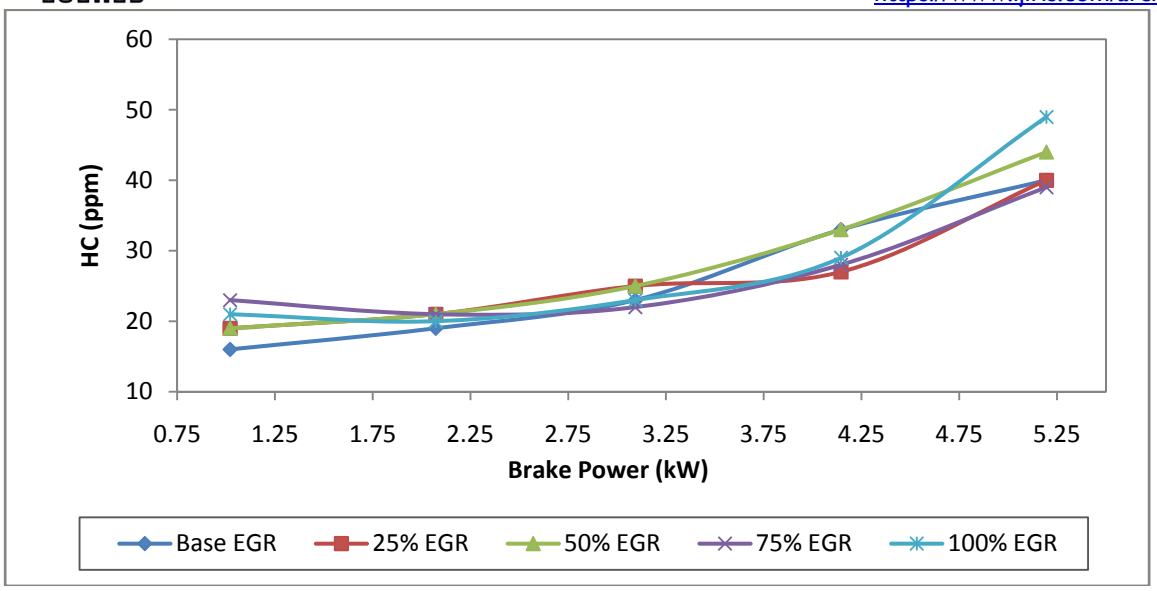


Fig.16 Emissionofhydrocarbon

- **EMISSION OF CARBON DIOXIDE**

Fig.17 gives relation between emission of Carbon dioxide with Brake power. Here emission CO2 increase with brake power.100% EGR gives maximum emission of CO2 and minimum emission of CO2 at 75% EGR compared with other EGR levels. Emission of CO2 should be decreases with increase in brake power, therefore 75% EGR is applicable.

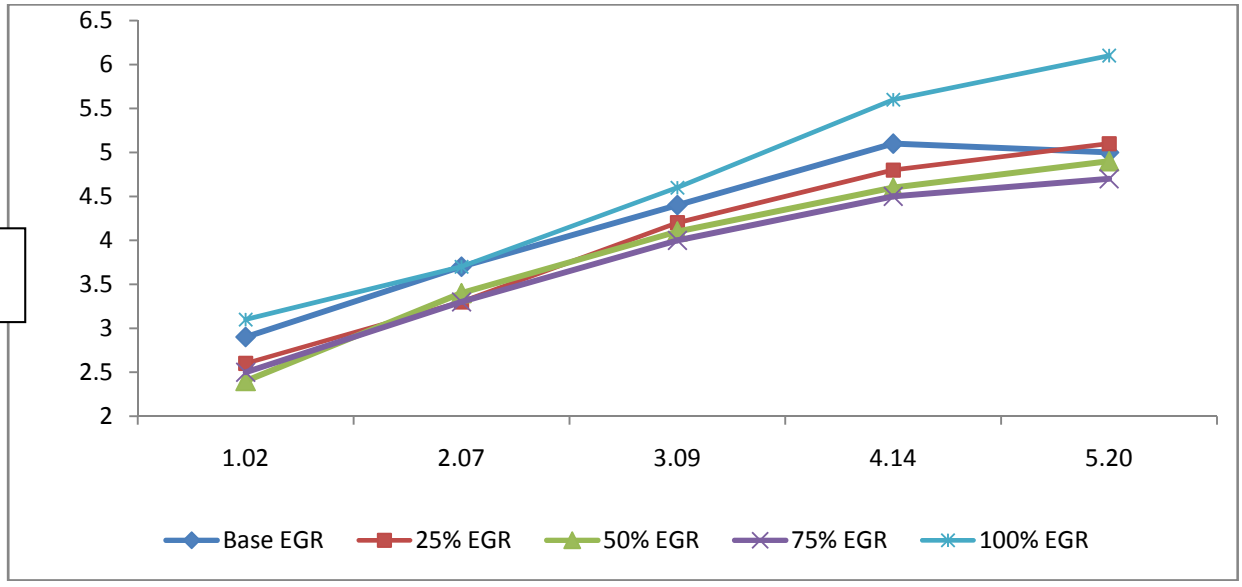


Fig.17 Emissionofcarbondioxide

- **EMISSION OF OXYGEN(% BY VOLUME)**

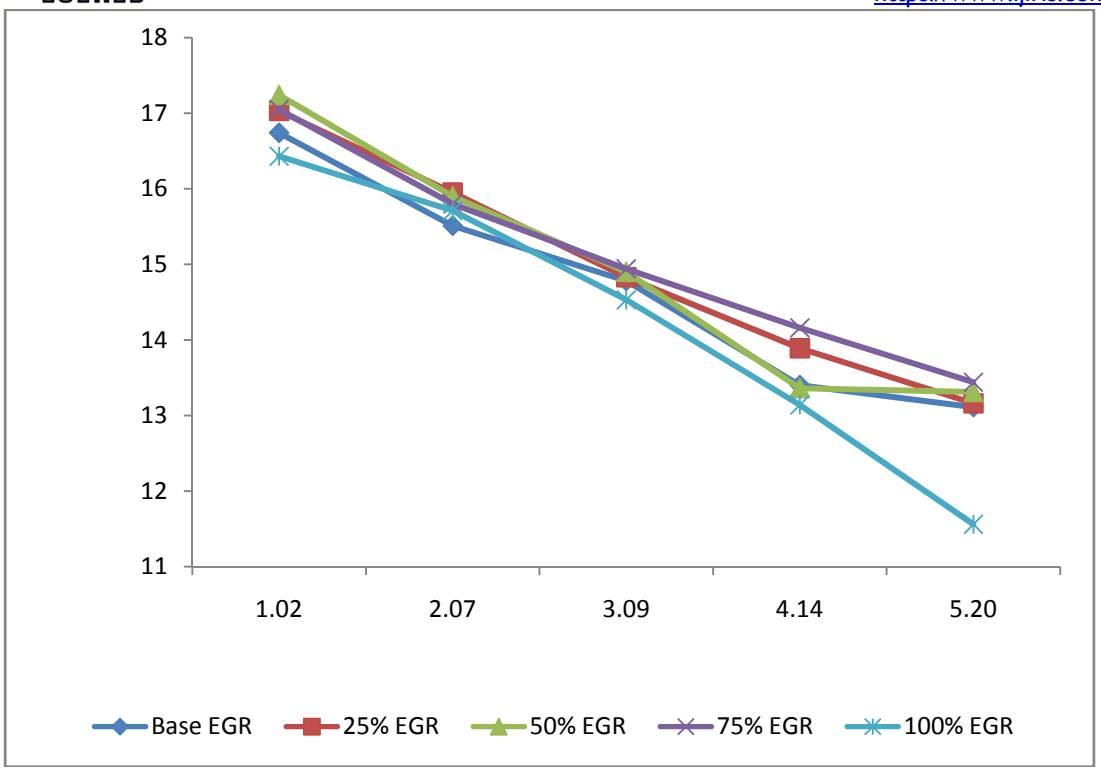


Fig.18 Emission of oxygen(% by value)

Fig.18 shows that relation between emission of oxygen with brake power, Here emission of O_2 decreases with increases in brake power. 100% EGR gives minimum emission of O_2 and maximum emission of O_2 gives 25% EGR compare with other EGR levels. Emission of O_2 should be increases with increase in brake power, therefore 25% EGR is applicable.

4.1.2COMBUSTION CHARACTRESTICS

- **Heat release rate**

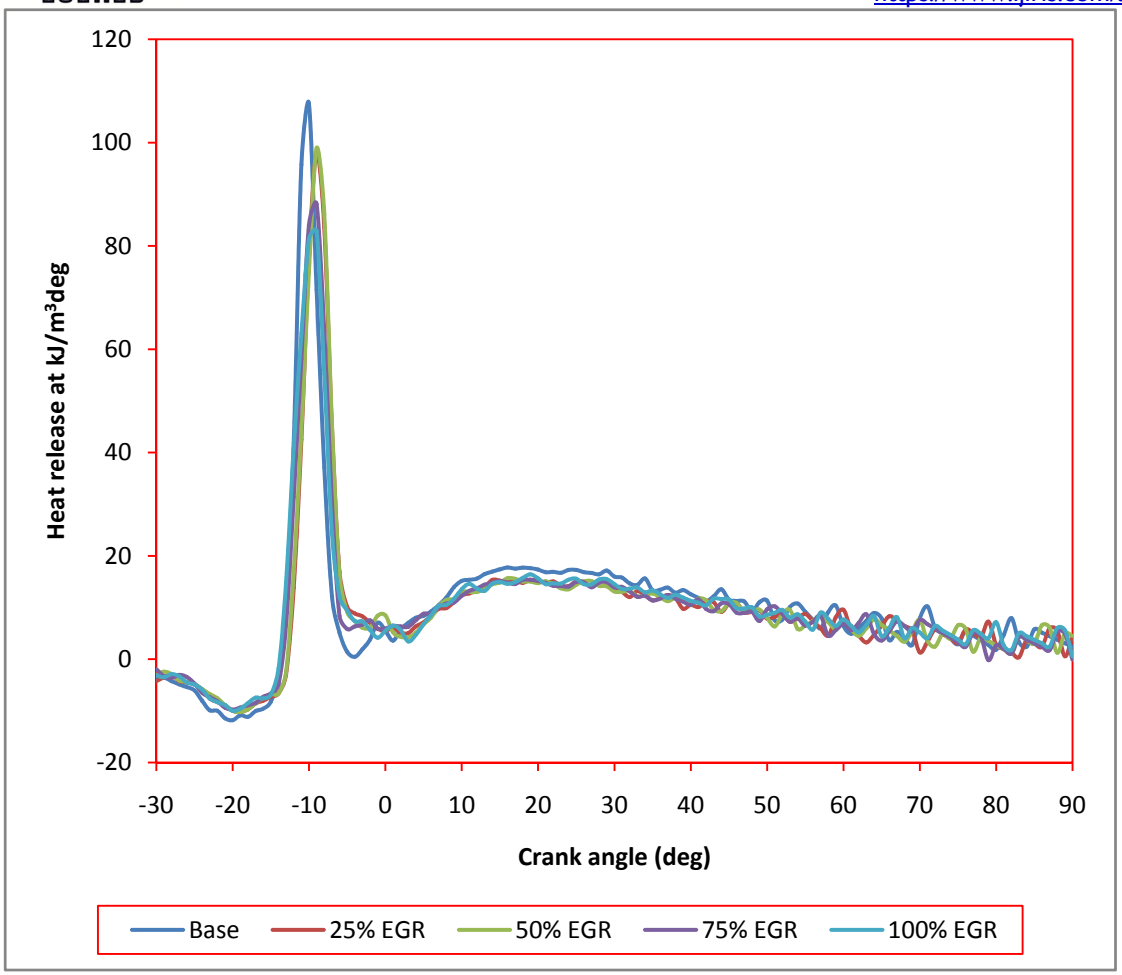


Fig.19 Heat release rate

Fig.19 shows that ,relation between heat release and crank angle .Intially heat release rate decreases at certain point ,then increases then gradually decreases and remains constant in increase with crank angle.100% gives minimum and 25% gives maximum heat release rate compare to other EGR levels. The heat release rate should be increase with crank angle therefore 25% EGR more applicable .

- **Cylinder pressure**

Fig. 20 shows relation between cylinder pressure and crankangle.I ntially cylinder pressure and gradually decreases with increase in crank angle . Here at zero degree base EGR gives maximum cylinder pressure , but at maximum crank angle all the EGR levels produces same cylindrical pressure. Therefore 25% more applicable.

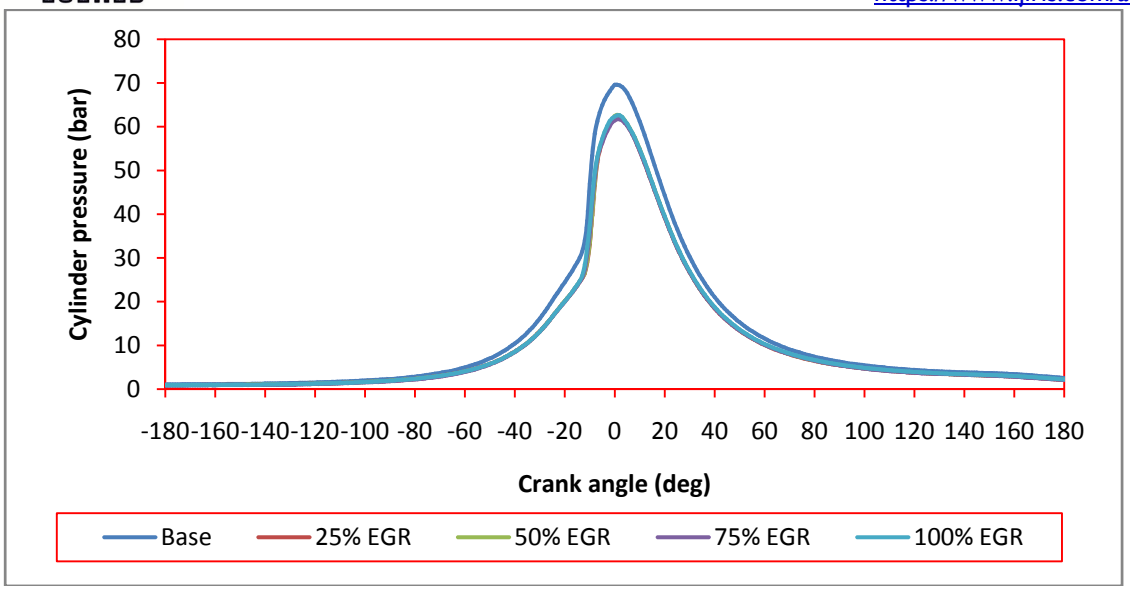


Fig.20 Cylinderpressure

- **Maximum cylinder pressure**

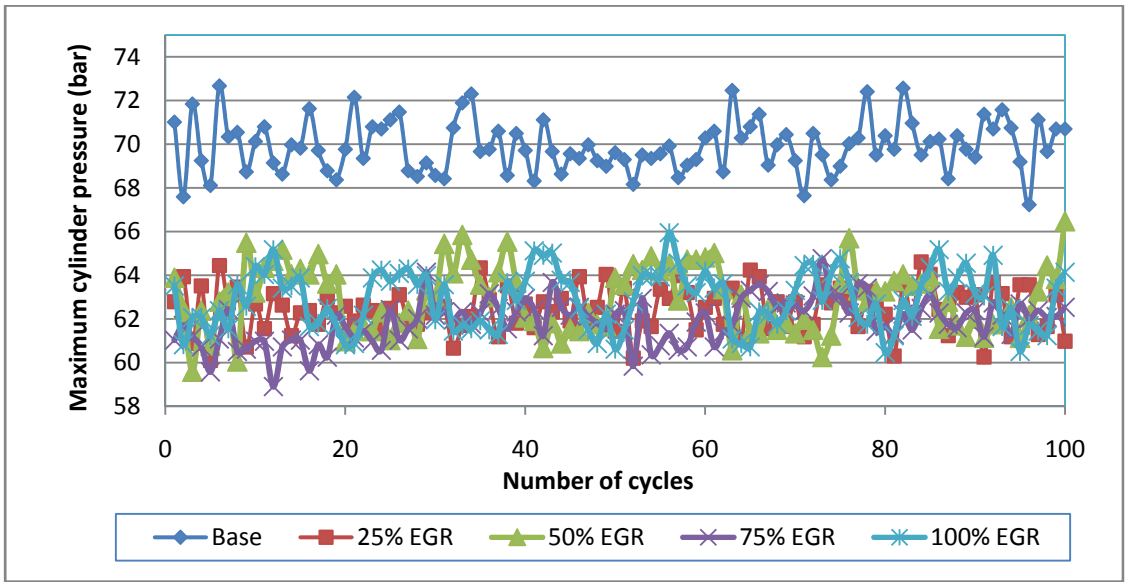


Fig.21 Maximum cylinder pressure

Fig.21 gives relation between maximum cylindrical pressure and number of cycles. Here base EGR gives maximum cylindrical pressure, but on the base of EGR levels 25% EGR gives maximum cylindrical pressure. Therfore 25% EGR is more applicable.

CHAPTER 5
CONCLUSIONS

The effect of EGR rates along with biodiesel fuel on performance parameters and exhaust emission were investigated. The main conclusion are summarized as follow

- 25% EGR is most applicable to run the engine.
- Smoke opacity, HC emissions increases with increase in EGR rates
- NOx emission decreases with increasing EGR rates

- Brake thermal efficiency increases at low EGR rates at low load and then decrease with increase in EGR rates at higher load
- The advantages of using EGR in solving the problem to reduce the amount of nitrogen oxide in exhaust gas emission and its effects to the performance and emissions of the diesel engine.

CHAPTER 6

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