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PERFORMANCE AND EMISSIONS OF THE PONGAMIA BIO DIESEL WITH AN ADDITIVE OF TERT-BUTANOL ON THE DIESEL ENGINE

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***Abstract*:**Diesel engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long-term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Because of the depletion of fossil fuels and the pollution that comes with them, the usage of biodiesel in the automobile industry has expanded significantly in recent years. Biodiesel has a larger beneficial influence on greenhouse gas emissions and has a modest energy content that is generated locally. In this area, you should look into it deeper. Rice bran, rapeseed, pal, canola, and other commonly used cooking oils are the main sources of biodiesels. In the present research, the Pongamia biodiesel, one of the alternative fuels can be the best choice for engine especially when blended with diesel and Tert-butanol as an additive. When compared to clean diesel (D), most previous research suggest that using bio-diesel produces less carbon monoxide, particulate matter, and hydrocarbons. The sole disadvantage is an increase in NOx emissions. It rises when the biodiesel-to-diesel blend ratio rises, and it rises even higher for plain biodiesel (D100).The goal of this study is to minimize NOx emissions by using Pongamia oil biodiesel produced using a transesterification method. The experiments are carried out for both neat diesel (D), biodiesel of Pongamia oil biodiesel and butanol as an additive. It is used to various percentages such as 5% and 10% on biodiesel blends.

Keywords: **Diesel, Biodiesel, Pongamia oil bio-diesel, Butanol**

I. INTRODUCTION

Many vegetable oils can be used in diesel engines, including peanut oil, linseed oil, rapeseed oil, and sunflower oil. Vegetable oil has numerous advantages, including sustainability, reduced greenhouse gas emissions, regional development, and agricultural improvement. When vegetable oils are burned, their chemical composition helps to reduce the emission of unwanted components. According to Murayama et al., vegetable oil fuels produced acceptable engine performance and exhaust gas emission levels for shortterm operation only but caused carbon deposit build-up and piston ring sticking after extended operation. Diesel fuels have a crucial purpose in the industries for an emerging state and utilized for transporting manufacturing and farming goods, operation of tractor and pump in farming sector. Unlike rest of world, India's claim for diesel is approximately '6' times larger than gasoline henceforth searching for substitute to diesel is an expected choice. Esters from vegetable oils are the best substitutes for diesel because they do not claim any alteration in the engine. When vegetable oils are burned, their chemical composition helps to reduce the emission of unwanted components. According to Murayama et al., vegetable oil fuels produced acceptable engine performance and exhaust gas emission levels for shortterm operation only but caused carbon deposit build-up and piston ring sticking after extended operation. They also proposed practical solutions to address these issues, such as raising the fuel temperature to 2200 degrees Celsius, blending 25% diesel fuel into vegetable oil, and blending 20% eth oils. The blending method improves the use of vegetable oil fuel while requiring minimal fuel processing and engine modification. The increasing fuel demand and pollution caused by automobile and industrial emission have made biodiesel to be considered as a major substitute for petro-diesel. Most of the energy desires are delivered by the petrochemical resources, coal and natural gases and at these existing usage rates it will be exhausted soon. Many vegetable oils can be used in diesel engines, including peanut oil, linseed oil, rapeseed oil, and sunflower oil. Vegetable oil has numerous advantages, including sustainability, reduced greenhouse gas emissions, regional development, and agricultural improvement.

II. BIOFUELS :A bio fuel is a source of fuel made from living organisms, most commonly plants or plant-derived materials. Due to their potential to reduce numerous environmental stresses caused by fossil fuel use, liquid bio fuels are increasingly being considered alternatives to gasoline and diesel fuel as energy sources.

- Biodiesel is an alternative fuel made from vegetable oil or animal fat that is designed specifically for diesel engines.
- Biodiesel is an environmentally friendly, cleanburning, nontoxic, biodegradable fuel that can be used in any compression ignition engine (diesel engine).
- It's a non-petroleum-based fuel, meaning it's produced without the use of fossil fuels like oil or coal. This green fuel is made from renewable resources such as vegetable oils and fats. These oils and fats are converted into a fuel called transesterification, which can be blended with conventional petroleum-based diesel in any proportion or used directly in any diesel engine without any modifications.
- Biodiesel can be mixed with petroleum diesel in any percentage between 1 and 99, denoted by a number after a B. For example, PB10D90 contains 10% biodiesel and 85% petroleum, PB15D85 contains 30% biodiesel and 70% petroleum, and PB10D90 contains 100% biodiesel and no petroleum.

III. RENEWABLERESOURCES & NON-RENEWABLE SOURCES : Renewable sources: Natural resources, also known as renewable resources, are replaced in the natural environment by natural processes and forces. There are intermittent and reoccurring renewable and recyclable materials that are used for a specific amount of time during a cycle and can be used for an unlimited number of cycles. Non-renewable sources: A non-renewable source is a natural resource that cannot be reproduced, grown, generated, or consumed at a rate that can be sustained; once depleted, there will be no more available for future use. Resources that are depleted much faster than nature can replenish them are also considered non-renewable. the use of fossil fuels (such as coal, petroleum, and natural gas) Examples include nuclear waste and certain aquifers. Metal ores are an excellent example of a nonrenewable resource. Renewable resources, on the other hand, include timber (when harvested sustainably) and wind (when used to power energy conversion systems).

IV. LITERATURE SURVEY: It was found that the ratio of mixed oil is an important factor in terms of conversion and quality of biodiesel. It is also revealed that the application of the ML technique is essentially useful to optimize production efficiency. The utilization of mixed oils will overcome the issues related to the non-availability of feedstock's and reduce the overall cost with improved quality of biodiesel[1].The experimental results showed that increase in blends of rice bran biodiesel with diesel reduces the carbon monoxide and increases the carbon dioxide and hydrocarbon in emission[2].The results indicate that 20% biodiesel blend leads to a lower ignition delay at higher loads which in turn increases the rate of vaporization of the fuel as it has higher cetane number. Moreover, the HCs, COx and NOx emissions decrease as the load increases since the increase in fuel atomization promotes the combustion process and thereby decreases the amount of unburnt biodiesel components[3]. Based on the experimental investigation the blends of crude rice bran bio-diesel can be used as fuel in diesel engine without making any modification to the diesel engine[4]. The engine test results concluded that the lower blends of biodiesel increased the brake thermal efficiency and reduced the fuel consumption. From the results, it has been established that 20-40% biodiesel blends can be used as a substitute for diesel without any modifications in the engine. 30% coconut oil and 70% diesel (B30) gave the optimum results[5]. Coconut oil biodiesel is a mixture rich in medium chain saturated methyl esters that exhibits similar properties to diesel. It is mostly within the limits set by ASTM and EN standards for biodiesel. The higher calorific value is 17% lower than diesel [6]. The blend containing 20% rice bran oil biodiesel and 80% petro diesel fuel, both in volume, could be the most effective composition considering the technoeconomic aspects of diesel engines[7]. The brake thermal efficiency is improved marginally when the injection timing was advanced. Decreased smoke, NOx emissions and increased CO emissions were observed for dual fuel mode for all the fuel combinations compared to single fuel operation[8]. Based on various emission-related studies, Mofijur et al. [9] reported that hydrocarbons (HC), particulate matter (PM), carbon monoxide (CO) have decreased with biodiesel, whereas carbon dioxide (CO2) and NOx emissions got increased. Net CO2 emissions are expected to be lesser as it is absorbed during the crop growth, whereas NOx emissions can be reduced with technologies like exhaust gas recirculation [9]. The high efficiency and cost effectiveness of diesel engines have made them to be widely used in most internal combustion engines. Their efficiency is due to high compression ratio that creates heat and cause spontaneous ignition of fuel [10]. The incessant recognition of diminishing petroleum fuel reserves and possibility of using readily available low cost non-edible plant and waste-oils as sources of environment-friendly renewable substitutes have created a lot of interest in biodiesel research [11]. Biodiesel consists of alkyl esters of fatty acids and can be easily prepared from animal fats, plant or vegetable seed and restaurant waste oils [12-13]. Base catalysed transesterification reactions employing sodium hydroxide (NaOH) or potassium hydroxide (KOH) which are extensively used in commercial production of biodiesel are pretty fast but are sensitive to presence of water and free fatty acids[14]. The most commonly employed biodiesel, fatty acid methyl esters are usually produced by trans-esterification of oils/fats with methanol in the existence of an alkaline substance [15-16]. The jatropha oil used here as a biofuel as a fuel in CI engine and the trans-esterified oil was compared with diesel. The trans-esterified jatropha oil is blended with diesel by proportion of B25 and B25 blend shows almost same fuel consumption, higher mechanical efficiency, higher indicated thermal efficiency and higher brake thermal efficiency by load variations than that of conventional diesel[17]. It is clearly seen that biodiesel blend has very low CO and CO 2 emission percentage than diesel. HC emission of B25 is also found to be less in biodiesel than diesel. NOx and O2 content present in exhaust emission is also less than the conventional diesel [18]. Continuous acceleration in demand of energy made to replace conventional fuels with seasonal alternative fuel s which can fulfill part of energy need [19]. Varieties of Biodiesels have promised the same but mean while NOx emissions are higher atmost of the cases [20].Blends of biofuels viz. Jatropha biodiesel and turpentine oil have shown lower emissions and lower brake thermal efficiency compared to diesel [21].

Ⅴ. FUELS : Performance, emission and combustion characteristics of diesel engine operating with pure diesel(D100) and blends of Jatropa oil biodiesel PB10D90, PB15D85 biodiesel at 50% and 100% load conditions are to be evaluated and compared with the results at variable injection pressures of 220bar and 240bar and at an injection timing of 23°bTDC.

DIESEL**:**Diesel fuel is a mixture of hydrocarbons—with boiling points in the range of 150 to 380°C—which are obtained from petroleum. Petroleum crude oils are composed of hydrocarbons of three major classes: (1) paraffinic, (2) naphthenic (or cycloparaffinic), and (3) aromatic hydrocarbons. Unsaturated hydrocarbons (olefins) rarely occur in the crude. It should be noted that the terms 'paraffinic' and 'naphthenic' sound obsolescent; we use them because they are still common in the petrochemical industry.

PONGAMIA OIL BIODIESEL : The calculated density of the Pongamia biofuel is 860-900 kg/m3 and the diesel density varies from 836-850 kg/m3.It shows that it approximately reaches the specified limit of ASTM standard. The calculated viscosity of the Pongamia biofuel is 4.2 cst at 30°C and it is also in the specified range of the ASTM. Also its viscosity is very similar to diesel which varies from 2.2 cst. Flash point of the Pongamia biofuel is 168°C and this obeys the ASTM standard of minimum of 93°C and for diesel it is about 80°C. The increase in flash point of the fuel causes start ignition delay of engine which tends to increase NO x emission. The tested calorific value of the Pongamia biofuel is found to be 39,000kJ/kg, which is very much similar to that of diesel which is 42,000kJ/kg. This little decrease in the calorific value of the biofuel tends to increase the specific fuel consumption by a tiny margin. The cetane number of the biofuel is found to be 49 meeting the ASTM standards and also very close to the value of diesel which varies from 51 to 60. Pongamia oil is processed into biodiesel and it will be used as per the blend ratio of PB10D90 and PB15D85 namely. PB10D90 means 15% of biodiesel addition with remaining percentage volume of diesel, and similarly PB15D85 means 30% of biodiesel addition with remaining percentage volume of diesel and using these fuels at different operating conditions and these results are to be compared with performance, emission and combustion of engine fueled with diesel D100.**TERT BUTONAL:**Tert-Butyl alcohol is derived commercially from isobutane as a coproduct of propylene oxide production. It can also be produced by the catalytic hydration of isobutylene, or by a Grignard reaction between acetone and methyl magnesium chloride. tert-Butyl Alcohol is a colorless liquid or crystalline solid with a mothball-like odor. Tert-Butanol possessing higher alcohols have higher cetane number and lower latent heat of vaporization than the ethanol such as lower alcohols. Therefore butanol suggested to be very reassuring alternate fuels to diesel engine due to their safety measurement and have lower viscosity and produce of lower exhaust emissions diesel fuel. However, Tert-Butanol is less vulnerable to water and it is less corrosive than Ethanol and can be transported through fuel supply pipeline. Tert-butanol is a tertiary alcohol alcohol that is isobutane substituted by a hydroxy group at position 2. It has a role as a human xenobiotic metabolite. It derives from a hydride of an isobutane. tert-Butyl alcohol is the simplest tertiary alcohol. Purification cannot be performed by simple distillation due to formation of an azeotrope with water, although initial drying of the solvent containing large amounts of water is performed by adding benzene to form a tertiary azeotrope and distilling off the water. Smaller amounts of water are removed by drying with calcium oxide (CaO), potassium carbonate (K2CO3), calcium sulfate (CaSO4), or magnesium sulfate (MgSO4), followed by fractional distillation. Anhydrous tert-butyl alcohol is obtained by further refluxing and distilling from magnesium activated with iodine, or alkali metals such as sodium or potassium. Other methods include the use of 4 Å molecular sieves, aluminium tert-butylate, calcium hydride (CaH2), or fractional crystallization under inert atmosphere. Tert-Butyl alcohol is derived commercially from isobutane as a coproduct of propylene oxide production. It can also be produced by the catalytic hydration of isobutylene, or by a Grignard reaction between acetone and methylmagnesium chloride. TertButyl Alcohol is a colorless liquid or crystalline solid with a mothball-like odor Tert-Butanol possessing higher alcohols have higher cetane number and lower latent heat of vaporization than the ethanol such as lower alcohols. Therefore butanol suggested to be very reassuring alternate fuels to diesel engine due to their safety measurement and have lower viscosity and produce of lower exhaust emissions diesel fuel. however, TertButanol is less vulnerable to water and it is less corrosive than Ethanol and can be transported through fuel supply pipeline. Properties of tert-butonal: Chemical formula: C4H10O Boiling temperature: 82˚C Density: 0.775g/ml Molar mass: 74.123 g/mol Melting point: 25to26o Figure 1 crystal structure

METHONAL: Methanol and ethanol are the most often used alcohols in biodiesel production. Methanol is particularly preferred because of its physical and chemical advantages. Beside its reaction with triglycerides is quick and it can be easily dissolved in NaOH, KOH is usually simpler to find compared to ethanol. For biodiesel production via transesterification reaction, methanol is the most common alcohol used. However, the level of water in an alcohol is crucial for its successful application in the production of biodiesel. This is because the presence of water during transesterification reaction causes hydrolysis of triglycerides to free fatty acids which leads to soap formation, and poor yield.

- **Properties of methanol:** · Chemical formula: C4H10O Boiling temperature: 118˚C Density:810 kg/m3 Molar mass:74.121 g/mol Melting point:-89.8o c

CATALYSTS : The catalysts employed in triglyceride transesterification can be classed as basic. Sodium hydroxide (NaOH), potassium hydroxide (KOH), carbonates, and their equivalent alcoxides are all basic catalysts (for instance, sodium methoxide or ethoxide).Enzymes, titanium silicates, alkaline earth metal compounds, anion exchange resins, and guanidines in organic polymers have all been investigated as heterogeneous catalysts for biodiesel generation. Lipases are the most often utilised enzymes in the synthesis of biodiesel.The catalysts contain lipase enzymes. ·

- **Potassium hydroxide**: Potassium hydroxide, also known as lye is an inorganic compound with the chemical formula KOH Also commonly referred to as caustic potash. Sodium hydroxide is a caustic base and alkali that decomposes proteins at room temperature and can cause chemical burns. Figure 2 sodium hydroxide

Fig-1 : Sodium hydroxide

- **Glycerin:**Glycerin, often known as glycerol, glycerin, or glycol alcohol, is the common term for 1, 2, 3-propanetriol. It is a viscous liquid with high viscosity at room temperature, is odorless, clear, and colorless, has low toxicity, and has a pleasant flavor. Glycerin has a high boiling point of 290°C (563°K), and its viscosity increases significantly at low temperatures, down to its freezing point of 18°C (291 K). It's a polar chemical that mixes well with water and alcohol and also works well as a solvent. Glycerin is a humectants and hygroscopic substance. Glycerin was a result of candle making (from animal fat) until the later years of the nineteenth century, and it was primarily employed in the creation of nitroglycerin for explosives. Figure 3 glycerin

Fig2: Glycerin

- **Alcohol-catalyst mixing :**Before adding the oil, the alcohol used in biodiesel manufacturing must be combined with the catalyst. The catalyst is entirely dissolved in the alcohol after stirring the mixture. It is important to note that the alcohol must be free of water (anhydrous) for the reasons stated in the preceding paragraph. The most commonly used basic catalysts are sodium and potassium hydroxides. Sodium or potassium methoxides or methylates are commercially available for industrial manufacture. When working with methanol, hydroxides, and methoxides, regardless of the size of production, extreme caution must be maintained and all applicable safety requirements must be observed.

TRANSESTERIFICATION PROCESS : Biodiesel was prepared from the non-edible oil of Pongamia pinnata by transesterification of the crude-oil with methanol in the presence of NAOH as catalyst. Vegetable oils can be transesterified by heating them with a large excess of an hydrous methanol and an acidic or basic reagent as catalyst. Both the acid as well as alkaline esterifications were subsequently performed to get the final product. A catalyst is usually used to improve the reaction rate and yield. NaOH was found to be a better catalyst than KOH in terms of yield. In a transesterification reaction, a larger amount of methanol was used to shift the reaction equilibrium to the right side and produce more methyl esters as the proposed product. Several aspects including the type of catalyst (alkaline, acid, or enzyme), alcohol/vegetable oil molar ratio, temperature, purity of the reactants (mainly water content) and free fatty acid content have an influence on the course of the transesterification. A maximum conversion of 94% (oil to ester) was achieved using a 1: 10 molar ratio of oil to methanol at 60 to 65 degrees C important fuel properties of methyl esters of pongamia oil (biodiesel) compare well with ASTM standards. **Figure 4 Transesterification process** When catalyzed by an acid catalyst, this reaction proceeds via the conversion of the carbonyl group through the donation of a proton to it. On the other hand, base catalysts take a proton away from the alcohol group, resulting in the formation of a highly nucleophilic alkoxide ion. It can be noted that methyl & ethyl esters can be used to form esters with relatively large alkoxy groups via the process of transesterification. This is usually done by heating the ester (methyl or ethyl) with the acid/base catalyst and the alcohol having a large alkoxy group, and subsequently evaporating off the smaller alcohol in order to drive the equilibrium reaction in the required direction. Figure 5 Pongamia oil biodiesel processing Figure 6 diesel and pongamia oil biodiesel Nowadays, in CI (compression ignition) engines, biodiesel is the popular alternative fuel used. It can be used without further variations in the engine's present design due to its sulfur-free, biodegradable and nontoxic nature. In the current era, diesel engines are more commonly used in the transportation field when compared to gasoline engines due to their advantages like wider torque range, low maintenance cost, and high power. The concerns over global warming are closely tied to the rising need for energy. Direct injection (DI) diesel engines generally offer an improvement in efficiency over indirect injection (IDI) systems. Direct injection system of diesel engine (DI) provides low fuel consumption compared with divided-chamber combustion system (in other words indirect injection system) (IDI), because of undivided combustion chamber and no loss at the throat. Hence, DI system is the main stream for automobile diesel engine. On the other hand, DI system is subjected to severe trade-off between NOx and PM in exhaust emission and additionally creates more white or blue smoke compared with IDI system, which requires reduction of these harmful substances from the viewpoint of global environmental protection.

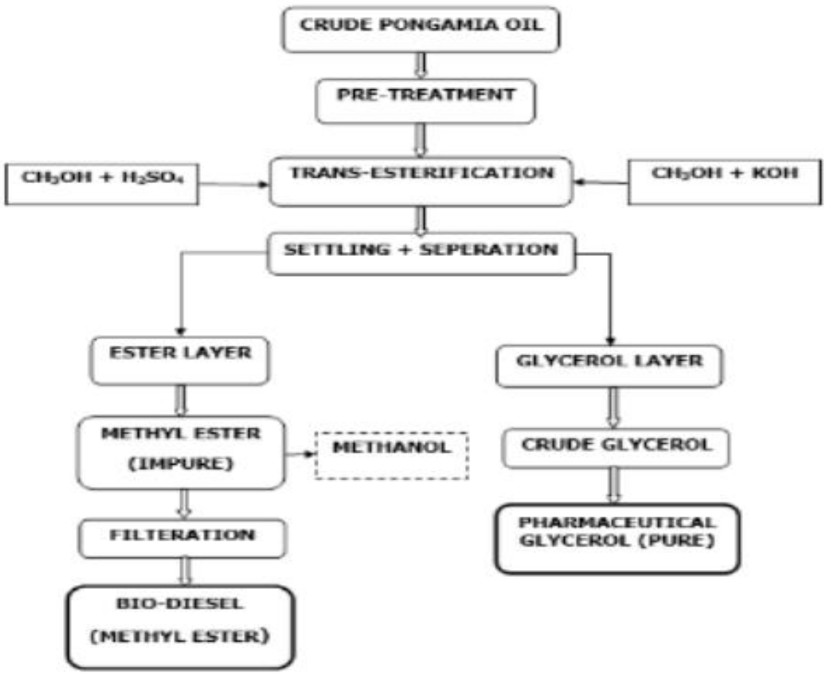

Fig3 : Transesterification process

INTERNAL COMBUSTION ENGINES

Heat Engines: - Heat engines are a device which transforms the chemical energy of a fuel into thermal energy and uses this energy to produce mechanical work. Heat engines are divided into two broad classes.

a) External combustion engines
b) Internal combustion engines.

In an external combustion engine the products of combustion of air and fuel transfer heat to a second fluid which is the working fluid of the cycle, as in the case of steam engine or a stem turbine plant where the heat of combustion is employed to generate steam which is used in the piston engine or turbine .Sterling engine is also an external combustion engine. In an internal combustion engine the product of the combustion is directly the motive fluid. Petrol, gas & diesel engines, Wankel engine, and open cycle gas turbine are example of internal combustion engine. Jet engine and rockets is also internal combustion engine. The main advantages of internal combustion engines over external combustion engines are greater mechanical simplicity, lower ratio of weight and bulk to output due to absence of auxiliary apparatus like boiler and condenser and hence lower first cost, higher overall efficiency, and lesser requirement of water for dissipation of energy through cooling system.

Fig4 :AVL smoke meter and experimental setup

VI.EXPERIMENTAL SETUP : The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank angle measurements. These signals are interfaced to computer through engine indicator for Pressure crank angle-PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. Figure 7 AVL smoke meter and experimental setup The set up has stand alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Figure 8 engine experimental setup and connection to computer Rota meters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Lab view based Engine Performance Analysis software package "Enginesoft" is provided for on line performance evaluation. While on line testing of the engine in RUN mode necessary signals are scanned, stored and presented in graph. Stored data file is accessed to view the data graphical and tabular formats. The results and graphs can be printed. The data in excel format can be used for further analysis. Figure 9 engine experimental setup line diagram

VII. UTILITIES REQUIRED ·

- Electric supply 230 +/- 10 VAC, 50 Hz, 1 phase
- Computer IBM compatible with standard configuration
- Water supply :

Continuous, clean and soft water supply @ 1000 LPH, at 10 m. head. Provide tap with 1" BSP size connection

BLENDS USED

In this analysis engine is operating at variable injection pressure 220 bar and 240bar, at an injection timing of tdc, at half load (50%) and full load (100%) conditions.

- D100- pure diesel
- PB10D90- mixture of 10 % Pongamia oil biodiesel and 80% Diesel of total 100% volume, 5 % Tert butanol
- PB15D85- mixture of 30% Pongamia oil biodiesel and 70% Diesel of total 100% volume, 5% Tert butanol

VIII.RESULTS AND CONCLUSION : Brake specific fuel consumption-Figure shows the variation in brake specific fuel consumption (BSFC) with increasing engine load for the various fuels D100, PB10D90, and PB15D85 at 220 bar & 240 bar injection pressure and at TDC injection timing at rated engine speed 1500 rpm for the various fuels D100, PB10D90, and PB15D85. With an increase in load, the specific fuel consumption for all fuels drops. Because of the lower heating value of the mix compared to diesel, increasing the percentage of Pongamia biofuel in the blend increases the specific fuel consumption. Figure 10 brake specific fuel consumption vs load

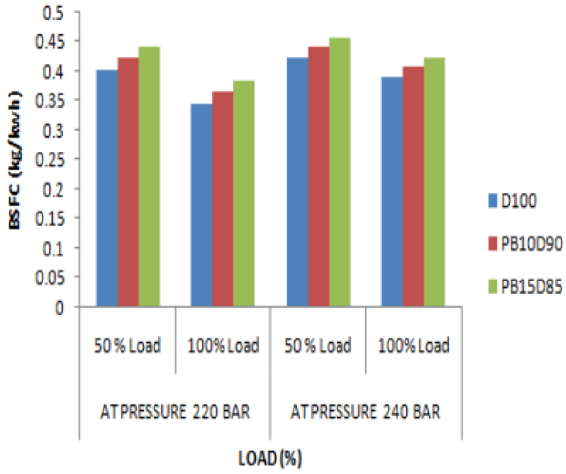

Fig5 : brake specific fuel consumption vs load

Ignition delay: Ignition delay is the time between the commencement of injection and the start of combustion in a diesel engine. Figure shows the change of ignition delay with load for diesel and Pongamia biodiesel mixes. The time between the commencement of injection and the start of combustion in a diesel engine is known as ignition delay. Figure shows the fluctuation of ignition delay with load for diesel, PME, and its blends. At all loads, it is noted that the ignition delay of PME and its blends is smaller than that of diesel, and that the ignition delay decreases as the percentage of PME in the blend increases.

Combustion duration: Figure shows the change of combustion duration with load for all of the test fuels. Because the bulk of fuel injected increases with the rise in load, the time of combustion for all fuels increases. When compared to diesel, the combustion period of PME and blended fuels is shorter. Figure 11 hydrocarbons vs load It means that putting PME in the fuel speeds up the combustion process and shortens the time it takes to burn. The reduction in combustion length is mostly due to the early start of combustion and the high oxygen content of PME, which causes a higher pressure and temperature rise in the combustion chamber, resulting in a speedier completion of the combustion process.

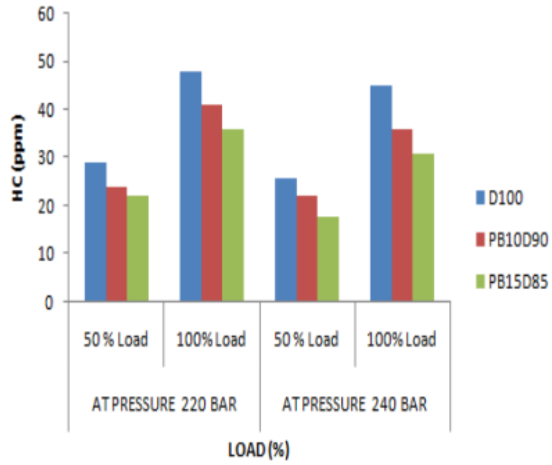

Fig6 : hydrocarbons vs load

Unburned hydrocarbon (UBHC) emissions: This graph depicts the variation in UBHC emissions for various test fuels as a function of load. As the load increases, there is an obvious increase in HC emissions for all fuels. The presence of fuel-rich mixes at greater loads may be the cause of this trend. Increasing the proportion of PME in the blend reduces UBHC emissions, according to research. This demonstrates that the presence of oxygen in PME, as well as the greater combustion temperature, increase hydrocarbon oxidation.

Carbon monoxide (CO) emissions: The graph shows that diesel oil emits more CO than PME and its blends. Because more fuel is pumped at increasing loads, CO emissions rise dramatically after 75 percent of the rated load due to incomplete combustion. Due to the presence of oxygen in biodiesel and its higher combustion temperature, CO emissions fall as the PME in the blends increases. Figure 12 oxides of nitrogen vs load

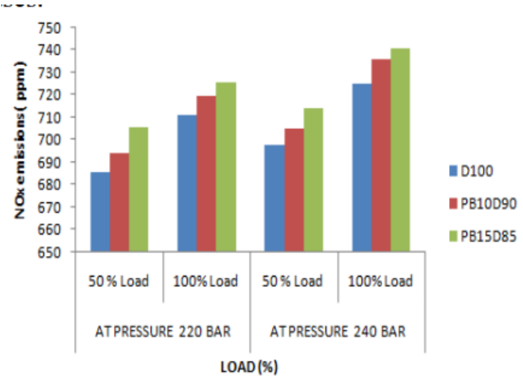

Fig7 : oxides of nitrogen vs load

Nitrogen oxide (NOx) emissions:A comparison of NOx emissions of diesel fuel with various PME blends at varying loads is shown in the figure. For all of the test fuels, NOx emissions increase as load increases. This is due to an increase in the amount of fuel consumed with load, which causes the combustion temperature to rise. It's also been discovered that as the amount of PME in the mix increases, so does the amount of NOx emissions. This increase could be attributable to the fact that PME is an oxygenated fuel, which allows for greater combustion and, as a result, a higher combustion temperature. The generation of NOx is aided by the increased temperature.

Exhaust gas temperature: The graph depicts the differences in exhaust gas temperature for various test fuels as a function of load. The temperature of the exhaust gas rises with load because more fuel is burned to supply the power demand at higher loads. In addition, for all loads, the exhaust gas temperature rises as the percentage of PME in the test fuel rises. This could be owing to the PME's high oxygen concentration, which promotes combustion and hence raises exhaust gas temperature. Figure 13 rate of pressure rise VS crank angle

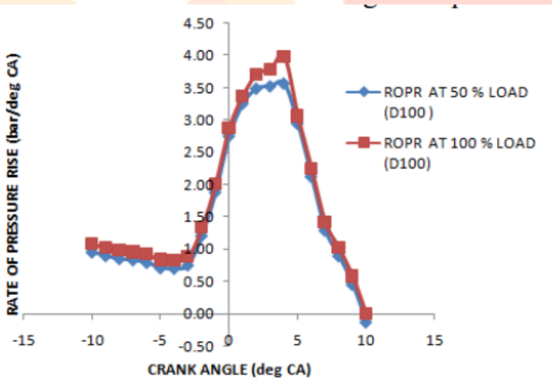

Fig8 : rate of pressure rise VS crank angle

IX. SAMPLE CALCULATIONS

Maximum load calculation Maximum load (W) = □□ ×60×1000 2□ □ □□ = ------ N = ----kgf
BP = Rated power in kw
N = Rated speed = 1500 rpm
Rm = Radius of the dynamometer arm length in m
1. Brake power (BP) = 2□ □(□ ×9.81)□□ 60×1000 = ----kw
N = speed of the engine in rpm
W = Applied load in 'N'
Rm = Radius of the dynamometer arm length in m
2. Indicated Power (IP) = □□□□×□□□/2×10 60×1000 5 = ----kw
IMEP = Indicated mean effective pressure in bar
L = Stroke length in m
D = Cylinder diameter in m
A = Cylinder area in m^2
Where, A = □× □ 4 2 = ---m^2
3. Total fuel consumption (TFC) = (q x Density of the fuel)/t = -----kg
Where, q = volume of fuel consumed = 10 x 10-6 m^3
t = time taken for 10g of fuel consumption in sec

4. Specific fuel consumption (SFC) = TFC/BP = kg/kwh
Where, TFC = Total fuel consumption BP = Brake power in kw
5. Mechanical efficiency (ηm) = (BP / IP) x 100 = ---- %
6. Brake thermal efficiency (ηbt) = BP / (TFC x Cv) x 100 = %

X. CONCLUSIONS : The performance, emission, and combustion characteristics of a single cylinder four stroke diesel engine running on diesel and Pongamia oil biodiesel blends at variable injection pressures of 220 bar and 240 bar at constant injection timing of 23°bTDC at engine rated speed of 1500 rpm are investigated. The key results are summarized below:

1. Due to the inherent oxygen content, the ignition delay of Pongamia and its blends PB10D90 and PB15D85 was found to be less than that of diesel oil D100.
2. The rate of pressure rise is higher for diesel D100 and lowers for the biodiesel blends PB10D90 and PB15D85 made from Pongamia oil. The rate of pressure rise decreases with an increase in the percentage of percentage volume of Pongamia oil biodiesel in the fuel.
3. As the percentage volume of biodiesel from Pongamia oil in the fuel increases, the rate of pressure rise lowers.
4. Due to the early onset of combustion of Pongamia oil biodiesel and its blends PB10D90 and PB15D85, which increases compression work, the brake thermal efficiency of Pongamia oil biodiesel and its blends PB10D90 and PB15D85 is slightly lower than that of diesel D100.
5. NOx emissions of Pongamia oil biodiesel blends PB10D90 and PB15D85 are generally greater than diesel, whereas HC, CO, and soot concentration emissions are lower than diesel D100. The aforementioned investigation suggests that Pongamia methyl ester and its mixes could be used as a diesel alternative. Blends of Pongamia oil biodiesel emit fewer pollutants than petroleum diesel, with the exception of NOx, and have good combustion and performance.
6. The emission test was conducted using a 437C smoke metre and an AVL DIGAS 444N, with the findings being recorded. It can readily be observed that biodiesel blends emit a far lower percentage of CO than diesel.
7. Based on the findings, it is concluded that the PB15D85 blend consumes about the same amount of fuel, has a greater mechanical efficiency, and has a higher brake thermal efficiency under load fluctuations than the traditional diesel D100. The brake thermal efficiency of the Pongamia oil biodiesel and its blends PB10D90 and PB15D85 are slightly lower than that of diesel D100 due to the early start of combustion of Pongamia oil biodiesel and its blends, which increases the compression work. 8. A sudden rise in in-cylinder gas pressure is seen after a 75 percent load condition. 9. The exhaust gas temperature of biodiesel is more compared to diesel this is due to the complete combustion which increases the combustion chamber temperature. 10. The CO and HC emission are lower for Pongamia biodiesel when compared to diesel this may be due to the fact that biodiesel contains more oxygen. 11. The NO x emission is seen continuously increasing when load on engine is increased, which may be due to increase in cylinder temperature. The formation of NO x is seen to be decreased when % EGR is increased, which due to the incomplete combustion which results lower cylinder temperature. 12. Finally, it is concluded that at 240 bar pressure, the engine has higher performance, combustion, and emission characteristics.

XI. SCOPE FOR FUTURE WORK :

1. There is a vast future scope of study on this work by changing the biodiesels and changing the injection timings and injection pressures, the performance, combustion and emission characteristics of diesel engine can be evaluated to obtain the better performance.
2. Further, as a future scope, performance, combustion and emission characteristics of an engine can be evaluated using ternary fuels with addition of low reactivity fuels (alcohols) to the diesel and biodiesel.
3. To reduce Nitrogen oxides, we can use exhaust gas recirculation as a method in further experimentation.

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