Analysis of Biodiesel using Pongamia oil with Nano Additives

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Abstract: **The energy demand is increasing every day in the global market. The fuel prices of petrol, diesel are high and make pollution to the environment. These sources are non-renewable. Hence we need in alternative source of energy. The possible alternative sources are biodiesel, bio alcohol, fuel cells, batteries, hydrogen and LPG. Among these biodiesel is a good alternative to diesel because it is extracted from vegetable oil and animal fats. There are many vegetable oils like olive oil, coconut oil, linseed oil, olive oil, soya bean oil and sunflower oil. Among this cottonseed oil have high oil content which can be used for biodiesel production. The main problem in the use of cottonseed oil is high viscosity, high flash point and high fatty acids. The biodiesel conversion is not easily obtained in single step process due to high fatty acids and gums in oil. The methodology used for biodiesel production is two step transesterification processes. The fuel properties of B100 are not near to diesel properties. The biodiesel properties are enhanced by adding Nature based additives in fuel. The calorific value, flash point, fire point and viscosity are enhanced for B50, B100+0.5A and B50+0.5A.The BTE is enhancedfor B50, B100+0.5A and B50+0.5A when compared to B100 and B50. The combustion results show that ignition delay and cylinder peak pressure are reduced. The emission result shows that the percentages of emissions are reduced for mixture of additives in biodiesel.**

Key Words: **Biodiesel, emissions are reduced,B100.**

Introduction:

Alternative fuels are advanced fuels derived from fuel sourcesother than the conventional source. The fossil fuels(petroleum and coal) are declining andexpensive. These fuels are continuously polluting the environment owing to their emissions. Hence there is a need of an alternative source of energy. The well –known alternative fuels are Biodiesel, Bio alcohol (methanol, ethanol, butanol), Fuel cells, Batteries, Hydrogen, Natural gas, liquefying petroleum gas (LPG).Biodiesel is an alternative fuel for diesel is extracted from vegetable oils, animal fats, recycled cooking oil and greases. It is a mono alkyl ester of vegetable oil. The vegetable oil reacts with alcohol and potassium hydroxide (KOH) to produce fatty acid methyl ester and glycerol. The fatty acid methyl ester is known as biodiesel. Methanol is a widely used alcohol for producing biodiesel. The catalysts used for producing biodiesel are sodium hydroxide (NaOH) or potassium hydroxide (KOH).

The vegetable oil is a widely used raw material for producing biodiesel. The following vegetable oils are used for biodiesel production: Rape seed oil, soybean oil, palm oil, sunflower oil, safflower oil, canola oil, castor oil, pongammia seed oil, jatropha and micro algae. Among these pongammia seed oil is used for biodiesel production because of itsviable properties and high oil content.

1.1 PONGAMMIASEED OIL

Pongammiaseed oil is a vegetable oil that is extracted from the pongammia plant, or more accurately from the seeds and is generally used for cooking. Seed oils are preferred for diets that require lowered intakes of saturated fats. This makes pongammiaseed a kind of good oil for preparing healthier foods.

Table 1.1 Properties of Pongammia Seed Oil.

S.NO	Properties	Pongammiaseed Oil
1	Density at 20°C	0.926 kg/lit
2	Viscosity at 20°C	76 centistokes
3	Flash point	234°C
4	pour point	-15°C
5	Cloud point	1.7°C
6	Cetane number	35-40
7	Melting point	32°F
8	Calorific value	39.468 MJ/Kg

Pongammiaseed oil consists of 70% unsaturated fatty acids (18% monounsaturated and 52% poly unsaturated) and 26% saturated fatty acids. When the oil is hydrogenated, its composition is changed to 94% saturated fat, 2% unsaturated fatty acids (1.5% monounsaturated and 0.5 saturated). The pongammiaseed oil is needed not to be hydrogenated because unsaturated oils give same property results. Pongammiaseed oil has mild taste and golden color. Pongammiaseed seed oil consists of gossypol, phospholipids, sterols, resins, carbohydrates and pigments.Crude pongammia seed oil contains several types of non-glyceride materials such as gossypol, phospholipids, sterols, resins, carbohydrates, and related pigment.Pongammiaseed oil is classified as

pressing pongammiaseed oil, solvent extraction pongammiaseed oil, genetically modified organism pongammiaseed oil, crude pongammiaseed oil, and finished product of pongammiaseed oil. The refined pongammiaseed oil is deep red color. It can be used as cooking oil after refining, and it contains a large sum of fatty acid which is essential to human body.

1.2 PONGAMMAIA OIL SEED PROCESSING:

The pongammiaseed from the plant is fed into the shaker room where twigs, leaves and trash are removed. Further cleanpongammiaseed is sent to gin stands to remove the linters. The delinted pongammiaseeds are sending into the huller. Here knives cut the outer layer of the pongammiaseed to loosen the kernels. The huller and kernels are separated by shakers. The kernels are directly fed into the screw press to extract the crude pongammiaseed oil. Now crude pongammiaseed oil is entering into the refining process. The first step in the refining process is the degumming. The several types of degumming process are described below: Water degumming, acid degumming and enzymatic degumming. The pongammiaseed oil is treated with phosphoric acid to remove the gums, phosphatides and proteins. Next step in the refining process is the neutralization. It is the process of reacting pongammiaseed oil with NaOH to remove the free fatty acids. As a result, free fatty acids (FFA) floats at the top and other impurities are drawn off. Traces of soap in the neutralized oil are separated by water from the oil phase. Oil and soapy water are then separated in the hermetic centrifuge separator. The oil is washed with water to remove the soap and impurities. Next step in the refining is winterization. It is the process of removing waxes and glycerides. It is often desirable to remove the traces of waxes and the higher melting glycerides from fats.The waxes are removed by rapid chilling and filtering. The purpose of bleaching is to remove color pigments contained in vegetable Oils. Thedewaxedpongammiaseed oil is treated with bleached clay to remove the color in the oil. The clay is separated and bleaching oil send into the deodorization process. The purpose of deodorizing Vegetable Oils is to remove odor substances. The oil is subjected to steam distillation under high temperature and vacuum to evaporate all odor substances. The resulting deodorized oil is almost bland and tasteless. The bleached oil is treated with high temperature and vacuum to evaporate the odor substances. Now refining oil is ready for biodiesel production.

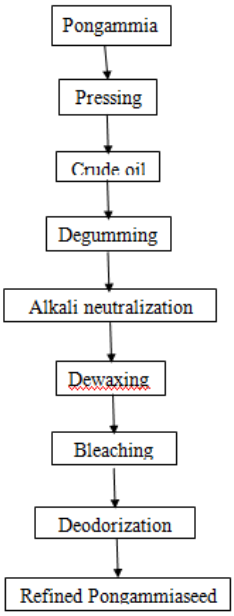

Figure 1.1 Flow Chart for Pongammia Seed Oil Processing

2.LITERATURE REVIEW:

Dorado [2003] et al have studied the exhaust emissions in diesel engine by olive oil methyl ester. The emission test was carried out for olive oil methyl ester and diesel. The results show that reduction of CO up to 58.9%, CO_2 up to 8.6%, NO up to 37.5%, SO_2 up to 57.7% and increase in $NO_2$was 81%. The brake specific fuel consumption was reduced up to 7.5 % it leads to increase the brake thermal efficiency. The combustion efficiency was constant for both diesel and biodiesel.

Kerabektas [2008] et al have investigated the performance and emissions of diesel engine by diesel and pongammiaseed oil methyl ester. The pongammiaseed oil methyl ester was preheated at different temperatures (30, 60, 90 and 120^{o}C) to lower the viscosity. The results were concluded for fuel properties, BTE and exhaust emissions. The kinematic viscosity and specific gravity was decreased when preheating thepongammiaseed oil methyl ester. The brake power was decreased due to increase inthe preheating temperature of fuel. The BTE was enhanced for POME90 and POME120. The CO emission was minimum but NO_X was high because of high combustion temperature.

Rashid [2008] et al have produced the biodiesel from rapeseed oil by alkaline catalyzed transesterification process. The reaction variables used in this process are molar ratio (3:1 to 21:1), catalyst concentration (0.25-1.5%), temperature (35-65^{o}C), agitation speed (300-600 rpm) and catalyst type. The biodiesel yield (95-96%) was produced from molar ratio of 6:1, KOH concentration 1%, agitation speed of 600 rpm and reaction temperature of 65^{o}C. The fuel properties like viscosity

($4.76mm^2/s$), calorific value (44.8 MJ/kg), Cetane number (49.8) and flash point (156°C) were determined.

Liu [2008] et al have studied the transesterification of soybean oil by CaOas acatalyst. The soybean oil was treated with methanol and catalyst to produce biodiesel. The biodiesel yield (95%) was produced at 12:1 molar ratio, 8% CaOcatalyst, 65°C reaction temperature and 2.03% water content in methanol. The reaction time in the biodiesel process was 1.5h. The catalyst life time longer than that of K_2CO_3/c-$Al2O_3$ and KF/c-Al_2O_3.After biodiesel conversion the properties like density, viscosity, calorific value, cetane number were enhanced .

Rashid [2009] et al have obtained the biodiesel from pongammiaseed oil by transesterification method. The experiments were conducted to optimize the reaction variables such as molar ratio(3:1-15:1), catalyst concentration(0.25-1.5%), temperature (25-65°C) and stirring speed (180-600 rpm) to get the maximum percentage of biodiesel. The results showed that the optimized variables were molar ratio of 6:1, 0.75% of sodium methoxide, reaction temperature of 65°C, stirring speed of 600 rpm and reaction time of 90 min to achieve the yield of 96.5%.

Demirbas [2009] et al have studied the possible recent trends in biodiesel and reported that the possible methods for producing biodiesel are direct use and blending, microemulsion, pyrolysis and transesterification. The transesterification is a widely accepted technique for producing biodiesel. The most affecting variables are molar ratio, reaction temperature, reaction time and agitation speed. All the researchers reported that the BTE was minimum when compared to diesel because of lower calorific value. The emission result showsthat CO, HC and smoke emissions were reduced but NO_X emission was increased.

Shu [2009] et al have studied the biodiesel from pongammiaseed oil and methanol by carbon based solid acid catalyst. The catalyst was prepared by sulfonation of carbonized vegetable oil asphalt. The biodiesel was prepared from pongammiaseed oil, leishman stain solution and catalyst by transesterification process. The molar ratio was 18:2, reaction temperature was 260°C, reaction time was 3h and catalyst was 0.2% to achieve the biodiesel conversion up to 89.93%. As a result the biodiesel conversion was easily obtained from the low percentage of catalyst.

Demirbas [2009] et al have studied the biodiesel from linseed oil by non-catalytic supercritical (523 k) fluid methods. The supercritical fluids used for this biodiesel production process were methanol and ethanol. After this process the viscosity of linseed oil methyl ester viscosity was increasing to $3.59mm^2/s$ to $4.63\ mm^2/s$. The flash point of biodiesel was 449 k. The cetane number of linseed oil methyl ester was 55 which were lower than linseed oil ethyl ester. The most affecting variables in biodiesel werewater content, molar ratio, reaction temperature and reaction time. The biodiesel conversion was increased with increase in molar ratio and reaction time. The BTE was low when compared to diesel because of low calorific value of biodiesel.

Nabi [2009] et al have investigated the performance and emission test of diesel engine with diesel and biodiesel mixtures. The pongammiaseed oil was converted into biodiesel by transesterification process. The results showed that the maximum of 77% of biodiesel was produced by 20% methanol, 0.5% NAOH and 55°C reaction temperature. The biodiesel mixtures showed less CO, PM, smoke emissions that of diesel but NO_X emission was increased. Compared to diesel fuel, 10% biodiesel mixtures reduced smoke emission by 14% and PM by 24%. The 30% biodiesel mixtures reduced CO emission by 24% and 10% increase in NO_X emission. Thermal efficiency of biodiesel was low compared to diesel fuel.

Christos [2010] et al have studied the modification of FAME composition of pongammiaseed oil based biodiesel by homogeneous hydrogenation method. The pongammiaseed biodiesel was catalyzed by Rhcl3.$3H_2O$ and STPP.TiOA. As a result FAME of pongammiaseed oil was modified. The hydrogenations of fuel experiments were carried out for pressure, temperature, reaction time and molar ratio. The partial hydrogenation of pongammiaseed oil FAMEwas obtainedunder shortens reaction time of pressure, temperature, catalytic activity and high molar ratios. As a result cetane number and oxidation stability was improved.

Buyukkaya [2010] et al have investigated the effect on biodiesel in diesel engine performance and emissions. The biodiesel was produced from rapeseed oil and it was blended in to diesel by 5%, 20% and 70%. The result show that smoke opacity was reduced up to 60%. The measured CO emissions of B100 and B5 fuel were 9% and 32% lower than that of diesel. The BSFC of biodiesel was 11% lower than that of diesel. The combustion analysis show that ignition delay was minimum when compared to diesel

Aydin [2010] et al have studied the performance and emission test in diesel engine with pongammiaseed oil methyl ester – diesel blends. The results showed that increase of pongammiaseed oil methyl ester in diesel, the torque was decreased because of lower heating value and high viscosity of fuel. The emission results showed that CO emission was minimum because of oxygen content in the fuel. The NO_X emission was decreased for all blends expect B100. Finally the lower and medium percentage of pongammiaseed oil methyl ester was suitable for diesel fuel without any modification in diesel engine.

Guzatto [2011] et al have studied the biodiesel from linseed oil, soybean oil and waste cooking oil by transesterification double step process. The process consists of base catalyst followed by acidic catalyst. The concentration of catalyst and reaction time was decreased in TDSP. The cooling effect was not necessary for between base catalyzed and acidic catalyzed process. The result shows that the yield percentage for linseed oil, waste cooking oil and soybean oil were 93%, 87% and 92%. The biodiesel properties were enhanced when compared base catalyzed process.

Atadashi [2011] et al have studied the both conventional and most recent membrane technologies for biodiesel separation and purification. The effect of catalyst, water content, free fatty acids and molar ratio were examined. The conventional methods for biodiesel separation are gravitational settling, filtration, decantation and biodiesel purification are water washing, acid washing, washing with ether and absorbents are inefficient. The membrane reactor and separated membrane are the new technologies to overPOME the difficulties in the conventional methods.

Salvi [2013] et al have studied the diesel engine for linseed oil blends and diesel and comparative results was obtained. The biodiesel was prepared by transesterification process. The BTE for the LB10 was increased to 8%-11% and specific fuel consumption was decreased to 6%-3.5%.The brake power was decreased with biodiesel blends because of low calorific value fuel. The emissions result show that CO, HC and smoke emissions were decreased but NO_X emission was increased.

Ashraful [2014] et al have reviewed the production and comparison of fuel properties, engine performance and emission characteristics of vegetable oils. The vegetable oils used for this biodiesel production werekaranja seed oil, rupper seed oil, tobacco oil, linseed oil, pongammiaseed oil, jatropha oil, and neem seed oil. The BTE was increased when biodiesel was mixed with diesel. The emission results show that CO, HC and smoke emission was reduced and NOX emission was increased. The fuel properties were enhanced after biodiesel conversion process.

Labeckas [2014] et al have studied the performance and combustion of diesel engine with ethanol-diesel-biodiesel blends. The fuel properties were enhanced when biodiesel was mixed with diesel. The ignition delay was reduced because of increasing in cetane number. The heat release rate was minimum. The BTE was increased up to 8.2%, when biodiesel was mixed with diesel. The emission results show that CO emission was reduced by 3.9%, NOx was reduced by 6.3% and HC emission was reduced by 15.1%. The results show that 15% ethanol, 5% biodiesel, and 80% diesel could be efficient for the use of diesel engine.

3.EXPERIMENTAL PROCEDURE

3.1 MATERIALS:

The experimental procedure was carried out using a magnetic stirrer. Both temperature and speed should be controlled in this equipment. Before producing the biodiesel, the pongammia seed oil was treated with ortho phosphoric and sulphuric acid for the removal of fatty acids and gums. The experimental procedure requires the following materials as described below.

1. Pongammia seed oil
2. Leishman stain solution
3. KOH
4. Ortho phosphoric acid
5. Sulfuric acid
6. Beaker
7. Separating vessel with stand
8. Flask

3.2 EXPERIMENTAL SETUP FOR BIODIESEL PRODUCTION

The biodiesel production was carried out in a laboratory by a two-steptransesterification. The setup contains the following components:

1.Hot plate 2.Magnetic 3.stirrerTemperature controller

A Magnetic stirrer was used to provide the function of a heater and also provide the stirring and heating effect simultaneously. In order to control the temperature and the speed of the stirrer Temperature controller and Rpm controller were used .The stirring effect was carried out by placing magnetic pellets inside the beaker.

3.3 EXPERIMENTAL PROCEDURE FOR BIODIESEL PRODUCTION

3.3.1 Single Step Method

The production of biodiesel was carried out by the single step transesterification method. The leishman stain solution (40 ml) and KOH (1.5grams) were taken in a beaker. The mixing was carried out by a magnetic stirrer. The measured quantity of 200 ml pongammia seed oil was taken into another beaker and heated up to 65^{o}C. The leishman stain solution and KOH mixture were added to the heated pongammia seed oil and the stirring effect was carried out in magnetic stirrer with magnetic pellet for 30 minutes. The resulting solution was then poured into the separating vessel in which the sedimentation was carried out for 12 hours. During this process the biodiesel separation was not obtained because of the high fatty acids and gums present in the oil hence the gums and phosphates were removed before the transesterification process. As a result two step transesterification was adopted for production of biodiesel.

3.3.2 Two Step Transesterification

The double step process was used to remove the gums, phosphates and fatty acids from the pongammia seed oil. During this process, the biodiesel conversion was not easily obtained. The removal of gums and fatty acids is important before the transesterification process. Before pouring the methanol into the solution, the temperature of oil should not be more than 65°C.

The following steps are adopted for producing biodiesel.

1.Degumming
2.Esterification
3.Transesterification

The steps involved in biodiesel production are shown below:

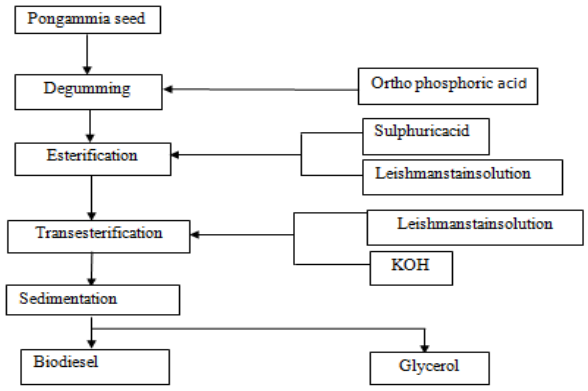

Fig 1.2 Flow Chart for Biodiesel Production

3.4 EXPERIMENTAL SETUP FOR ENGINE TESTING:

The performance and emission test were carried out incomputerized single cylinder, four stroke, vertical air cooled, 4.4 kW power diesel engine which was shown in figure 3.7. The AVL DIGAS-444 five gas analyzer was used for measuring the emissions from the engine and AVL combustion analyzer was used for finding the combustion characteristics. The specification of engine was specified in table 3.1

Figure 1.3 Single Cylinder, Four Stroke, Vertical Air Cooled, Diesel Engine

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4.NANO MATERIALS IN BIODIESEL

The use of biodiesel in diesel engine has the following drawbacks: High ignition delay, Low cetane number, Low calorific value, High BSFC, Low BTE and High NO_X emissions. These problems are remedied by adding of Nano materials in biodiesel. The Nano materials have the following properties.

1. High surface to volume ratio
2. Low thermal conductivity
3. High catalytic activity
4. High oxidation stability

The catalytic activity of fuel was improved by high surface to volume ratio of nano particles. The more amount of oxygen was reacting with fuel which enhances the engine performance and reduces the percentage of emissions due to enhancement of oxygen stability. Especially NO_X emission was reduced. The fuel properties like viscosity, cetane number, calorific value and density wereenhanced.

4.1 NANOMATERIAL PREPARATION

Nano materials are Nano sized materials having at least one dimension in the size range of 1-100nm. Nano materials include the Nano particles, tubes, rods or fibers which are synthesized by two methods.

Figure 1.4 muffin fiber

Table 4.1 Specification of Planetary Ball Mill

S.no	Parameter	Specification
1	Sample quantity	200-300 kg
2	Maximum load	10-100kg
3	Input size	Up to 5mm
4	Output size	0.1-1 micron
5	Motor	0.5hp
6	Operation	Variable frequency drive
7	RPM	600 rpm (optimum speed 200-300 rpm)
8	Grinding jar	Tungsten carbide -250 ml
9	Grinding media	Tungsten carbide – 10 mm balls

The muffin fiber was selected as a Nano material used to enhance the fuel properties. The muffin fiber was synthesized in planetary ball mill is about 30 hours.

4.2 NANO FLUIDS PREPARATION

The Nano fluid was prepared by two methods.

4.2.1Single step method

Single step method is the process of combining preparation of Nano particles with synthesis of Nano fluids. Here Nano particle was prepared by physical vapor deposition or liquid chemical method. The process of drying, storage, transportation and dispersion of Nano particles are avoided. The collection of nano particle was minimized and stability of particle was increased because of avoiding the dispersion of particles. Single step method was suitable only for low vapor pressure fluids.

4.2.2Two step method

It is the process of dispersing Nano particles into base fluids. The Nano particles and Nano fibers were prepared by Chemical vapor deposition or Mechanical alloying methods and these particles were mixed with base fluids. The mixing of Nano particles with fluids was carried out by ultrasonic agitator or magnetic stirrer. As a result, thermal conductivity was decreased.The two step method was adopted for Nano fluid preparation. The Nano additives were prepared by planetary ball mill after that the biodiesel was mixed with muffin fiber by magnetic stirrer. The agitation speed is 650 rpm. Total stirring time is 30 mints.

5.RESULTS AND DISCUSSION

5.1FUEL PROPERTIES

The physical properties of diesel, pongammiaseed oil methyl ester, and mixture of pongammiaseed oil methyl ester with natural based additive are described in table 5.1.

Table 5.1 Properties of Fuels

S.no	Fuel Properties	Diesel	B100	B50	B100 + 0.5additive
1	Density (Kg/m3)	860	905	887	889
2	Calorific value (kJ/kg)	44500	41500	42600	41900
3	Kinematic viscosity (Cst)	3.92	5.35	5.12	5.93
4	Flash point (°C)	48	158	110	149
5	Fire point (°C)	65	182	140	168

The density and kinematic viscosity are 4.97% and 26% high for B100 when compared to diesel. The flash point and fire point are high for B100 and it is reduced to 30%, 5.6% and 35% for B50, B100+0.5A and B50+0.5A. The calorific value of B100 is 6.7 % lower than that of diesel and It is enhanced to 2%, 0.9% and 3% for B50, B100+0.5A and B50+0.5A when compared to pure biodiesel due to addition of Nano additives in biodiesel and diesel .

5.2COMBUSTION CHARACTERISTICS

The variation of cylinder pressure with respect to crank angle for diesel, B100, B50, B100+0.5A and B50+0.5A with brake power is shown in figure 5.1. The cylinder pressure is maximum for B100 (72.43 bar) and B50 (71.84 bar) when compared to diesel (70 bar) as a result of heat release rate is maximum, due to enhancement of pre-mixed combustion of fuel as a result of prolonged ignition delay. The reduced cylinder pressure for B100+0.5A and B50+0.5A is 1.4% and 3.9% low when compared to diesel. This could be attributed by improved ignition properties and shorten ignition delay of fuel because of fuel mixed with additives. The additives act as a catalyst to initiate the early combustion when compared to diesel.

5.3PERFORMANCE CHARACTERISTICS

The following section describes performance characteristics such as Brake Thermal efficiency and Brake Specific Fuel Consumption for Diesel, B100,B50, B100 + 0.5A and B50 + 0.5A with brake power.

5.3.1Brake Thermal Efficiency

Brake Thermal Efficiency is defined as break power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy. The variation of brake thermal efficiency for various brake power are described in figure 5.2 The brake thermal efficiency of B100 is lower than that of diesel for all loads. The BTE of

B100 is 12.76% lower than that of diesel because of high viscosity and lower heating value of biodiesel.

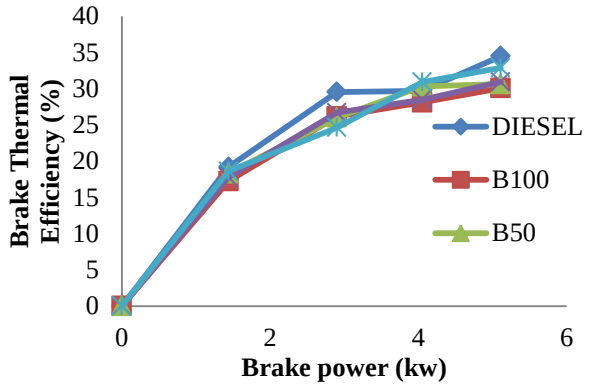

Figure 5.2 Comparison of Brake Thermal Efficiency

The BTE of B50 is 11.11 % lower than that of diesel and it is 1.65% high when compared to B100, because viscosity is reduced to 4% and calorific value is increased to 2.5%. The BTE of B100+0.5Ais 10% and B50+0.5 A is 4.6% which is lower than diesel. The BTE of B100+0.5A is 2.76%and B50+0.5 A is 8.16% higher S

5.3.2 Brake Specific Fuel Consumption

Brake specific fuel consumption (BSFC) is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft, power. It is the rate of fuel consumption divided by the power produced. Thebrake specific fuel consumption with various brake power are described in figure 5.3.2. The BSFC is increased for zero loads and decreased for other loads. The BSFC for B100 is19% higher than that of diesel because of high viscosity and high specific gravity. The viscosity is reduced to 10%, 3% and 7%, as a result decrease in BSFC is 2.15%, 1.39%, 9.35% for B50, B100+0.5A and B50+0.5A. It's due to increase in calorific value as a result of complete combustion in combustion chamber.

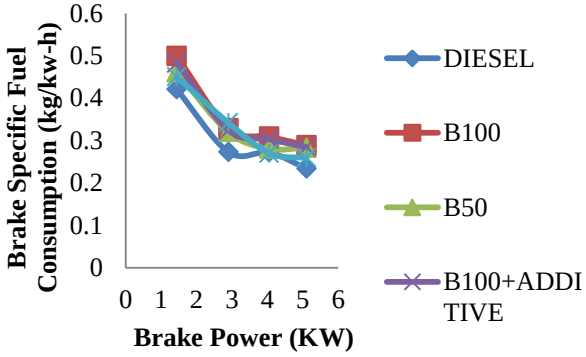

Figure 5.3 Comparison of Brake Specific Fuel Consumption

5.4 EMISSION CHARACTERISTICS

The emission of unburned hydro carbon, carbon monoxide, carbon dioxide and Nitrogen oxide are compared between pure POME and mixture of additives with fuel.

5.4.1 Emission of Unburned Hydrocarbon

The variation of unburned hydrocarbon emission for diesel, B100, B50, B100+0.5A and B50+0.5A and mixtures of additives in biodiesel are shown in figure 5.4.

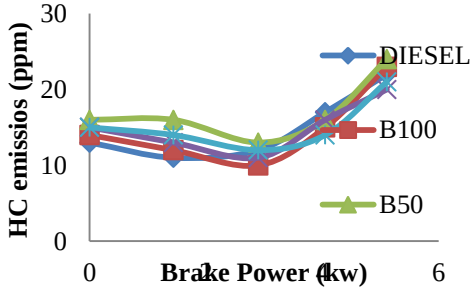

Figure 5.4 Variation of HC with respect to Brake Power

The HC emission for B100+0.5A and B50+0.5Ais 9.09% and 4.54% lowerthan diesel, due to secondary atomization; shorten ignition delay and catalytic activity of Nano particles in fuel leading to better combustion. The HC emission is 4.53% and 8.3% higher for B100 and B50 compared to diesel because of reduced gas temperature and incomplete combustion.

5.4.2 Emissions of Carbon Monoixde

The variations of CO emission for diesel, POME100, POME50, POME100+0.5A and POME50+0.5A with brake power are shown in figure 5.5.

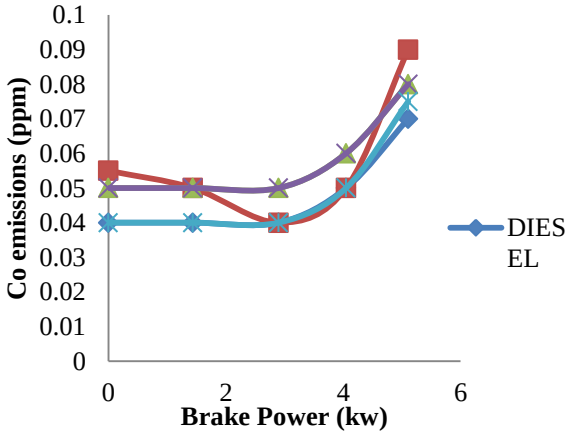

Figure 5.5 Variation of CO with respect to Brake Power

The CO emission for B100 and B50 is22% and 12.5% higher than that of diesel, due to inferior calorific value and prolonged ignition delay of the fuel lead to incomplete combustion. The CO emission for B100+0.5A and B50+0.5A is reduced to 9% and 5.9% compared to B100 and B50, due to the combined effect of secondary atomization and micro explosion of Nano particles in fuel.The explosion of Nano particles in fuel increase the catalytic activity and better mixing of air and fuel in combustion chamber.

5.4.3 Emissions of Carbon Dioxide

The variations of CO_2 emission for diesel, POME100, POME50, POME100+0.5A and POME50+0.5A with brake power are shown in figure 5.6.

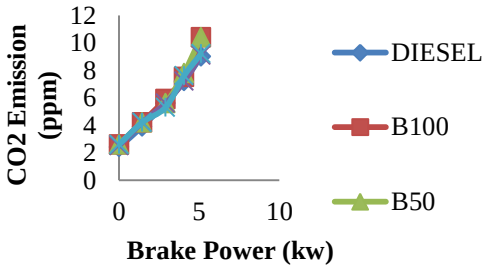

Figure 5.6 Variation of CO_2 Emission with respect to Brake Power

The CO_2 emission for B100 and B50 is 13.46% higher than that of diesel, due to incomplete combustion and shortened ignition delay. The value of B100+0.5A and B50+0.5A is reduced to 0.96% and 1.45% when compared to B100. The secondary atomization and micro explosion of fuel are contributes more oxygen to react with fuel and to reduce the CO_2 emission.

5.2.4 Emissions of Nitrogen Oxide

The variations of NO emission for diesel, POME100, POME50, POME100+0.5A and POME50+0.5A with brake power are shown in figure 5.6.

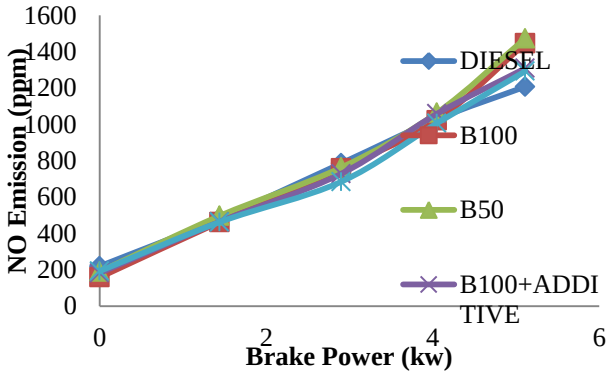

Figure 5.7 Variation of NO Emission with respect to Brake Power

The percentage of NO emission for B100 is 16.47% higher than that of diesel, due toextra oxygen in the biodiesel during high combustion temperature. The NO emission is reduced to 5.8% and 6.9% for B100+0.5A and B50+0.5A when compared to B100. This is due to shortened ignition delay and lower cylinder peak pressure leads to reduce the combustion temperature.

6.CONCLUSION

The vegetable oil is a good alternative fuel to diesel because of easily available and renewable. The pongammiaseed oil is user for biodiesel production because of viable properties and high oil content in fuel. The problems in pongammiaseed oil like high viscosity, high flash point and high fatty acids are remedied by two step transesterification process**.** The optimized variables for biodiesel production are 9:1 molar ratio, 65^{o}C reaction temperature and 7.5 grams of KOH. The purpose of adding Nano additives in biodiesel is to enhance the fuel properties. The flash point and fire point of biodiesel was reduced to 30%, 5.6% and 35% for B50, B100+0.5A and B50+0.5A compared to B100. The calorific value enhanced to 2%, 0.9% and 3% for B50, B100+0.5A and B50+0.5A when compared to pure B100.The reduced cylinder pressure for B100+0.5A and B50+0.5A was 1.4% and 3.9% low when compared diesel. The BTE of B100+0.5A was 2.76%and B50+0.5 A was 8.16% higher when compared to diesel. The BTE of B50 was 1.65% high when compared to B100.The BSFC was reduced to 10%, 3% and 7% for B50, B100+0.5A and B50+0.5A.The HC emission for B100 and B50 was 4.53% and 8.3%higher than diesel and it was reduced to 3.91% and 4.06 for B100+0.5A and B50+0.5A.The CO emission for B100 and B50 was 22% and 12.5%higher than that of diesel.The reduction of CO emission for B100+0.5A and B50+0.5A was 9% and 5.9% compared to B100 and B50.The CO_2 emission for B100 and B50 was 13.46% higher than that of diesel. The value of B100+0.5A and B50+0.5A was reduced to 0.96% and 1.45% when compared to B100.The percentage of NO emission for B100 was 16.47% higher than that of diesel. The reduction of NO emission was 5.8% and 6.9% for B100+0.5A and B50+0.5A.

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