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Experimental Investigations on single cylinder Diesel Engine using various Bio Diesels

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ABSTRACT

The interest on alternative fuels is continuously increasing to meet the growing energy requirement and protect the environment. The comparison of fuel performance and combustion characteristics of various biodiesel (Rapeseed biodiesel, Cotton biodiesel, Mahuva biodiesel, Jatropa biodiesel and Rubber seed biodiesel) has been carried in direct injection diesel engine and best one for application was evaluated on four stroke single cylinder diesel engine under various load at no load, 25%, 50%,75%, and full load was assessed. At full load the Rapeseed biodiesel has been recorded highest rate of pressure rise , heat release and thermal efficiency and lowest brake specific fuel consumption compared to other tested fuels at full load condition. The rapeseed biodiesel has recorded less CO & HC emissions as compared to other bio diesels. So on the basis of performance, combustion and emission parameters Rapeseed Biodiesel appears to be best alternative fuel than other of Cotton seed biodiesel, Mahua biodiesel, Jatropha biodiesel and Rubber seed biodiesel even than diesel.

KEYWORDS: Bio-diesels; Alternative fuels; CO and HC emissions; Performance; Combustion

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1. INTRODUCTION

To fulfill the energy demand of the world, the search for energy independence and concern for a cleaner environment have generated significant National interest in biodiesel, despite its shortcomings. India happens to be world's fourth largest consumer of crude and petroleum products after United States, China and Japan. The net oil import dependency of India rose from 43% in 1990 to 71% in 2012 that resulted in a huge strain on the current account. Evidently India's energy security would remain vulnerable until alternative fuels are developed to substitute or supplement petro-based fuels. Biodiesel is an alternative diesel fuel which can be obtained from the transesterification of vegetable oils or animal fats and methyl or ethyl alcohols in the presence of a catalyst (alkali or acidic). Rudolph Diesel, the father of diesel engine, demonstrated the first use of vegetable oil in compression ignition engine in 1910. He used peanut oil as fuel for his experimental engine.

Biodiesel is produced through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. Transesterification is processes in which a triglyceride is made to react with alcohol in the presence of a catalyst. The process leaves behind two products namely methyl esters (the chemical name for biodiesel) and glycerine. According to literature, the use of vegetable oils as fuel in diesel engines causes several problems, namely poor fuel atomization and low volatility originated from their high viscosity, high molecular weight and density[1,2]. The optimization study was performed by the authors using response surface methodology. biodiesel derived from waste frying oil by using lime as catalyzing material[3]. The variation in cylinder gas pressure and the heat release rate with respect to crank angle for the Jatropha Methyl Esters with 2% surfactant and 5% water with and without addition of Carbon Nano tube by varying ppm levels to the fuels at the full load condition in Single cylinder, four stroke, naturally aspirated, air cooled, constant speed, direct injection. JME, JME2S5W, The addition of CNT to the JME emulsion fuel (25, 50 and 100 ppm) has exhibited a gradual decrement in the cylinder pressure on the account of shortened premixed burning phase[4]. The possibilities of using different types of micro algal species as source of oil, techniques for algal growth, harvesting, oil extraction and conversion to biodiesel and its future scope in India[5].The feasibility of the transesterification of waste canola cooking oil using lower alcohol to oil molar ratios Some important variables such as volumetric ratio, types of reactants and shaking time were selected to obtain a high quality biodiesel fuel and examine the considerable difference of biodiesel yield produced by methanol, ethanol and 1-butanol[6]. The researchers presented detailed technology and economics of substituting biodiesel for diesel and made an effort in three areas. First, the benefits of biodiesel are examined, and the technical problems of large-scale implementation. Second, the biodiesel production possibilities are examined for soybean oil, corn oil, tallow, and yellow grease, which are the largest sources of feedstocks for the United States. Examining in detail the production possibilities allows to identity the extent of technological change, production costs, byproducts, and greenhouse gas (GHG) emissions. Finally, a U.S. agricultural model, FASOMGHG was used to predict market penetration of biodiesel, given technological progress, variety of technologies and feedstocks, market interactions, energy prices, and carbon dioxide equivalent prices [7].The fuel properties of biodiesel, production process (transesterification) and the most important variables that influence the transesterification reaction[8].The characterization of Waste Palm Cooking oil for Biodiesel Production. And reported the spectroscopic analysis was performed for the used and unused cooking oil samples[9] R L Krukaran et. al1 revealed that the 20% blend resulted in 4.18%, 5.12% more prominent performance characteristics of brake thermal efficiency, brake specific energy consumption, and superior emission diminution of 5.26% of HC, 16.6% of CO, 6.2% of smoke when compared with base diesel fuel, despite marginal penalty of 5.26% of carbon dioxide and 4.8% of oxides of nitrogen emission at full load condition. Characteristics of combustion parameters like pressure inside the cylinder and rate of the heat released were superior for 20% blend of MEME at the peak load condition.[10]. The results showed that the brake thermal efficiency was improved by 8% when the nanoparticle additive dosage level was varied from 25 to 100 ppm, and a maximum improvement was observed at dosing levels of 25 and 75 ppm. Specific fuel consumption was reduced up to 0.05 kg/kWh at 80% load with the addition of 25 ppm. The carbon dioxide (CO2), carbon monoxide (CO), nitrogen oxide (NOx) and hydrocarbon (HC) emissions were reduced to a greater extent with the addition of γ-Al_2O_3 nanoparticle additive, when compared to the biodiesel without γ-Al_2O_3 nanoparticle at all load conditions of the engine. The dosage of nanoparticle to biodiesel fuel results in appreciably improved engine efficiencies, lower values of smoke, and lower CO and HC emissions. Thus, the experimental results proved that nanoparticle-added PME is one of the most suitable alternatives to diesel fuel.[11]. Experimental investigation revealed that the 20% blend resulted in 4.18%, 5.12% more prominent performance characteristics of brake thermal efficiency, brake specific energy consumption, and superior emission diminution of 5.26% of HC, 16.6% of CO, 6.2% of smoke when compared with base diesel fuel, despite marginal penalty of 5.26% of carbon dioxide and 4.8% of oxides of nitrogen emission at full load condition. Characteristics of combustion parameters like pressure inside the cylinder and rate of the heat released were superior for 20% blend of MEME at the peak load condition[12]. Advancement in injection timing for B20+25 ppm TiO2 nanoparticle additive results in an increase of brake thermal efficiency, decreases brake specific fuel consumption and giving out less HC, CO, smoke emissions but the marginal increase in the NOX emission[13].

2. MATERIALS AND METHODS

2.1 *Rapeseed:*

Rapeseed is a bright-yellow flowering member of the family Brassicaceae (mustard or cabbage family). Rapeseed oil was produced in the 19th century as a source of a lubricant for steam engines. It was less useful as food for animals or humans because it has a bitter taste due to high levels of glucosinolates. According to the United States Department of Agriculture, rapeseed was the third-leading source of vegetable oil in the world in 2000, after soybean and palm oil. Leading producers of Rapeseed include the European Union, Canada, China, India and Australia. Rapeseed oil is positioned to supply a good portion of the vegetable oils needed to produce that fuel. Every ton of rapeseed yields about 400 kg of oil. Worldwide production of rapeseed was 61 million metric tons (MT) in 2011. China was the top rapeseed producing country, producing 14.7 million MT, and India was second, producing about 7.3 million MT.

2.2 Transesterification:

The major components of vegetable oils and animal fats are Triglycerides. To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed Transesterification.

Table.1 : Properties of various Bio Diesels:

S.No	Parameter tested	Rapeseed biodiesel	Cotton seed biodiesel	Mahua biodiesel	Rubber seed biodiesel	Jatropa Biodiesel
1.	Density @ 15°C (kg/m^3)	898	868	828	845	887
2.	Cetane Index	65	57	62	65	59
3.	Kinematic viscosity,@40°C (Cst)	7.52	6.52	7.82	8.82	8.82
4.	Gross Calorific value (MJ/kg)	38.95	36.95	38.95	37.95	39.85
5.	Flash point °C	165	168	156	165	192
6.	Fire point °C	181	191	161	171	200

Table .2:Test Engine Specifications

S.No.	Component	Specification
1	Engine	Single cylinder four stroke, Make Kirloskar
2	Power	5.2kW
3	Speed	1500 rpm
4	Stroke	110 mm
5	Bore	87.5 mm
6	Dynamometer	Eddy Current, water cooled Type
7	Piston	Yttria-Stabilised Zirconia
8	Piezo Sensor range	5000PSI
9	Crank Angle Sensor Resolution	1^0, speed 5500rpm with TDC Pulse
10	Temperature Sensor Type	RTD PT100
11	Thermo Couple Type	K
12	Software	Engine Soft- Lab view based

The Transesterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol. A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerine. The nature of the fatty acids can in turn affect the characteristics of the biodiesel. During the esterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerol. In most production methanol or ethanol is the alcohol used (methanol produces methyl esters, ethanol produces ethyl esters) and is base catalyzed by either potassium or sodium hydroxide. Potassium hydroxide has been found to be more suitable for the ethyl ester biodiesel production; either base can be used for the methyl ester. A common product of the transesterification process is Rapeseed Methyl Ester (RME) produced from raw rapeseed oil reacted with methanol. The figure below shows the chemical process for methyl ester biodiesel. The reaction between the fat or oil and the alcohol is a reversible reaction and so the alcohol must be added in excess to drive the reaction towards the right and ensure complete conversion. the comparision of all biodiesel are mentioned in Table.1

3. EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ - PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters 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 “EnginesoftLV” is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided.

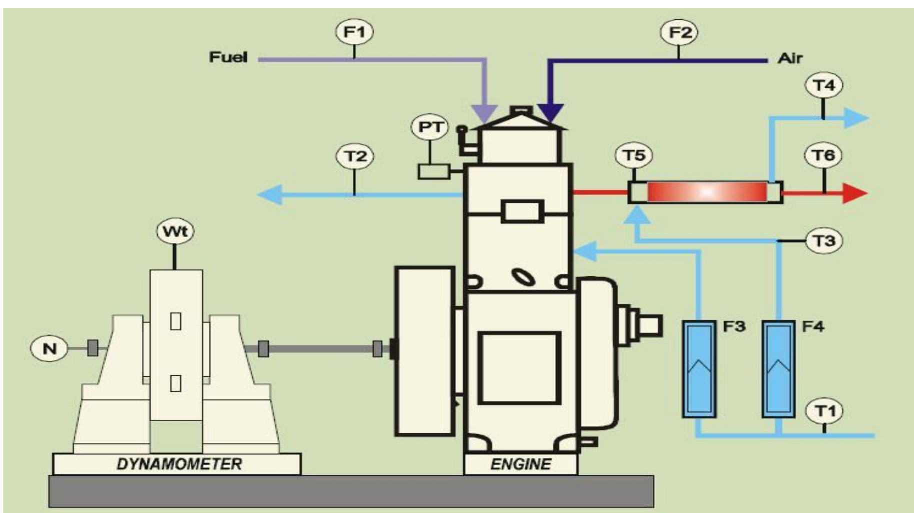

Fig.1: Schematic diagram

Fig 2: Experimental set- up

4. RESULTS AND DISCUSSION

Using the data obtained from experimental investigation, different parameters related to performance ,combustion and emissions are considered and graphs are plotted. The results that are obtained is discussed in following subsections.

4.1 Variation of Brake thermal efficiency with BP

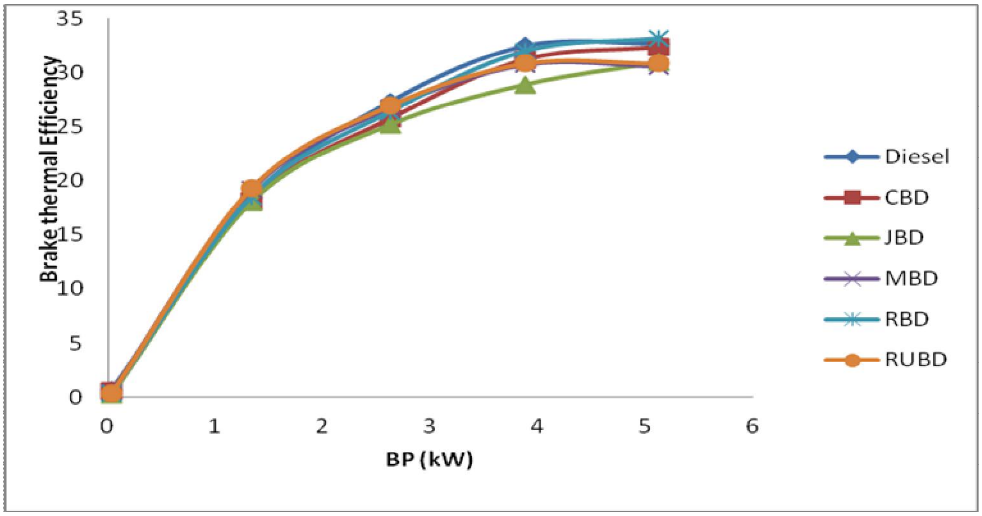

Fig. 3: Variation of Brake thermal efficiency with BP

Figure 3shows Brake thermal efficiency is higher for Rapeseed oil compared to all biodiesel at full load condition and at no load condition almost all bio diesels have same brake thermal efficiency and upto 50% of the load.the curve trend shows tthat gradually increased. Rubber seed Biodiesel is at full load shows less brake thermal efficiency.

4.2 *Variation of Brake specific fuel consumption with BP*

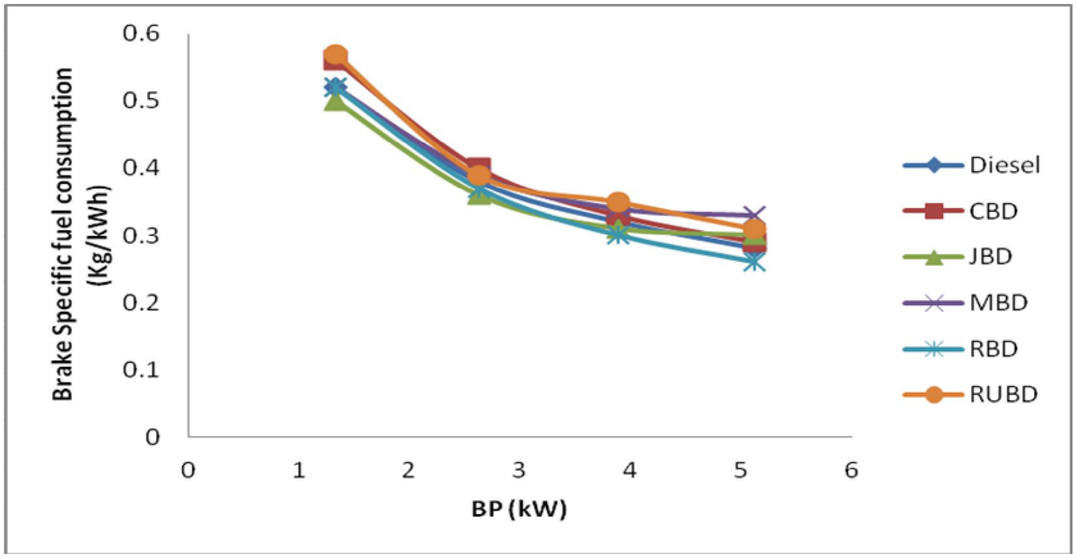

Fig. 4: Variation of Brake specific fuel consumption with BP

Figure 4 shows shows Brake specific fuel consumption is higher for cotton biodiesel & rubber seed bio diesel compared to all biodiesel at initial condition and at full load condition for Rapeseed bio diesel have less Brake specific fuel consumption and upto 50% of the load the curve trend shows that gradually decreased.

4.3 Variation of cylinder pressure with respect to crank angle

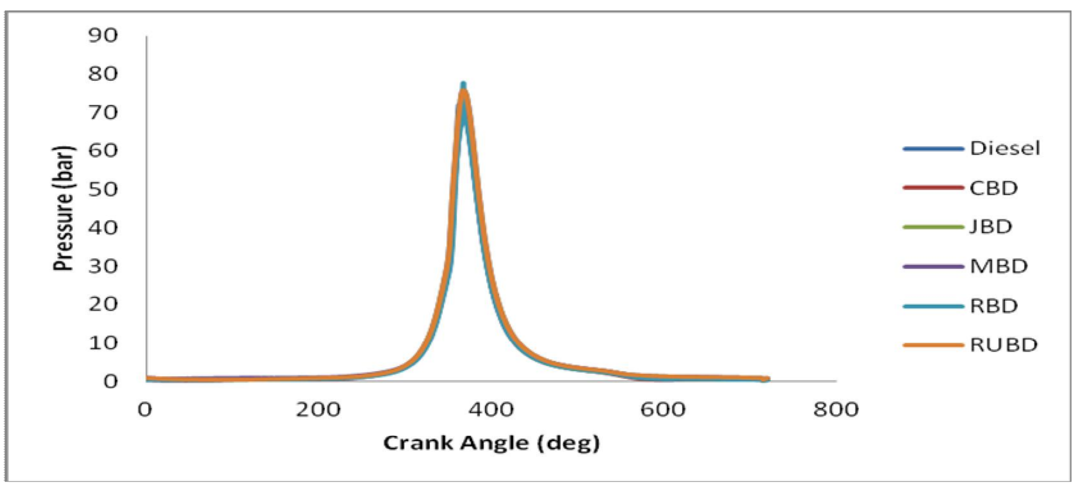

Fig 5: Variation of cylinder pressure with respect to crank angle

Figure 5 shows that variation in cylinder pressure with respect to crank angle for all biodiesels ,and it is observed rapseed seed biodiesel has good characteristics and the pressure attained is 75.8 bar compared to all biodiesels. Rapeseed biodiesel has lowest cylinder pressure as compared to all Biodiesels.

4.4 Variation of Heat Release Rate with respect to crank angle

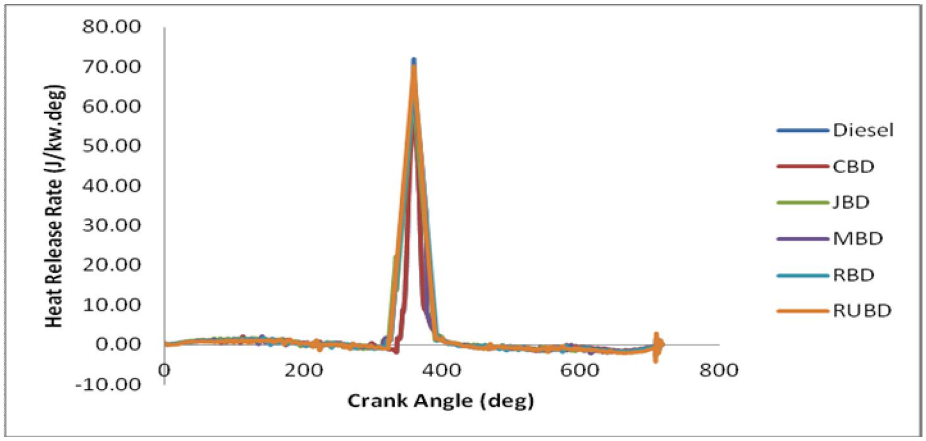

Fig. 6: Variation of Heat Release Rate with respect to crank angle

Figure 6 shows that variations in the heat release rate with respect to crank angle for all bio diesels, the results shown that higher caloric value achieved for Rapseed oil.

4.5 Variation of HC Emissions for all biodiesels

Figure 7 shows variation of Hydro Carbon emissions with respect to brake power the evidence that at initial brake power cotton seed ,mahuva, rapeseed biodiesels are have very less emissions 0.8 PPM. At maximum brake power compared to all bio diesels rapeseed biodiesel has less emissions 10 PPM.

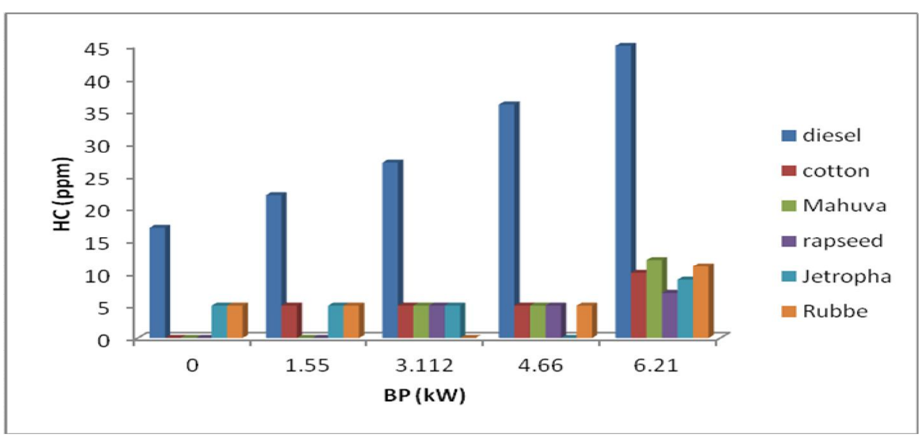

Fig. 7: Variation of HCEmissions with respect to brake power for all biodiesels

4.6 *Variation of Carbon Monoxide Emissions for all biodiesels*

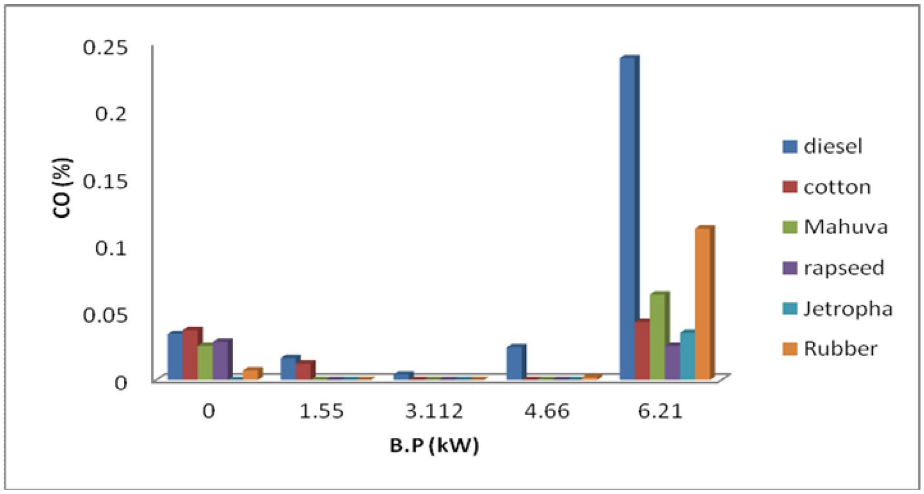

Fig. 8: Variation of CO Emissions with respect to brake power for all biodiesels

Figure8 shows variation of Carbon Monoxide emissions with respect to brake power the shows evidence that at initial brake power Jatropa biodiesels are have very less emissions 0.6 %. At maximum brake power compared to all bio diesels rapeseed biodiesel has less emissions 0.03%.at brake power 3.112 KW all biodiesels are no emissions but diesel producing 0.01% of CO .

4.7 *Nitrogen Oxide Emissions*

Figure 9 shows variation of NOx emissions with respect to brake power the shows evidence that at initial brake power Cotton seed biodiesels are have very less emissions 78 PPM. At maximum brake power compared to all bio diesels has less emissions 2000 PPM . In the figure as brake power increases NOx emissions are increasing drastically due to low heat release rate.

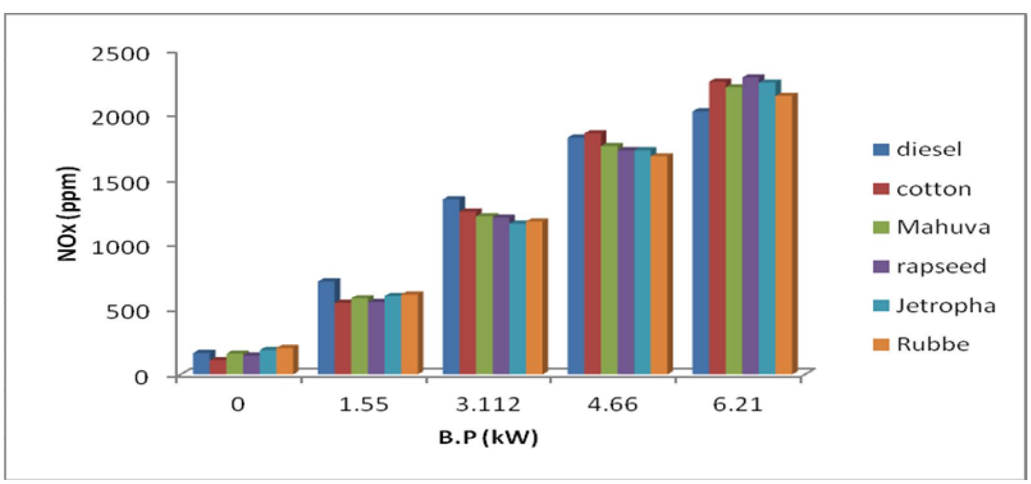

Fig. 9: Variation of NO Emissions with EGR for Rapeseed Oil Methyl Ester

Fig. 7: Variation of NOx Emissions respect to brake power for all biodiesels

Fig. 9: Variation of NOx Emissions with respect to brake power for all biodiesels

4.8 *Variations of CO2 Emissions in all biodiesels*

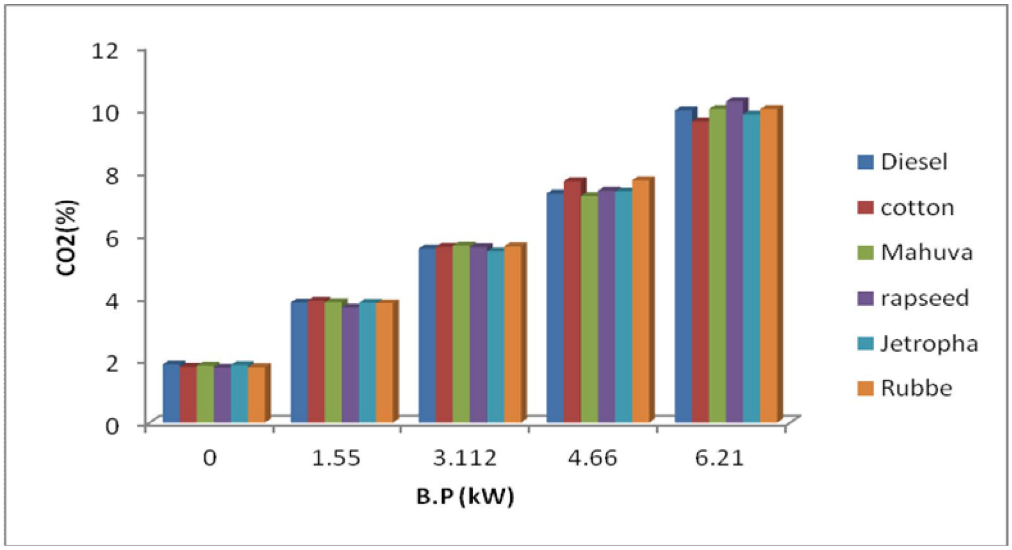

Fig. 10: Variation of CO_2 Emissions respect to brake power for all biodiesels

Figure 10 shows variation of CO_2 emissions with respect to brake power the shows evidence that at initial brake power all biodiesels are have very less emissions 1.8% . At maximum brake power compared to all bio diesels cotton seed biodiesel has less emissions 9.2 % . In the figure as brake power increases CO_2 emissions are increasing drastically due to lower calorific value .

4.9 *Variations of Smoke Emissions in all biodiesels:*

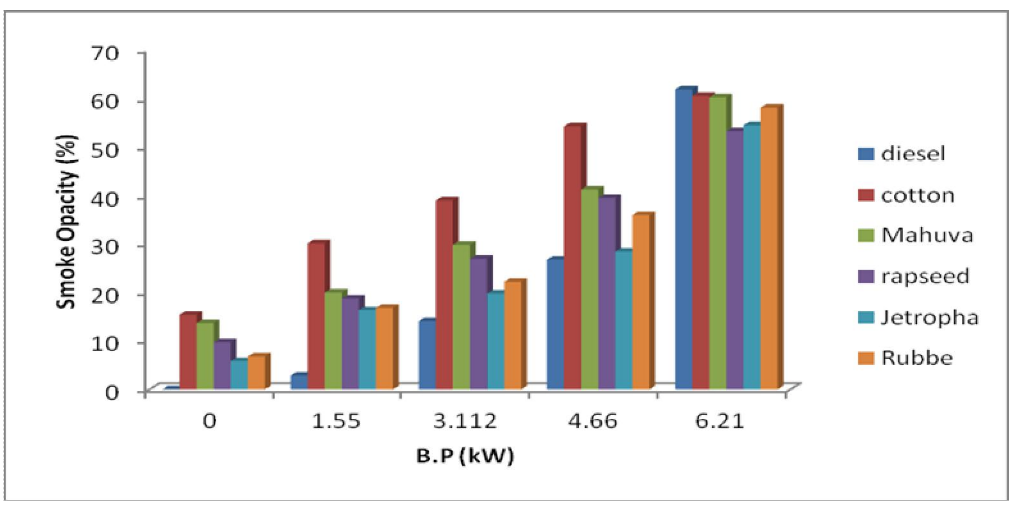

Fig. 11: Variation of Smoke Emissions respect to brake power for all biodiesels

Figure 11 shows variation of smoke emissions with respect to brake power the shows evidence that at the rapeseed bio diesel shown lower value when compared to that of diesel fuel at full load condition.

5. CONCLUSIONS

The calorific value of various biodiesel are less as compared to diesel which causes increase in specific fuel consumption, and any biodiesel has heat release rate will be low due to lower calorific value as compared with the diesel as shown in the results. Attaining pressure inside the cylinder operating with various biodiesels rapeseed biodiesel shows better results as compared diesel. From experimental investigation it is found that rapeseed biodiesel shown Brake thermal efficiency increases and specific fuel consumption decreases as compared to other biodiesels. In emission parameters, at full load operating condition of engine rapeseed biodiesel emissions of carbon monoxide CO was 0.04% as less compared to other biodiesels, and Unburnt Hydrocarbons (HC) was found to be decreased due to availability of Oxygen in the Rapeseed biodiesel as 10ppm very less compared to diesel . However emission of Nitrogen oxide (NO),carbon dioxide was increased as load increases . Biodiesel as an oxygenated fuel undergoes improved combustion in engine due to presence of molecular oxygen that leads to higher Nitrogen oxide emissions. The present experimental result supports that Rapeseed biodiesel can be successfully used in existing diesel engine without any modifications.

6. REFERENCES

1. Meher, L.C., Sagar, D.V. Naik, S.N. “Technical aspect of biodiesel production by transesterification- a review”, Renewable and Sustainable Energy Review .2006;10 : 248-256
2. T Hari Prasad, K Hema Chandra Reddy, M Muralidhara Rao, “Combustion, performance and emission analysis of diesel engine fuelled with methyl esters of Pongamia oil”, International Journal of Oil, Gas and Coal Technology.2010;3(4):374-383.
3. R. Ghanei1, A. Heydarinasab, G.R. Moradi, V. Falahati1 Process optimization for biodiesel production from waste frying oil with constructional lime. International Journal of Biosciences. 2014;4(6): 36-45.
4. J. Sadhik Basha a, R.B. Anand b, “Performance, emission and combustion characteristics of a diesel engine using Carbon Nanotubes blended Jatropha Methyl Ester Emulsions”. Alexandria Engineering Journal . 2014;53, 259–273. Production and hosting by Elsevier.

5. Shalini Rajvanshi, Mahendra Pal Sharma. "Microalgae: A Potential Source of Biodiesel". Journal of Sustainable Bioenergy Systems, 2012, 2, 49-59
6. A. B. M. S. Hossain, A. N. Boyce, A. Salleh and S. Chandran. Impacts of alcohol type, ratio and stirring time on the biodiesel production from waste canola oil. African Journal of Agricultural Research. 2010; 5(14): 1851-1859.\
7. R. Selvan, Dr. K. Maniysundar, "Performance and Emission Analysis of single cylinder Diesel Engine using Jatropha oil with EGR" International Journal of Science, Engineering and Technology Research (IJSETR).2014;3(1): 14-18.
8. V Achuthanunni, B Baiju , "Experimental Investigation of a Diesel-Biodiesel Fuelled Compression Ignition Engine with Exhaust Gas Recirculation (EGR)" International Journal of Engineering and Advanced Technology (IJEAT).2014;4(1):23-29.
9. J. G. Suryawanshi, N. V. Deshpande, "Effect of EGR on Performance and Emissions in a Diesel Engine Fuelled with Jatropha Oil Methyl Ester" Symposium on International Automotive Technology. 2005;26(28): 445-457.
10. R.L. Krupakaran, T. Hariprasasd, A. Gopalakrishna & Pejjai Babu The performance and exhaust emissions investigation of a diesel engine using γ-Al2O3 nanoparticle additives to biodiesel DOI: 10.1080/17583004.2016.1218713.
11. R.L. Krupakaran, T. Hariprasasd, A. Gopalakrishna Impact of various blends of Mimusops elengi methyl esters on performance and emission characteristics of a diesel engine https://doi.org/10.1080/15435075.2018.1469496.
12. R. L. Krupakaran, T. Hariprasasd & A. Gopalakrishna Influence of injection timing on engine performance, emission characteristics of Mimusops Elangi methyl ester. https://doi.org/10.1080/01430750.2018.1472639.
13. A. Paykani A, Akbarzadeh and M. T. Shervani Tabar, "Experimental Investigation of the Effect of Exhaust Gas Recirculation on Performance and Emissions Characteristics of a Diesel Engine Fueled with Biodiesel" IACSIT International Journal of Engineering and Technology. 2011;3(3): 239-243.
14. M. Ghazikhani, M.R. Kalateh, Y. K. Toroghi, "An experimental study on the Effect of EGR and Engine speed on CO and HC Emissions of Duaal Fuel HCCI Engine", Proceedings of world academy of science, Engineering and Technology, 2009;40: 136-141.