Experimental Investigation of Injectors Nozzle Hole on CI engine Using Jatropha Oil as Bio-fuel

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ABSTRACT

Depleting petroleum reserves, rising petroleum prices, threat to the environment from exhaust emissions and global warming demands an intensive international interested to developing alternative non petroleum fuels for engines. Fossil fuels are the chief contributors to urban air pollution and major source of green house gases (GHGs) and considered to be the prime cause behind the global climate Performance and emission characteristics are evaluated for three non-edible vegetable oils viz.sea lemon, tobacco, palm and sea lemon methyl ester to study the effect of injection pressures In the context of fast depletion of fossil fuels and increasing of diesel engine vehicle population, the use of renewable fuel like vegetable oils becomes more important. The present work has focused on the performance of Jatropha non-edible vegetable oils and its blend with diesel. The viscosity of Jatropha oil is reduced first by blending with diesel in 20%, 40%,60%,80% and 100% on the volume basis, then analyzed and compared with diesel. The performance and emission characteristics of blends are evaluated at variable loads at constant rated speed of 1500rpm and results are compared with diesel. The tests were conducted for injection pressure of 210 bar with fuel injector of 5, 7,9,11 holes. In this investigation it is found that the nozzle having 9 holes gives good performance results and lower rate of emissions. Thus the nozzle with 9 holes can be used preferably than the 5,7,11holes nozzle.

Keywords: *Performance, emission characteristics, Jatropha oil, Injectors, diesel Engine*

1. INTRODUCTION

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources. The search for alternative fuels, which promise a harmonious correlation with sustainable development, energy conservation efficiency and environmental preservation, has become highly pronounced in the present context [1,17].Petroleum based fuels play a vital role in rapid depletion of conventional energy sources along with increasing demand and also major contributors of air pollutants. Major portion of today's energy demand in India is being met with fossil fuels [5,8,16]. Hence it is high time that alternate fuels for engines should be derived from indigenous sources. Bio fuel is a renewable energy source produced from natural (plant) materials, which can be used as a substitute for petroleum fuels. The most common bio fuels, such as ethanol from jatropha, wheat or sugar beet and biodiesel from oil seeds, are produced from classic food crops that require high-quality agricultural land for growth [2, 3,18]. Serious problems face the world food supply today. Food versus fuel is the dilemma regarding the risk of diverting farmland or crops for liquid bio fuels production in detriment of the food supply on a global scale [4,6]. As India is an agricultural country, there is a wide scope for the production of vegetable oils (both edible and non-edible) from different oil seeds. The present work focused only on non-edible oils as fuel for engines, as the edible oils are in great demand and far too expensive. The past work revealed that uses of vegetable oils for engines in place of diesel were investigated. Though the concerned researchers recommended the use of vegetable oils in diesel engines, there was no evidence of any practical vegetable oil source engines [7,15,23]. The fuel injection performance is important for low emission combustion. In the case of agricultural applications, fuels that can be produced in rural areas in a decentralized manner, near the consumption points will be favoured. The permissible emission levels can also be different in rural areas as compared to urban areas on account of the large differences in the number density of engine [9,11,13]. Current combustion chambers for passenger car and truck diesel engines typically utilize direct injection system with a fairly shallow piston bowl and a central fuel injector with 5,7,9,11 holes. Sea lemon oil, Karanji oil, Coconut oil, Sunflower oil, Rapeseed oil and Neem oil are some of the vegetable oils that have been tried as fuels in internal combustion engines earlier. It was also found that the heat release rate is very similar to diesel with vegetable oils. This paper the main aspects of Jatropha biodiesel as fuel in CI engine operated with fuel injector having 5 and 7 holes and injection pressure of 210 bar [10,15,18, 21]. These fuels tend to burn cleaner with its performance comparable to conventional diesel fuel and combustion similar to diesel fuel. Biodiesel is a non-polluting fuel made from organic oils of vegetable origin. Chemically it is known as free fatty acid methyl ester [12, 22, 24]. Studied the effect of fuel injection pressures play a vital role in engine exhaust emissions. Higher injection pressures create faster combustion rates which result in higher gas temperatures as compared to the conventional low pressure system [24].

2. TRANSESTERIFICATION

Tranesterification is the most common method to produce biodiesel, which refers to a catalyzed chemical reaction involving Vegetable oil, and an alcohol to yield fatty acid alkyl esters and glycerol i.e. crude glycerine [15-17,19]. The process of 'transesterification' is sometimes named methanolysis or alcoholysis. This method is used to convert the Jatropha oil in to jatropha oil methyl ester. After transesterification, viscosity of Jatropha oil methyl esters (JOME) is reduced by 75-85%. It is also called fatty acid methyl esters, are therefore products of transesterification of Jatropha oil and fats with methyl alcohol in the presence of a KOH catalyst [25]. During the reaction, high viscosity oil reacts with methanol in the presence of a catalyst KOH to form an ester by replacing glycerol of triglycerides with a short chain alcohol [14, 23, 26].

[Triglycerides (Jatropha oil) + Methanol $\longrightarrow$ Jatropha oil methyl ester + Glycerol]

Methanol/methyl alcohol is preferred for JOME preparation by using transesterification as it provides better separation of methyl ester and crude glycerin thus facilitating the post-reaction steps of obtaining biodiesel.

3. EXPERIMENTAL SETUP

The set up consist of a single cylinder, water cooled, four stroke direct injection (DI) compression ignition engine with a compression ratio of 16.5: 1 and developing 3.7 kW power at 1500 rpm. The specification of the test engine is shown in table 2. The engine was coupled with an eddy current dynamometer .Standard diesel is used to start the single cylinder engine and is allowed to warm up. The Redwood Viscometer is used to measure the viscosity of fuels at various temperatures. A crank angle encoder was fitted to the output shaft to measure the crank angle. The cylinder pressure was measured by a Kistler piezoelectric pressure transducer (Type 6056A) mounted on the cylinder head in the standard position. The pressure signals was sent to data acquisition system and combustion data like cylinder pressure, ignition delay, cumulative heat release, cyclic pressure variation, heat release rate and rate of pressure rise were directly obtained.

Figure 1: Experimental Setup

Variable load tests are conducted for 0, 0.847, 0.169, 0.254, 0.35, and 0.435 4Mpa at a constant rated speed of 1500 rpm with fuel injection pressure of 210 bar, and cooling water exit temperature of 40°C. The performance characteristics of the engine are evaluated in terms of brake thermal efficiency, brake specific fuel consumption (BSFC), brake specific energy consumption (BSFC), and exhaust temperature. Two gas exhaust gas analyse and smoke opacity meter are used to find the emission characteristics.

4. ENGINE SPECIFICATIONS

Table.1: Specification of test engine

Make	Kirloskar AV-1
Type	Single cylinder, water cooled,
Max.power	3.7 kW at 1500 rpm
Displacement	550 CC
Bore x Stroke	80 x 110 mm
Compression ratio	16.5:1
Fuel injection timing	21deg BTDC
Loading device	Eddy current dynamometer

Table.2: Properties of diesel and jatropha

Fuel	Diesel	jatropha
Calorific value (MJ/kg)	46.22	42.56
Kinematic viscosity,(mm^2/s)@ 30°C	4.56	42.2
Density @ 20 C kg/m^3	0.83	0.875
Flash Point °C	54	143
Fire Point °C	64	149

5. RESULT AND DISCUSSION

5.1. Brake thermal efficiency

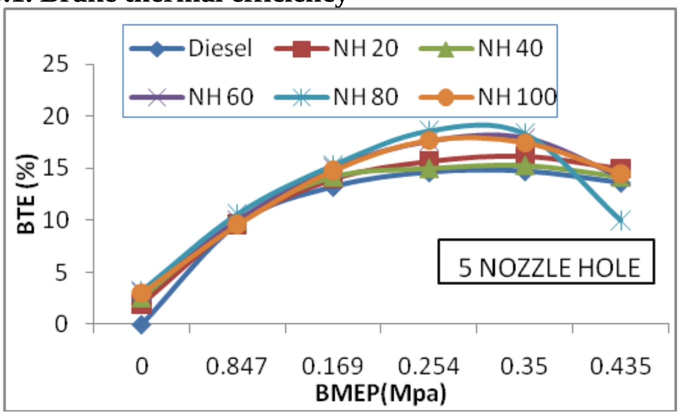

Fig.2 BTE Vs BMEP with 5 hole nozzle

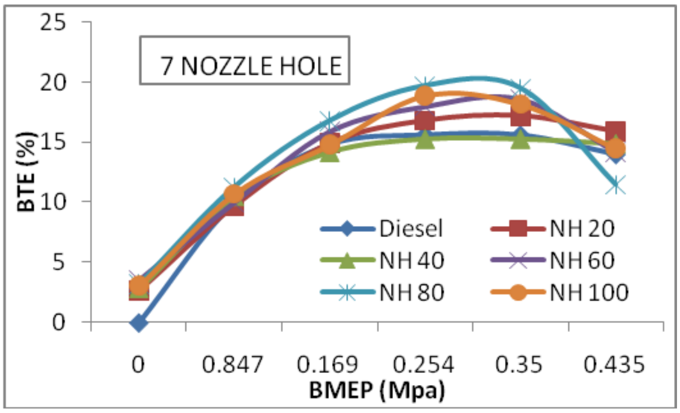

Fig.3 BTE vs BMEP with 7 hole nozzle

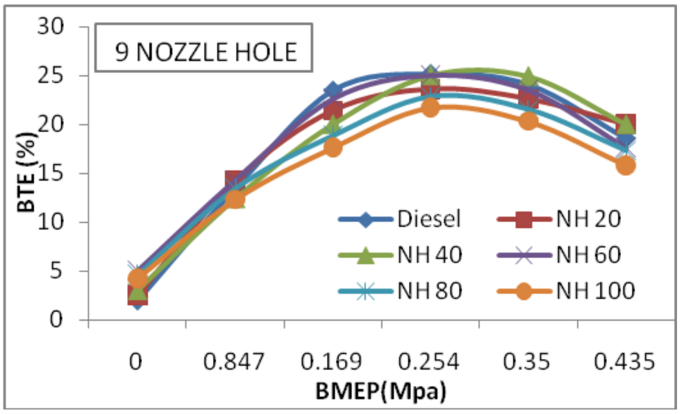

Fig.4 BTE Vs BMEP with 9 hole nozzle

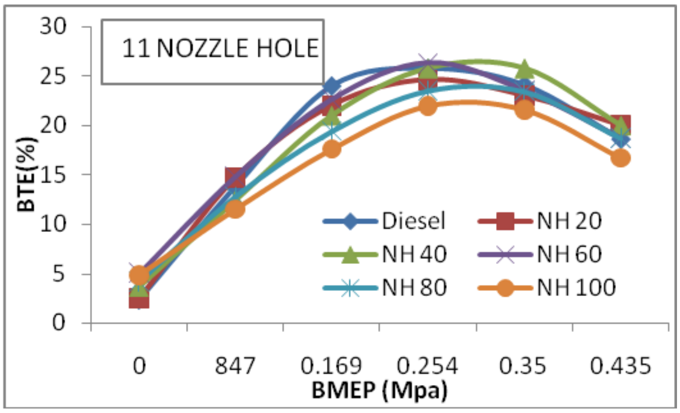

Fig.4 BTE Vs BMEP with 11 hole nozzle

The different nozzle used in the various percentage of the jatropha oil in the different nozzle shown in the Figure 2,3,4 and 5 shows the comparison of break thermal efficiency with 5,7,9 and 11 hole nozzle for Jatropha oil and its blends with respect to brake power. It was noticed that break thermal efficiency of 23.5% for diesel and 25% for N60 for 9 hole nozzle, and 24% for diesel and 26.03% for N60 was obtained for 11 hole nozzle. The main reason for increase in the brake thermal efficiency is due to more homogeneous mixture formation and spray characteristics are maintain the presence of the oxygen in the bio fuels.

5.2. Indicated thermal efficiency:

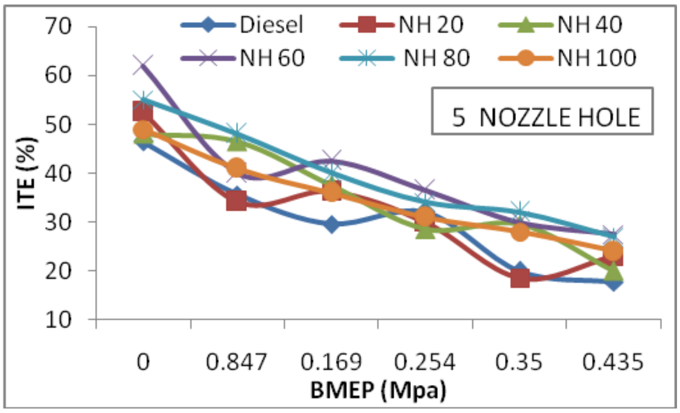

Fig.6 ITE Vs BMEP with 5 hole nozzle

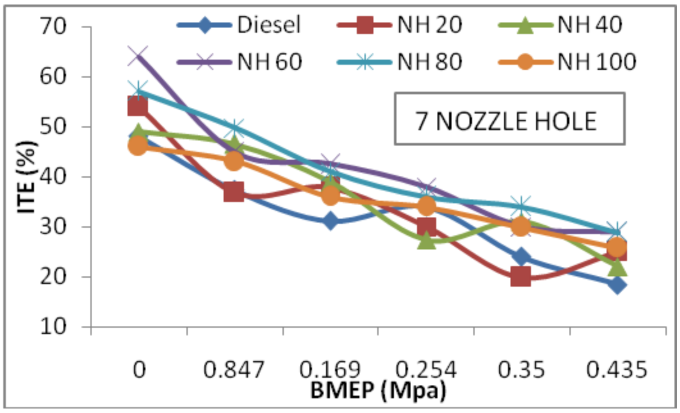

Fig.7 ITE Vs BMEP with 7 hole nozzle

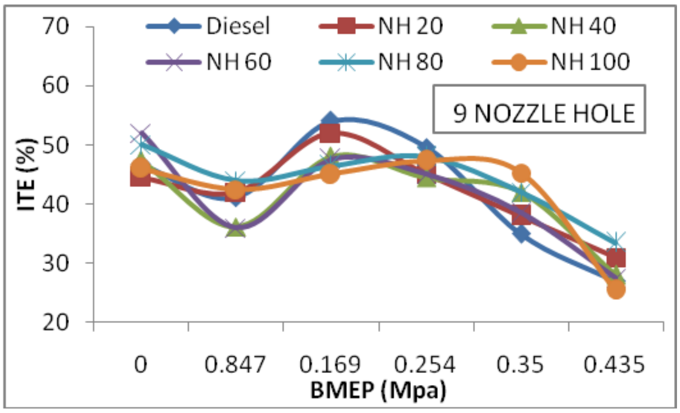

Fig.8 ITE Vs BMEP with 9 hole nozzle

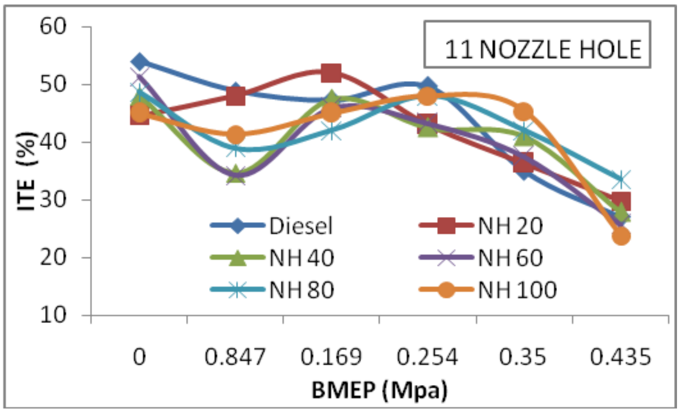

Fig.9 ITE Vs BMEP with 11 hole nozzle

Figure 6, 7, 8 and 9 shows the comparison of indicated thermal efficiency with 5,7,9 and 11 hole nozzle for Jatropha oil and its blends with respect to brake power. It was noticed that indicated thermal efficiency of 27% for diesel and 33.5% for N80 for 9 hole nozzle, and 27.8% for diesel and 28.8% for N25 was obtained for 11 hole nozzle.

5.3. Brake Specific fuel consumption:

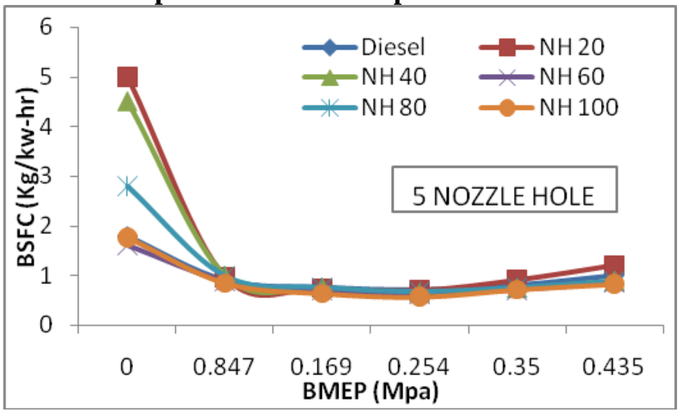

Fig.10 BSFC Vs BMEP with 5 hole nozzle

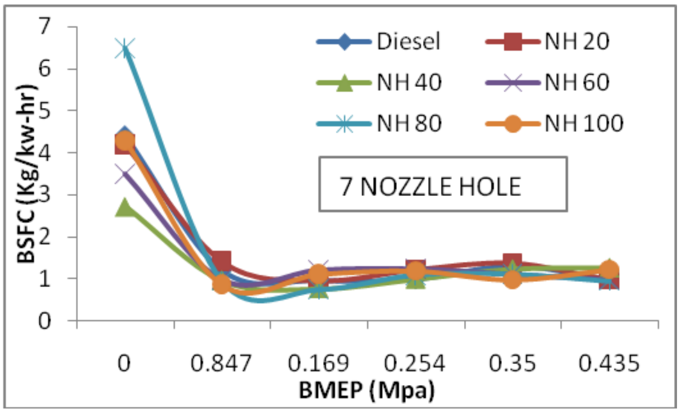

Fig.11 BSFC Vs BMEP with 7 hole nozzle

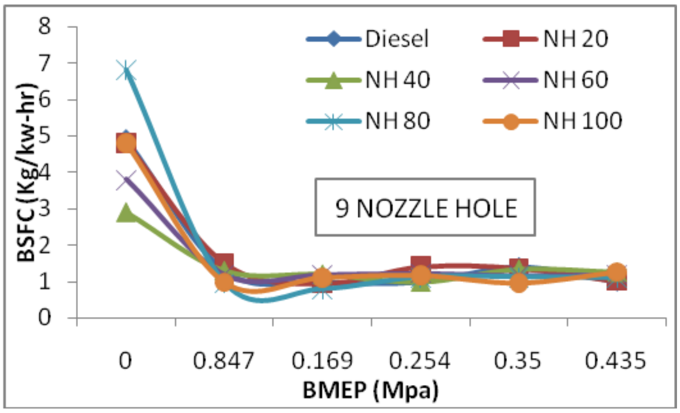

Fig.12 BSFC Vs BMEP with 9 hole nozzle

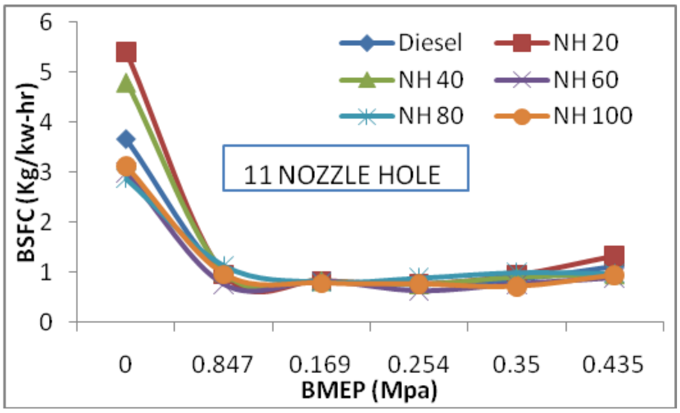

Fig.13 BSFC Vs BMEP with 11 hole nozzle

Brake specific fuel consumption in all cases , it decreased significantly with increase of all the loads of all the fuels. The main reason for this may be increase that the percentage of the mean effective pressure. Figure 10,11,12 and 13 shows the comparison of specific fuel consumption of 5,7,9 and 11 hole nozzle for Jatropha oil and its blends with respect to brake power. It was noticed that SFC of 0.49% for diesel and 0.68% for N80 for 9 hole nozzle, and 0.36% for diesel and 0.54% for N20 was obtained for 9 hole nozzle which is maintained due to presence of oxygen in the bio fuels.

5.4. Carbon monoxide emission:

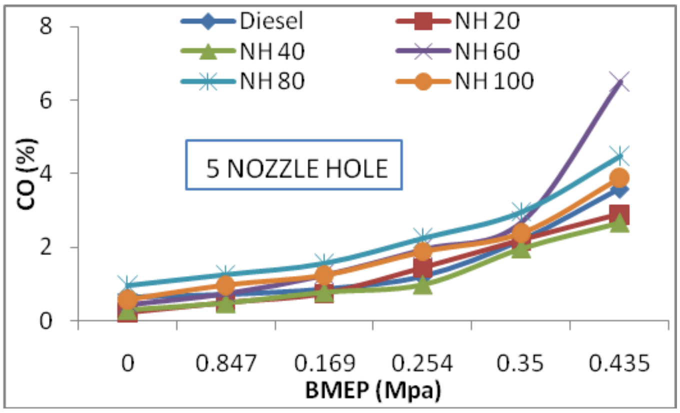

Fig.14 CO Vs BMEP with 5 hole nozzle

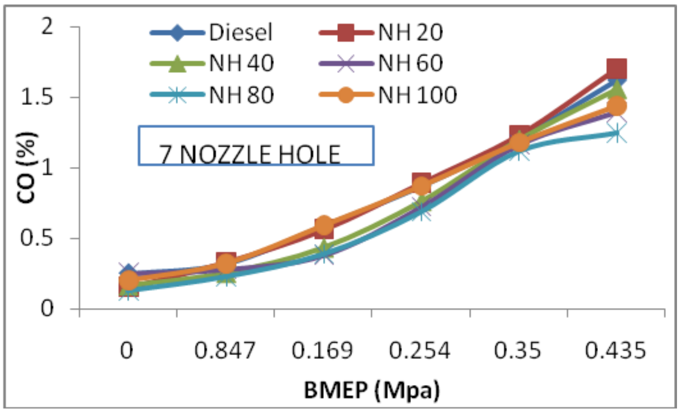

Fig.15 CO Vs BMEP with 7 hole nozzle

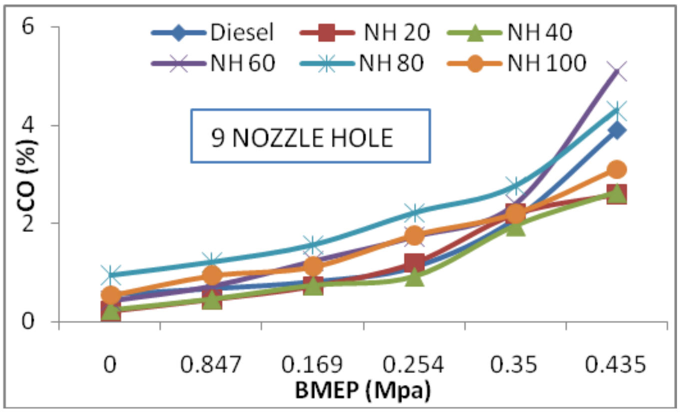

Fig.16 CO Vs BMEP with 9 hole nozzle

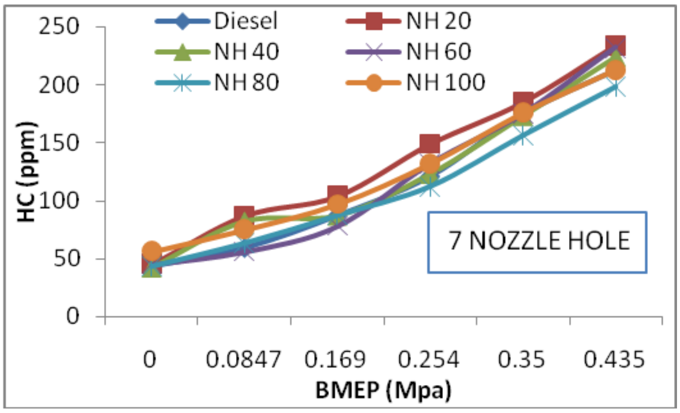

Fig. 19 HC Vs BMEP with 7 hole nozzle

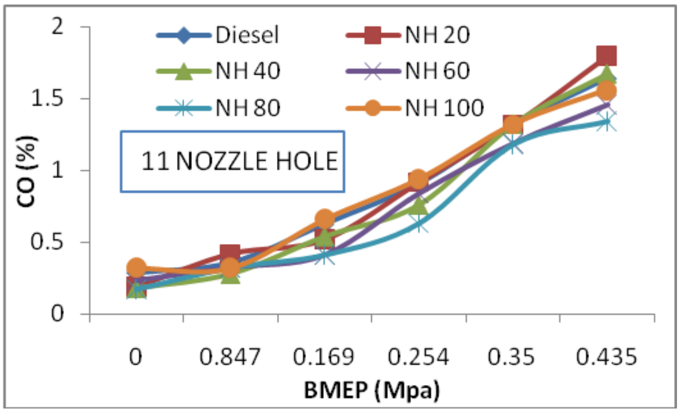

Fig.17 CO Vs BMEP with 9 hole nozzle

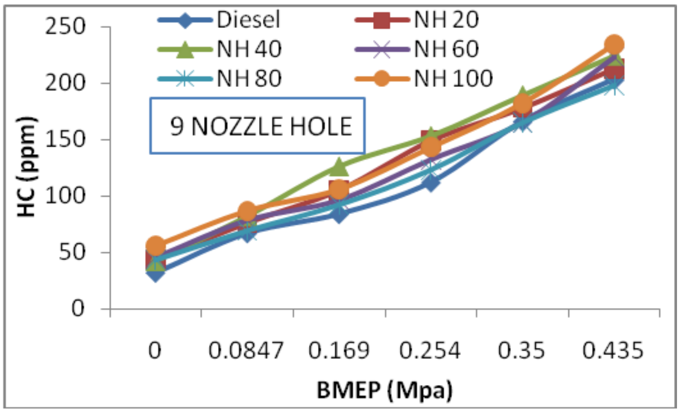

Fig 20 HC Vs BMEP with 9 hole nozzle

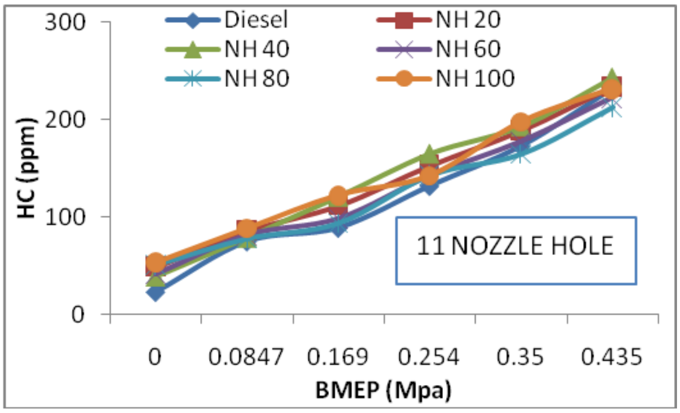

Fig 21 HC Vs BMEP with 11 hole nozzle

Carbon monoxide emission from engine exhaust is lower in the compression ignition engine compared to spark ignition engine since the compression ignition are always operated with lean mixture. The important variation of the nozzle hole is slightly move the comparison of carbon monoxide for 14,15,16 and 11 hole nozzle for Jatropha oil and its blends with respect to brake power. It was noticed that Co emission of 3.9% volume for diesel and 5.1%volume for N60 for 9 hole and 1.34% volume for diesel and 1.8% volume for N20 for 11 holes nozzle was obtained which is maintained due to presence of oxygen in the bio fuels. The bio fuels initially actuate the diesel value in the nozzle hole of the other two position of the injector.

5.5. Hydro-carbon emission:

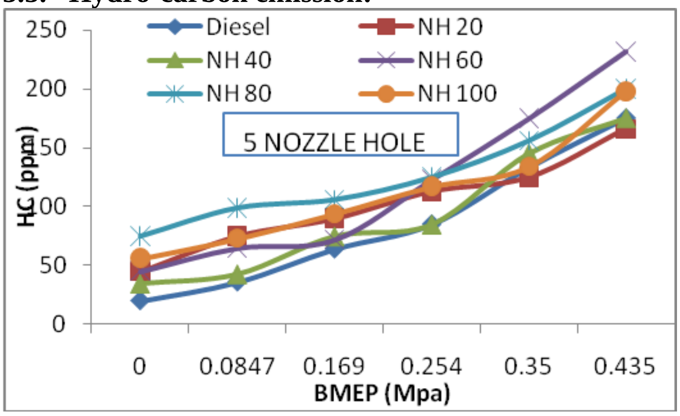

Fig. 18 HC Vs BMEP with 5 hole nozzle

Un burnt Hydrocarbon is the direct result of incomplete combustion in the combustion chamber .Figure shows the comparison of Hydrocarbon for 18,19,20 and 21 hole nozzle for Jatropha oil and its blends with respect to brake power. It was observed that diesel has the maximum rate of hydrocarbon 140 ppm and hydrocarbon of 20 ppm for N50 for 5, 7 hole nozzle among the tested fuels. It is also found that the hydrocarbon of 160 ppm for diesel and 70 ppm for N50 was obtained for 9 hole nozzle.

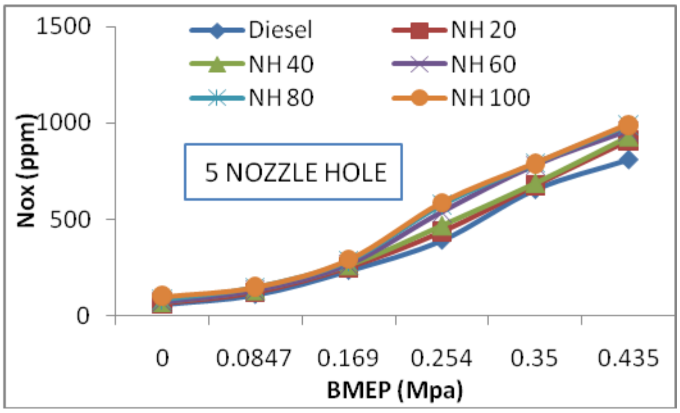

Fig 22 NOx Vs **BMEP with 5 hole nozzle**

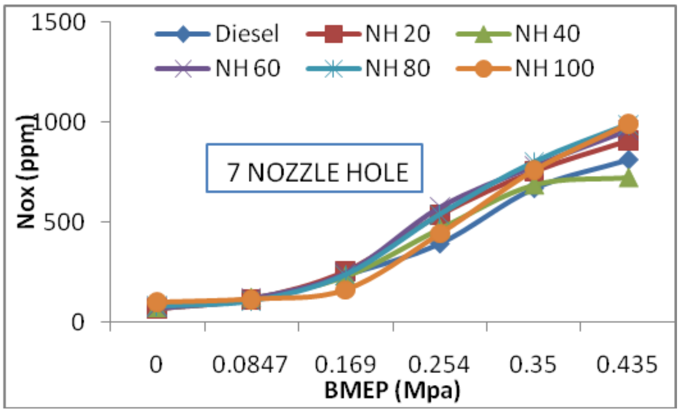

Fig 23 NOx Vs **BMEP with 7 hole nozzle**

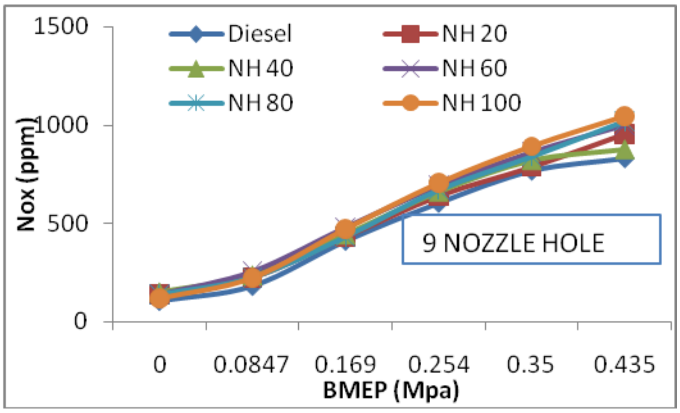

Fig 24 NOx Vs **BMEP with 9 hole nozzle**

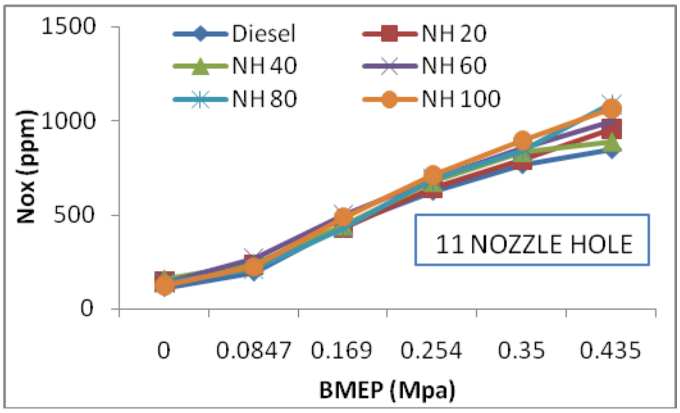

Fig 25 NOx Vs **BMEP with 11 hole nozzle**

Nitric oxide formation in a combustion ignition engine depends on the oxygen availability and combustion temperature. Nox emission are high in the case of the oxygen present in the ester molecule that enhances the combustion process that increases combustion temperature. Figure shows the comparison of Hydrocarbon for 18, 19, 20 and 21 hole nozzle for Jatropha oil and its blends with respect to brake power. It was observed that diesel has the maximum rate of hydrocarbon 1200 ppm and hydrocarbon of 700 ppm for N50 for 5,7 hole nozzle among the tested fuels. It is also found that the hydrocarbon of 1100 ppm for diesel and 800ppm for N20 was obtained for 9 hole nozzle.

6. CONCLUSION

- The performance characteristics of Jatropha biodiesel and its blends are evaluated with 5,7, 9 and 11 holes nozzle at 210 bars.
- The brake thermal efficiency for 5 hole nozzle is lower than that of 9 hole nozzle. These variation can be attributed to the increase in the thermal efficiency of the engine with different injectors holes.
- The indicated thermal efficiency for 5,7,9 hole nozzle is also lower than that of 11 hole nozzle due to the calorific value of the fuel and to get the better atomization.
- The specific fuel consumption for 5 hole nozzle is slightly lower than the nozzle of having 9 holes. This may be due to better combustion, and increase in the energy content of the blend.
- The emission of CO is more in 9 hole nozzle as compared with 11 hole nozzle. this is due to the presence of oxygen content in the fuels, which promotes more complete combustion.
- The emission of NOx is more in 9 hole injector nozzle compared to the other nozzle due to the longer chains fatty acids and higher degrees of saturation.

REFERENCES

[1] G Amba Prasad Rao and P Rama Mohan. Effect of Supercharging on the Performance of a DI Diesel Engine with Vegetable Oils, International Journal of Energy Conversion and Management, vol 44, no 6, April 2003, pp 937-944.9].
[2] Ramesh and Sampathrajan, "Investigation on Performance and Emission Characteristics of Diesel Engine with Neem Biodiesel and Its Blends", Agricultural Engineering International: the CIGR journal. Manuscript EE 07 013 Vol X March 2008.
[3] Srinivas, R.P., and Gopalakrishnan, K.V., "Vegetable Oils and their Methyl esters as Fuels for Diesel Engines", Indian Journal of Technology, (29) PP: 292-297, 1991.
[4] Mahesh P. Joshi and Dr. Abhay A. Pawar, "Experimental Study of Performance-Emission Characteristics of CI Engine Fuelled with Cotton Seed Oil

Methyl Ester Biodiesel and Optimization of Engine Operating Parameters", International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 1, 2013, pp. 185 - 202, ISSN Print:0976 - 6340, ISSN Online: 0976 - 6359.

[5] Ramaraju. A and Ashok Kumar T V, "Biodiesel Development from High Free Fatty Acid Marotti Oil", International Journal of Mechanical Engineering & Technology (IJMET),Volume 1, Issue 1, 2010, pp. 227 - 237, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[6] Manu Ravuri, D.Harsha Vardhan, V.Ajay and M. Rajasekhar reddy, "Experimental Investigations and Comparison of Di Diesel Engine Working on Jatropha Bio-Diesel and Jatropha Crude Oil", International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 3, 2013, pp. 24 - 31, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[7] Rajan Kumar, Dr. Manoj K Mishra and Dr. Shyam K Singh, "Performance and Emission Study of Jatropha Biodiesel and its Blends on C.I. Engine", International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 3, 2013, pp. 85 - 93,ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[8] B. Murali Krishna, A. Bijucherian, and J. M. Mallikarjuna ,"Effect of Intake Manifold Inclination on Intake Valve Flow Characteristics of a Single Cylinder Engine using Particle Image Velocimetry", International Journal of Engineering and Applied Sciences 6:2 2010.

[9]. De RisiA., Colangelo G., Laforgia D., "An Experim ntal Study of High-Pressure Nozzles in Consideration of Hole-To- Hole Spray Abnormalities", SAE 2000-01-1250, 2000.

[10]. Payri F., Payri R., Salvador F.J., Gimeno J., "Comparison Between Different Hole-To-Hole Measurement Techniques in a Diesel Injection Nozzle", SAE 2005-01-2094, 2005.

[11]. Semin and Bakar, R.A. (2007). Nozzle Holes Effect on Unburned Fuel in Injected and In-Cylinder Fuel of Four Stroke Direct Injection Diesel Engine. The research Journal of Applied Sciences 2 (11): 1165-1169.

[12]. Semin., Bakar, R.A. and Ismail, A.R. (2007). Effect Of Engine Performance For Four-Stroke Diesel Engine Using Simulation, Proceeding The 5th International Conference On Numerical Analysisin Engineering, Padang-West Sumatera, Indonesia.

[13]. Hasegawa T, Matsui K, Iwasaki T, Kobayashi T & Matsumoto Y.: Injection Characteristics and Spray Features of the Variable Orifice Nozzle (VON) for Direct Injection Diesel Engines. SAE 980807.

[14]. Jankowski A., Sandel A.: Influence of Fue Quality on Mixture Preparation and Exhaust Emissions From Diesel Engines with Common Rail System. Journal of KONES Internal Combustion Engines 2003, vol. 10, No. 3-4.

[15] Mahesh P. Joshi and Dr. Abhay A. Pawar, "Experimental Study of Performance-Emission Characteristics of Ci Engine Fuelled with Cotton Seed Oil Methyl Ester Biodiesel and Optimization of Engine Operating Parameters", International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 1, 2013, pp. 185 - 202, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[16] Ramaraju. A and Ashok Kumar T V, "Biodiesel Development from High Free Fatty Acid Marotti Oil", International Journal of Mechanical Engineering & Technology (IJMET), Volume 1, Issue 1, 2010, pp. 227 - 237, ISSN Print:0976 – 6340, ISSN Online: 0976 – 6359.

[17] Manu Ravuri, D.Harsha Vardhan, V.Ajay and M.Rajasekharreddy,"Experimental Investigations and Comparison of Di Diesel Engine Working on Jatropha Bio-Diesel and Jatropha Crude Oil", International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 3, 2013, pp. 24 - 31, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[18] A. P. Patil and H.M.Dange, "Experimental Investigations of Performance Evaluation of Single Cylinder, Four Stroke, Diesel Engine, using Diesel, Blended with Maize Oil", International Journal of Mechanical Engineering & Technology (IJMET), Volume 3, Issue 2, 2012, pp. 653 - 664, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[19] Rajan Kumar, Dr. Manoj K Mishra and Dr. Shyam K Singh, "Performance and Emission Study of Jatropha Biodiesel and its Blends on C.I. Engine", International Journal of Mechanical Engineering & Technology (IJMET), Volume4, Issue 3, 2013, pp. 85 - 93, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[20]. Patterson MA, Kong SC, Hampson GJ, Reitz RD. Modeling the effects of fuel injection characteristics on diesel soot and NOx formation. SAE Paper 940523, 1994.

[21]. Patterson MA, Reitz RD. Modeling the effects of fuel sprays characteristic on diesel engine combustion and emission. SAE Paper 980131, 1998.

[22]. Han Z, Uludogan Ali, Hampson GJ, Reitz RD. Mechanism and NOx emissions reduction using multiple injection in a diesel engine. SAE Paper 960633, 1996.

[23].Gamma Technologies: GT-POWER User's Manual 7.0, Gamma Technologies Inc., September 2009.

[25]. Iliev S, Stanchev H. Simulation on four-stroke diesel engine and effect on engine performance. Proceedings of the union of scientist-Ruse., 2012

[26]. S. Kobori, T. Kamimoto, H. Kosaka, Ignition, Combustion and Emissions in a DI Diesel Engine Equipped with a Micro-Hole Nozzle, SAE 960321, 1996.