Influence Of Varied Injection Timing On Exhaust Emissions With Crude Jatroph Oil On Di Diesel Engine With High Grade Insulated Combustion

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Abstract -- Depletion of fossil fuels and increase of pollution levels with fossil fuels, search for alternative fuels has become Inevitable. Increased the importance of vegetable oils as their properties are comparable to diesel fuel. Experiments were conducted to study performance of diesel engine with crude jatropha oil with 3mm air gap insulated piston, 3mm air gap insulated liner and ceramic coated cylinder head. Air gap of 3mm were maintained by screwing the crown to the piston body. Crown was made of superni-90 whose thermal conductivity is poor. Air gap of 3mm was maintained by inserting the suprni-90 insert into the liner. Exhaust emissions [particulate emissions and nitrogen oxide levels] were determined at various values of brake mean effective pressure (BMEP) of the high grade Low Heat Rejection Combustion chamber (LHR–3) with crude jatropha oil at varied injection timing and compared with neat diesel operation at a injector pressure of 190 bar.

Index Terms: Alternative fuels, Vegetable oil, Exhasut emissions, Particulate Emissions, Nitrogen oxide levels, Conventional engine, LHR engine, Injection pressure

I. INTRODUCTION

Increasing population of vehicles at an faster rate and use of diesel fuel in transport sector agriculture sector…etc, leading to fast depletion of diesel fuels. Increase of fuel prices is an another burden on economic sector of Govt. of India. The users and researchers were involved in the area of combustion research. [Matthias Lamping et al, 2008] for the conservation of diesel fuel.

Dr. Diesel who made a mark for his invention of diesel engine, used in applications like power plants for automotive applications as it is having their excellent fuel efficiency and durability. Internal combustion engine which is used for powering agricultural implements, industrial applications, and construction equipment along with marine propulsion. [Cummins et al, 1993; Avinash Kumar Agarwal et al, 2013].

The concept of Low Heat Rejection Combustion chamber is to burn the high viscous and low cetane number vegetable oils, thereby gaining the thermal efficiency. Various other techniques can be used for achieving LHR ceramic coated engines inside the head and air gap insulated engines with creating air gap in the piston and other components with low-thermal conductivity materials like superni (an alloy of nickel), cast iron and mild steel etc.

Ceramic coating with 500 microns inside the cylinder is said to be engine low grade Low Heat Rejection (LHR1) Combustion chamber. Air gap of 3mm in the piston by means of screwing the crown to piston body and air gap of 3mm in the liner by inserting the superni-90 insert in the liner is called medium grade Low Heat Rejection (LHR2) combustion chamber. The combined insulation of LHR1 and LHR2 is called high grade Low Heat Rejection combustion chamber. Authors conducted with neat diesel operation with ceramic coated diesel engine [Paralak et al, 2005; Ekrem et al, 2006; Ciniviz et al, 2008; Janardhan et al, 2014; Janardhan et al, 2015]. They revealed that brake specific fuel consumption decreased by 3-4% with ceramic coated diesel engine in comparison with conventional engine. Air gap in the piston has not become successful as it given the complications [Parker et al, 1987].

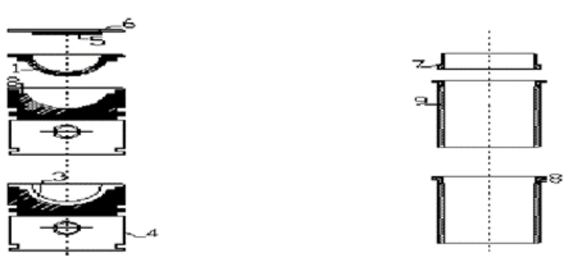
Screwing the crown to the piston has become a successful in providing the complete seal. [Ramamohan et al, 1999; Janardhan et al, 2015]. The optimum injection timing was found to be 29.5o bTDC. BSFC decreased by 12% at part–load and 4% at full load at an injection timing of 29.5° bTDC with the optimized insulated piston engine in comparison with CE operating at an injection timing of 27° bTDC. Experiments were conducted with LHR3 with varied injection timing and injector pressure to study pollution levels of particulate emissions and nitrogen oxides levels. [Janardhan et al, 2013].

Investigations were carried out engine with air gap insulated piston, air gap insulated liner and ceramic coated cylinder head(LHR-3) with varied injection timing and injection pressure to study pollution levels of particulate emissions and nitrogen oxide levels. [Janardhan et al, 2013]. It was came to know that from their investigations that smoke levels were almost negligible and drastically increased NOx levels. Vegetable oils are more suitable in engine with high grade Low Heat Rejection combustion chamber. Experiments were conducted in engine with Low Heat Rejection combustion chamber with varied injection timing and varied injection pressure with crude vegetable oil. . [Kesava Reddy et al, 2012; Janardhan et al, 2012; Chowdary et al, 2012]. The Brake Thermal Efficiency were found to be improved in comparison with Conventional engine with diesel fuel.

Biodiesel extracted from crude vegetable oil by esterification process in order to reduce viscosity and improve cetane value. Experiments were conducted on same configuration with Biodiesel crude vegetable oil based biodiesel with varied injection timing pressure. [Kesava Reddy et al, 2012; Janardhan et al, 2012; Chowdary et al, 2012]. Improvement were found with biodiesel with engine LHR3 combustion chamber.

II. METHODOLOGY

The experimental set up for conducting the performance test with crude jatropha oil and with diesel fuel as shown in figures below. Their specifications, operating conditions, definitions and fabrication method were also explained here. The details of the fabrication method of high grade Low Heat Rejection combustion chamber which is being used in the experimentation given in the Fig.1. Engine with high grade Low Heat Rejection combustion chamber consists of two parts piston crown and the piston. The crown was made of superni-90(an alloy of nickel) material which is screwed in to the piston and a gap of 3mm was maintained between crown and the piston surface.



1. Crown 2. Gasket 3.Air gap 4.Body 5.Ceramic Coating 6. Cylinder head 7. Insert 8. Air gap 9. Liner

Fig.1. Details of air gap piston, air gap liner and ceramic coated cylinder head assemblies.

The optimum thickness of 3mm was taken in the gap which has given the improved performance [36]. A gap of 3mm was maintained in between the insert and the liner body by screwing the insert on the top portion of the liner. Engine with ceramic coated cylinder head is called LHR1 engine. Engine with air gap insulated piston and air gap insulated liner is called LHR2 engine. The thermal conductivities of superni-90 and air are 20.92 and 0.057W/m-k. The superni-90 properties are given in the table.

Table.1.Properties of superni-–90 material

Thermal conductivity at 5000 C	21 W/m–K
Melting Point	14000C
Young's modulus at 5000C	1328 N/mm2
Mean coefficient of Thermal expansion	14.1 × 10-6°C−1
Electrical resistivity at room temperature	1ohm m2 /m

Table.2.Composition of superni-90 material

Cobalt -- 2.0 %,
Chromium---2.93 %,
Aluminum-- 1.5 %,
Titanium – 2.5 %,
Carbon—0.07%,
Iron – 1 % and Nickel – Balance.

The Conventional engine specifications are 3.68kW, 1500rpm, compression ratio 16:1, direct injection type and injector has 3 holes and 0.25mm size.

The inside cylinder portion of head was coated with ceramic (Partially Stabilized Zirconium) by Plasma spray technique. Initially experimented with diesel at manufacturer recommended injection time 270C bTDC and injector pressure of 190bar. Experiments were conducted with crude jatropha oil at their recommended and optimum injection timings at 270bTDC and 320bTDC with the same conventional engine. Later the engine was equipped with LHR3 combustion chamber and experimented with crude jatropha oil with varied injection timings at 270bTDC and 290bTDC. The optimum Injection timings of Conventional and engine with high grade Low Heat Rejection combustion chamber were observed 320bTDC and 290bTDC.

Table-3. Properties of non-edible vegetable oil and diesel

Test Fuel	Viscosity at 25 º C (centi-poise)	Specific gravity at 25º C	Cetane number	Calorific value (kJ/kg)
Diesel	12.5	0.84	55	42000
Jatropha oil (crude)	125	0.90	45	36000

Injection timing were changed by inserting the copper shims between the fuel pump and the engine body. Engine is directly connected with dynamometer for measuring the power and burette method can be employed for measuring the fuel consumption, air-box method used for measuring the air consumption.

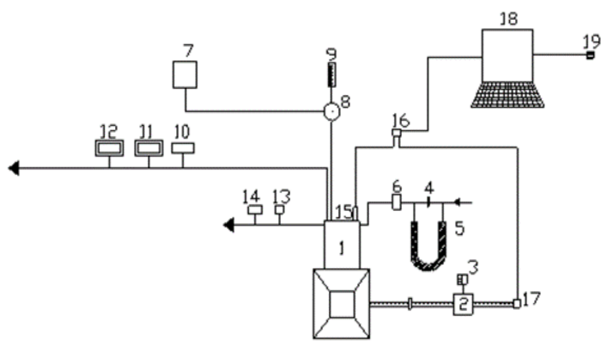


Fig.2. Experimental Setup for Vegetable Oil Operation

1.Engine, 2.Electical Dynamo meter, 3.Load Box, 4.Orifice meter, 5.U–tube water manometer, 6.Air box, 7.Fuel tank, 8, Pre–heater , 9. Burette, 10. Exhaust gas temperature indicator, 11.AVL Smoke meter, 12.Netel Chromatograph NOx Analyzer, 13.Outlet jacket water temperature indicator, 14. Outlet-jacket water flow meter, 15Piezo electric pressure transducer, 16Console, 17 TDC encoder, 18 Pentium Personal Computer and 19 Printer.

Cooling load can be calculated by measuring the water outlet temperature through Outlet jacket water temperature indicator. NOx levels can be measured by Netel Chromotograph NOx Analyser. Piezo electric pressure transducer can be used for measuring the peak pressure. Smoke intensity (in HSU) can be measured by AVL smoke meter. Exhaust Gas Temperature can be measured by Exhaust gas indicator.

Definitions of used values:

$m_f = \frac{10 \times \rho_d \times 3600}{t \times 1000}$--(1)

BP= $\frac{V \times I}{\eta_d \times 1000}$ (2)

BTE= $\frac{BP \times 3600}{m_f \times CV}$ (3)

BSEC=$\frac{1}{BTE}$----(5)

BP= $\frac{BMEP \times 10^5 \times L \times A \times n \times k}{60000}$-- -(6)

CL= $m_w \times c_p \times (T_o - T_i)$ (7)

$$m_a = C_d \times a \times \sqrt{2 \times 10 \times g \times h \times \rho_a} \times 3600$$

(8)

$$a = \frac{\pi \times d^2}{4}$$

$\eta_v = \frac{m_a \times 2}{60 \times \rho_a \times N \times V_s}$ (9)

$\rho_a = \frac{P_a \times 10^5}{750 \times R \times T_a}$ (10)

III. RESULTS AND DISCUSSION

The variation of brake thermal efficiency (BTE) with brake mean effective pressure (BMEP) in the conventional engine (CE) with crude jatropha oil, at various injection timings at an injector opening pressure of 190 bar, is shown in Figure.7.1.

Fig.3.Shows the variation of Exhaust gas temperature in conventional and engine with LHR3 combustion chamber at recommended and their optimum injection timings with different test fuels. The exhaust gas temperature found to be decreased in 12% in conventional engine with diesel fuel at optimum injection timing when compared with recommended injection timing. It was due increase of injection timing increases the oxygen availability to the fuel will increase the conversion the fuel energy into useful work.

Exhaust gas temperature in conventional engine with crude jatropha oil was found to be 10% less compared at optimum injection timing when compared with at recommended injection timing. It was due to the fuel residence time more in the combustion chamber and fuel molecules will have association with oxygen molecules thereby improved fuel energy conversion into useful work.

Exhaust gas temperature was found to be decreased 4% in engine with LHR3 combustion chamber at optimum injection timing when compared with engine with same configuration at recommended injection timing. It was due to hot environment improve the volatility causes improve the useful work reduce the Exhaust Gas Temperature.

Exhaust gas temperature found to be 18% more in engine with high grade LHR engine at recommended injection time when compared with the diesel fuel. It was due hot environment in the chamber combustion, combustion starts early and availability of oxygen is less causes the fuel conversion efficiency will be reduced. Therefore most of the heat comes out through the exhaust gasses.

Injection Timing (^{o} bTDC)	Test Fuel	EGT at Full load operation (degree centigrade)
		Injector Opening Pressure (bar)
		190
27(CE)	DF	425
	CJO	480
27(LHR)	DF	500
	CJO	460
28(LHR)	DF	430
29(LHR)	CJO	440
31(CE)	DF	375
32(CE)	CJO	430

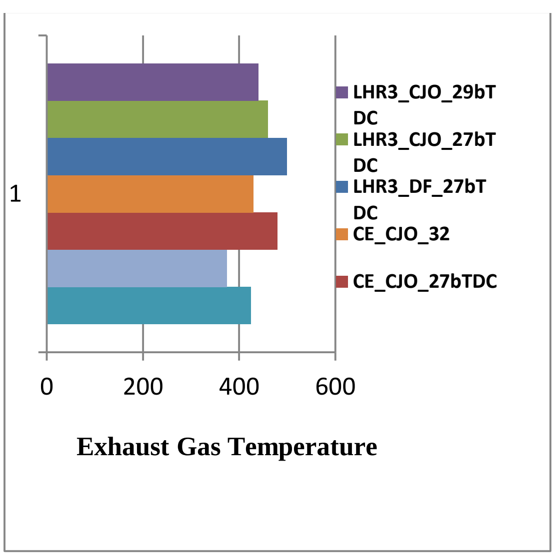


Fig.3.The variation of peak Exhaust Gas Temperature at varied injection time at recommended and optimum in Conventional engine and engine with high grade Low Heat Rejection combustion chamber

Fig.4.Shows the variation Smoke Levels in conventional and engine with LHR3 combustion chamber at recommended and their optimum injection timings with different test fuels. The Smoke levels are found to be decreased in 38% in conventional engine with diesel fuel at optimum injection timing when compared with recommended injection timing. It was due increase of injection timing increases the oxygen availability to the fuel will increase the conversion the fuel energy into useful work.

Smoke Levels in conventional engine with crude jatropha oil was found to be 23% less compared at optimum injection timing when compared with at recommended injection timing. It was due to the fuel residence time more in the combustion chamber and fuel molecules will have association with oxygen molecules thereby improved fuel energy conversion into useful work.

Smoke Levels were found to be decreased 46% in engine with LHR3 combustion chamber with crude jatropha oil at optimum injection timing when compared with engine with same configuration at recommended injection timing. It was due to hot environment improve the volatility causes improve the useful work reduce the Exhaust Gas Temperature.

Smoke Levels found 25% less in engine with high grade LHR engine at optimum injection time when compared with the same configuration with diesel fuel. It is due to oxygen availability more as increasing the advancement of the fuel injection causes the combustion successful.

Injection Timing (^{o} bTDC)	Test Fuel	Smoke Levels full load operation (HSU)
		Injection Pressure (Bar)
		190
		NT
27(CE)	DF	48
	CJO	65
27(LHR)	DF	60
	CJO	35
28(LHR)	DF	45
29(LHR)	CJO	30
31(CE)	DF	30
32(CE)	CJO	50

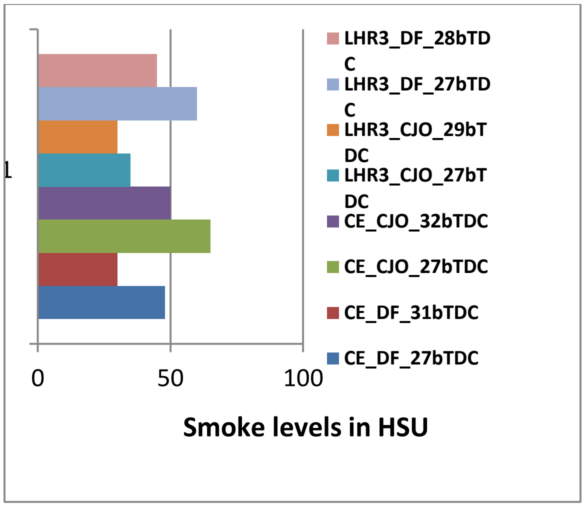


Fig.4.The variation of peak Smoke Levels at varied injection time at recommended and optimum in Conventional engine and engine with high grade Low Heat Rejection combustion chamber.

Fig.5.Shows the variation NOx Levels in conventional and engine with LHR3 combustion chamber at recommended and their optimum injection timings with different test fuels.

NOx levels were found to be 29% improved in Conventional engine at optimum injection time with diesel fuel when compared with Conventional engine with diesel fuel at recommended injection time. It is due to the improved useful work done as increased oxygen availability. NOx levels were increased.

NOx levels were increased 31% in conventional engine with crude jatropha oil at optimum injection timing when compared with same configuration with same fuel at recommended injection time.

NOx levels were found to be decreased 4% in engine with LHR3 combustion chamber with diesel fuel at optimum timing when compared with same configuration with the same fuel at recommended injection timing. It was due to increase the oxygen availability and high grade insulation causes the increase fuel conversion efficiency therefore decrease the NOx levels.

NOx levels were found to be decreased 4% in engine with LHR3 combustion chamber with crude jatropha oil at optimum timing when compared with same configuration with the same fuel at recommended injection timing. The reason was same with diesel fuel.It was due to increase the oxygen availability and high grade insulation causes the increase fuel conversion efficiency therefore decrease the NOx levels.

Injection Timing	Test Fuel	NOx Levels (ppm) at full load operation
(° bTDC)		Injection Pressure (Bar)
		190
		NT
27(CE)	DF	850
	CJO	650
27(LHR)	DF	1200
	CJO	1250
28(LHR)	DF	1150
29(LHR)	CJO	1200
31(CE)	DF	1100
32(CE)	CJO	850

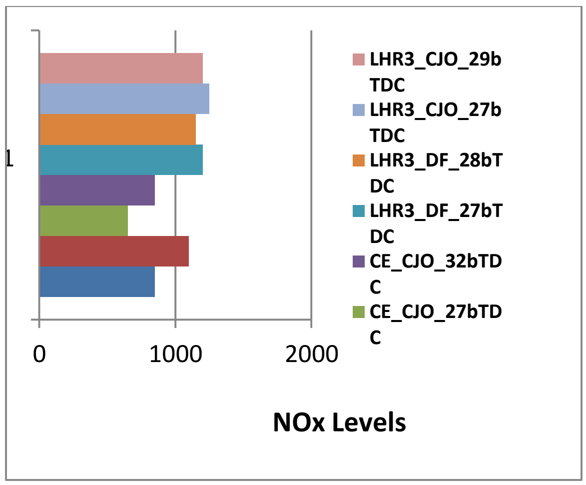


Fig.5.The variation of peak NOx Levels at varied injection time at recommended and optimum in Conventional engine and engine with high grade Low Heat Rejection combustion chamber.

IV. CONCLUSION

A. Smoke levels were found decreased as injection timing varied in both conventional engine and engine with LHR3 combustion chamber at 190bar with diesel and crude jatropha oil.

B. NOx levels were found to be increased in conventional engine and decreased with engine with LHR3 combustion chamber with diesel and crude jatropha oil as injection timing varied from recommended time to optimum timing at 190bad injector opening pressure.

Future scope of work

Further work can be extended doing research influence on performance parameters in diesel engine with injecting the crude jatropha oil at different operating condition

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