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Study of Smoke Levels Using crude Jatropha Oil with Preheated Condition and at Normal Condition Injection in High Grade Low Heat Rejection Combustion Chamber of Diesel Engine at Different Operating Pressures

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Abstract
Smoke levels were determinedon high grade insulated diesel engine which consisting of ceramic coated cylinder head, 3mm air gap insulated liner and 3mm air gap insulated piston with different operating conditions of jatropha oil(at normal temperature and preheated temperature) with varied injection pressures from 190 to 230 and 230 to 270 bar and varied injection timing from 270 bTDC to 320 bTDC . Smoke levels were calculated at various values of brake mean pressure(BMEP) of the insulated engine and the data is compared with the neat diesel operation of standard engine.

Keywords: Vegetable oils. Conventional Engine, LHR Engine

1. INTRODUCTION
Increasing the import cost of crude oil, depletion of fossil fuel, increasing the pollution levels and usage of more diesel fuel leading replace the diesel fuel.The only alternative to diesel fuels are vegetable oils and alcohols. Production of alcohols aresuffice for the pharmaceutical companies and the other problem during the combustion formation of aldehydes takesplace. Edible oils are being consumed along with the food.Non-edible oils like cotton seed oil, crude jatropha oils, etc are the best substitutes for the diesel.The concept of low heat rejection(LHR) engines are being introduced by the researchers for the restricting the heat flow through all three possible ways, the cylinder head, line and through the piston. It keeps the combustion chamber very hotand helps in complete combustion of high viscous low calorific value vegetable oils.Ceramic coating inside the cylinder head(LHR1) which restrict the heat flow through the head , Air gap 3mm in the liner and the piston(LHR-2)which restrict the heat flow through the liner and piston. The combination of LHR-1 and LHR-2(LHR-3), restrict the heat flow in all three possible ways. Experiments were conducted on single cylinder four stroke water cooled diesel engine of 3.68kw brake power at a speed of 1500 rpm at a compression ratio of 16:1 with the engine with engine with LHR-3 combustion chamber with crude jatropha oil[4-6]. Particulate emissions were found to be decreased by 10-15% and increased nitrogen oxides by 40-45% in comparison with conventional engine with mineral diesel operation.Experiments were also conducted on the same configuration of the engine using biodiesel with varied injection timing and injection pressure. Particulate emissions decreased by 25-30% and nitrogen oxides levels increased by 45-50%[7-9].Experiments were conducted with different degrees of insulation LHR-1,LHR-2 and LHR-3 combustion chamberswith varied injection pressure and injection timing of 270bTDC[10-12:13]. It was showed that particulate emissions were found to be decreased while increasing nitrogen oxides levels with the increasing degree of insulation and further improve increasing pressure. However, there is gap in investigations on study of exhaust emissions on LHR-3 combustion chamber using crude jatropha oil at normal condition and preheated condition and comparing with conventional engine with neat diesel fuel operation.

2.MATERIALS AND METHOD.

2.1.Crude Jatropha Oil.

If we use effectively non forest waste to cultivate plants like jatropha curcas which can produce oilseeds for the extraction of oil,can be substituted as fuel in the diesel engine. India imports jatroha for worth about 400 crores annually for making soap. The plant has several distinguished properties rapid growth and easily propagation and wide ranging usefulness. It grows on any type of soil and can be well adopted to cultivation, has no major diseases or insect pests and not browsed by cattle or sheep.The plant can grow without water in year and yield of the plant starts the third year onwards but extraction of oil from the seeds is only 25%. The properties of the vegetable oil are shown in Table.1.

Table.1. Properties of Test Fuels

Test Fuel	Viscosity at 25^0C(centi-poise)	Specific gravity At 25^0C	Cetane number	Lower Calorific value(kJ/kg)
Diesel	12.5	0.84	55	42000
Jatropha Oil(Crude)	125	0.90	45	36000
ASTM Standard	ASTM D 445	ASTM D 4809	ASTM D 613	ASTM D 7314

2.2.Diesel fuel

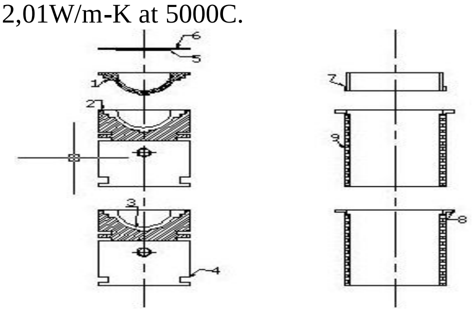
The physical-chemical properties of the diesel fuel are given in the table-2. Fuels with flash point above 520C are considered as safe. It has high cetane number, which gives very good combustion in compression ignition engine.It's value of viscosity in the suitable range, hence there are no injection problems.

Table.2. Properties of Diesel Fuel

Fuel	Diesel
Specific gravity	0.84
Flash point (Open cup) (o C)	68
Low Calorific value (kJ/kg)	42000
Cetane Number	55

2.3.Engine with LHR Combustion chamber

Fig-1 shows the schematic diagram of assembly of air gap insulated piston, air gap insulated liner and ceramic coated cylinder head of LHR-3 engine.The piston was made into two parts. The top portion of the piston(crown), made of low thermal conductivity material(superni-90)screwed to aluminum body of the piston providing air gap of 3mm between the crown and the body of the piston.Using plasma arc coating method, partially stabilized zirconium with 500 microns was coated inside the cylinder head. The low thermal conductivity of air in the gaps and partially stabilized zirconium provides thermal resistance keeps the combustion chamber very hot. The optimum thickness of 3mm air gap in the liner and the piston was found to be improved performance with the fuel diesel[8]. Thermal conductivities of superni-90, air and PSZ are 20.92, 0.057 and 2,01W/m-K at 5000C.



1.Superni crown, 2. Superni gasket, 3.Air gap in piston, 4. Body of the piston, 5. Ceramic coating on inside portion of cylinder head,6. Cylinder head, 7. Superni insert, 8. Air gap in liner and 9. Body of liner.

Fig.1. Assembly details of air gap insulated piston and air gap insulated liner,ceramic coated cylinder head.

2.4.Experimental Set Up

Fig.2 shows the schematic diagram of the experimental setup used to conduct the investigations on the engine with LHR-3 engine using crude jatropha oil. The specifications of the test in engine is given in Table.3. The investigations were carried out on the 3,68kw engine at a speed of 1500 rpm and the compression ratio of the engine is 16:1.Manufacturer has given the injection timing as 270bTDC and injection pressure as 190bar.The brake power of the engine was measured by means of dynamometer which is coupled to the engine shaft and using loading rheostat

Dynamometer was loaded.Digital tachometer can be used for measuring the speed of the engine. Fuel consumption of the engine was measured by using the burette and the stop watch. Conventional injection system was adopted in injecting the vegetable oil into the engine.A special arrangement was made for pre-heating the vegetable oil heating to 900C to equalize the viscosity to the diesel fuel which is at room temperature.

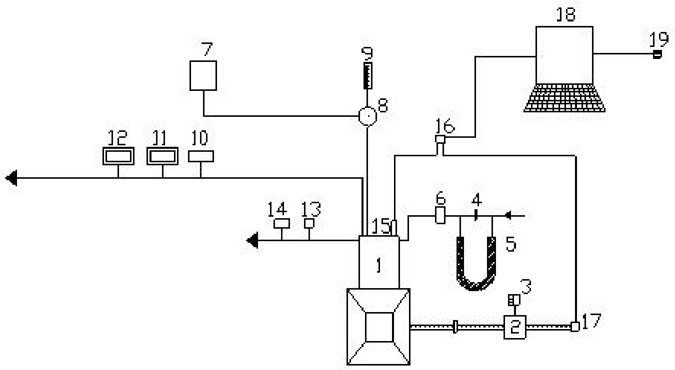


Fig.2. Schematic diagram of experimental set–up

Engine consists of direct injection type and no special arrangement for swirling motion of air. Fuel consumption can be measured with the help of Burette(Part No.9) method which connects fuel tank and three way valve(Part No.7).The specifications of the experimental engine was given below.

Table.3. Specifications of the Test Engine.

Descriptions	Specifications
Engine Make and Model	Kirloskar (India) AV1
Maximum power output at a speed of 1500 rpm	3.68kW
Number of cylinders ×cylinder position× stroke	One × Vertical position × four-stroke
Bore × stroke	80 mm × 110 mm
Method of cooling	Water cooled
Rated speed (constant)	1500 rpm
Fuel injection system	In-line and direct injection
Compression ratio	16:1
BMEP @ 1500 rpm	5.31 bar
Manufacturer's recommended injection timing and pressure	27obTDC × 190 bar
Dynamometer	Electrical dynamometer
Number of holes of injector and size	Three × 0.25 mm

The combustion chamber consisted of a direct injection type with no special arrangement for swirling motion of air.Burette (Part No.9) method was used for finding fuel consumption of the engine with the help of fuel tank (Part No7) and three way The specifications of the experimental engine are shown in Table-4. Experimental setup used for study of exhaust emissions on high grade LHR diesel engine with crude jatropha oil in Fig.2. The specification of the experimental engine (Part No.1) is shown in Table.4.The engine was connected to an electric dynamometer (Part No.2. Kirloskar make) for measuring its brake power. Dynamometer was loaded by loading rheostat (Part No.3).

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Compression ratio	16:1
BMEP @ 1500 rpm	5.31 bar
Manufacturer's recommended injection timing and pressure	27^{o}bTDC × 190 bar
Dynamometer	Electrical dynamometer
Number of holes of injector and size	Three × 0.25 mm
Type of combustion chamber	Type of combustion chamber
	MICO-BOSCH No- 0431-202-120/HB
Fuel injection pump Make:	BOSCH: NO- 8085587/1

valve (Part No.8). The amount of air that has been consumed was measured with Air-consumption of the engine was measured by air-box method consisting of an orifice meter (PartNo.4), U–tube water manometer (Part No.5) and air box (Part No.6) assembly. The naturally aspirated engine wasprovided with water-cooling system in which outlet temperature of water is maintained at 80^{o}C by adjusting the waterflow rate. Engine oil was provided with a pressure feed system. No temperature control was incorporated for lube oil temperature. Exhaust emissions were studied with increase its injection pressure from 190 to 270 bar with an increment of 40 bar using nozzle testing device. Injection timing can be varied by inserting the copper shims between the pump and engine body. Tests were on conventional engine with diesel fuel and LHR-3 engine with crude jatropha oil at normal temperature and pre-heated condition.Test fuel will be pre-heated to 90^{0}C to reduce the viscosity and become equal to diesel viscosity and then injected into the engine.

3. RESULTS AND DICUSSION

Table-5..Data of smoke levels at the full load operation oils with the injection timing and injector opening pressure in conventional engine (CE) and in LHR-3engine at different operating conditions of the vegetable oil

Injection Timing (^{o} bTDC)	Test Fuel	Smoke Levels full load operation (HSU)					
		Injection Pressure (Bar)					
		190		230		270	
		NT	PT	NT	PT	NT	PT
27(CE)	DF	48	--	38	--	34	--
	CJO	65	60	63	58	58	54
27(LHR)	DF	60		55		50	
	CJO	35	30	30	25	25	20
28(LHR)	DF	45		40		35	
29(LHR)	CJO	30	25	25	20	20	15

31(CE)	DF	30	---	30	--	35	--
32(CE)	CJO	50	45	55	52	52	49

In the Fig.3.shows the variation of emission levels at different injection pressures using conventional engine with diesel fuel. It shows that the particulate emissions are more at manufacturer injection pressure at 190 bar when compared to 270 bar. Particulate emissions are less at optimum injection pressure at 31bTDC.This is due to the more interaction time between the atomized fuel particle and oxygen molecules.As injection timing varies from 190 bar to 270 bar particulate emissions will fall due the same reason the interaction of the oxygen levels are increased. Reduction in emission levels increased from 21% to 29%.

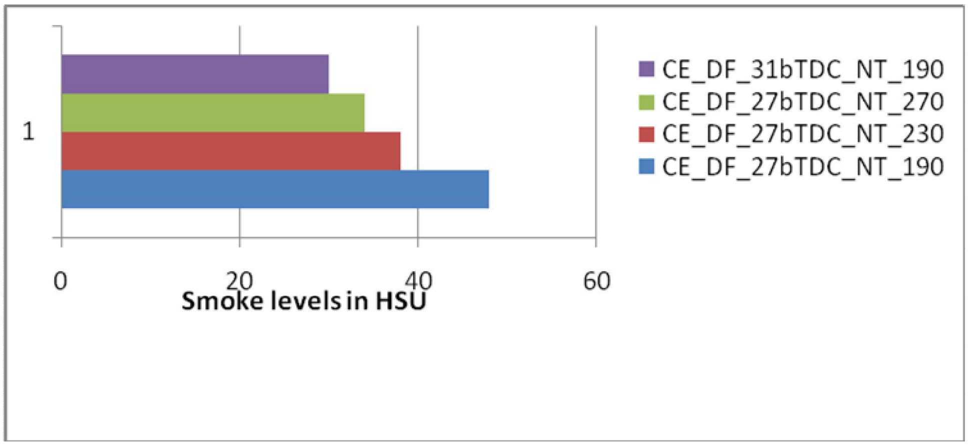

Fig.3 Shows variation of Emission Levels of Conventional Engine using Diesel Fuel at Normal Temperature and at different Operating Pressures

In the Fig.4 shows the variation of emission levels using conventional engine with crude jatropha oil at normal temperature and at preheated condition and at recommended injection timing and at optimum injection timing. The test fuel crude jatropha oil having high viscosity than diesel fuel. Preheating the jatropha oil to 80^0C will makes the viscosity equal to diesel fuel.The test results were compared with conventional engine with diesel fuel at recommended injection timing and normal temperature condition. Particulate emission are more at recommended injection timing in conventional engine using crude jatropha oil (CJO) at normal temperature condition. The emission levels were reduced 3% when injecting the test fuel (crude Jatropha Oil) at 80^0C.Same trends were found to be same in all other injection pressures at 230 bar and 270 bar at preheated and normal condition of the fuels.

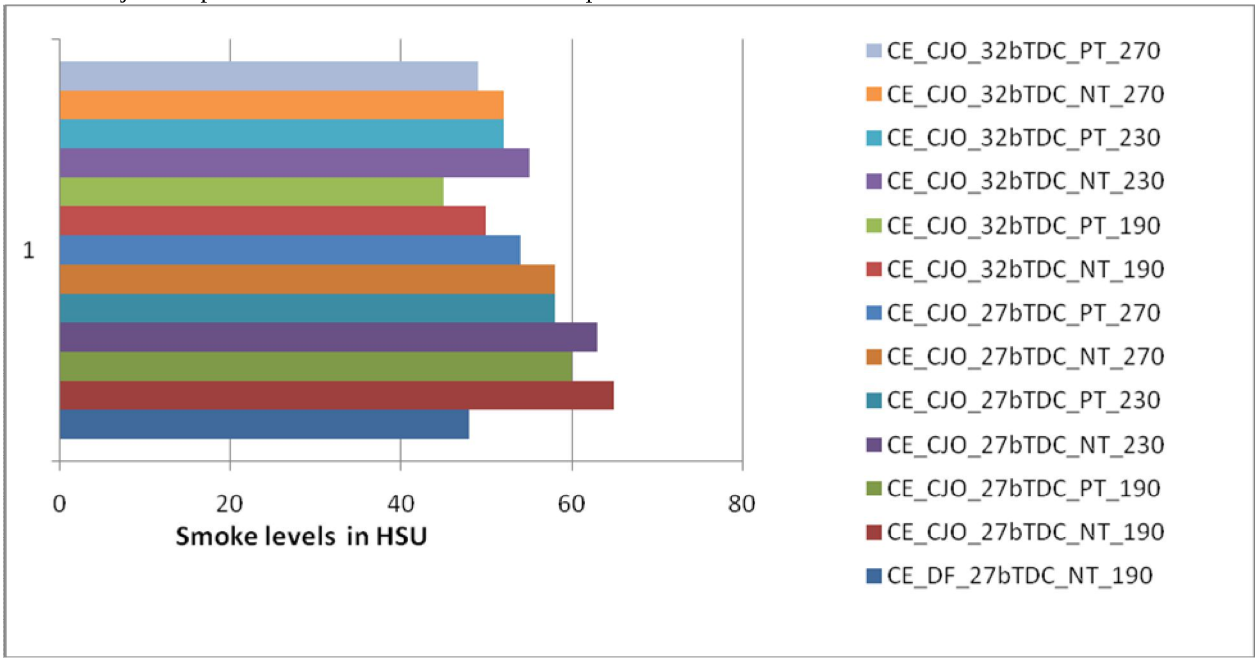

Fig.4. Shows variation of Emission Levels of Conventional Engine using Diesel Fuel at Normal Temperature and at Pre-heating Temperature and at different Operating Pressures

In Fig.5.shows the emission levels were found to be very less in high grade low heat rejection chamber (LHR3) compared to Conventional engine at pre-heated condition of the test fuel with crude jatropha oil at 270 bar at its optimum injection timing. It is due to hot combustion chamber, fuel viscosity will be reduced and equal to that of diesel and due to early submitting the fuel into the engine, have very good interaction with the oxygen molecules made the heat energy will be converting into useful thrust force and most of the fuel will combust completely Emission levels were to be very high in conventional engine using crude jatropha oil at recommended injection pressure.Emissions were to be reduced 54% Using LHR3 engine using crude jatropha oil at manufacturer recommended injection pressure(190 bar)at normal temperature condition over the conventional engine and 58% reduction using LHR3 engine using crude jatropha oil at the same recommended injection pressure at pre-heated injection over the conventional engine.Same trend were observed at different injection pressures using jatropha oil atinjection temperatures. It is observed in conventional engine and in the LHR3 engine, increasing the injection pressure will reduce the p emission levels. It is due to the improvement in atomization of the fuel and also improvement in interaction with oxygen particles.It also observed that pre-heating before injection will also reduction further in the emission levels. This is due to the decrease in viscosity of the fuel and increase the atomization of the fuel further.

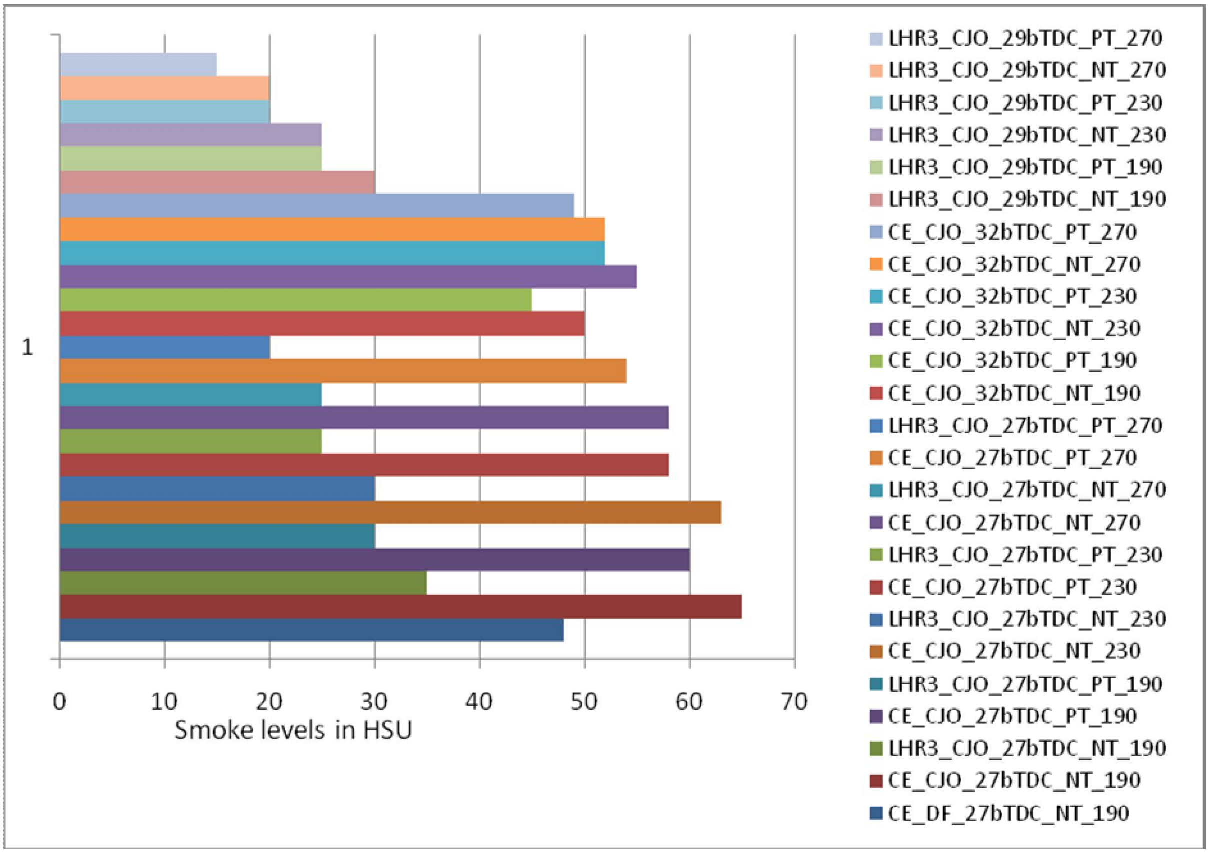

Fig.5. Shows variation of emission levels in the conventional engine and in the LHR-3 engine using Jatroha oilat Normal and Preheating Temperature and at different Operating Pressures.

4. CONCLUSIONS.

1. Emission levels were to be very high in conventional engine at manufacturer recommend injection time and at recommended injection pressure at 190bar.
2. Emissions levels were to be decreased in conventional engine as injection pressure increases from 190 to 270 bar.
3. Same trend were to be observed in LHR3 engine.
4. Decrease in smoke levels were to be more LHR3 engine than that of in conventional engine.

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REFERENCES

[1]. Avinash Kumar Agarwal and Atul Dha. "Performance, emission and combustion characteristics of jatropha oil blends in a direct injection CI engine," SAE Paper 2009–01–0947.

[2]. R.D. Misra, M.S. Murthy, " Straight vegetable oils usage in a compression ignition engine—A review," Renew Sustain Energy Rev, 14, pp. 3005–3013,,2010.

[3]. No. Soo-Young,"Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: A review," Renew Sustain Energy Rev, 15, pp. 131–149,2011.

[4]. Avinash Kumar Agarwal and Atul Dhar. "Experimental investigations of performance, emission and combustion characteristics of Karanja oil blends fuelled DICI engine," Renewable Energy , 52, pp. 283–291,2013.

[5]. N. Venkateswara Rao, M.V.S. Murali Krishna, and P.V.K. Murthy, " Comparative studies on performance of tobacco seed oil in crude form and biodiesel form in direct injection diesel engine," Int J Aut Eng Res & Dev, 3 (4), pp. 57–72,2013.

[6]. D. Srikanth, M.V.S. Murali Krishna and P. Ushasri, "Performance evaluation of a diesel engine fuelled with cottonseed oil in crude form and biodiesel form," Int J Acad Res Multidiscip, 1 (9), pp. 329–349,2013.

[7]. Maddali Krishna, and R. Chowdary, "Comparative studies on performance evaluation of waste fried vegetable oil in crude form and biodiesel form in conventional diesel engine," SAE Paper 2014–01–1947, 2014.

[8]. N.Durga Prasada Rao, M.V.S. Murali Krishna, and B. Anjeneya Prasad, " Effect of injector opening pressure and injection timing on exhaust emissions and combustion characteristics of rice bran oil in crude form and biodiesel form in direct injection diesel engine, ", IOSR J Eng, 4(2), pp.9–19,2014.

[9]. I.Celikten, "An experimental investigation of the effect of the injection pressure on the engine performance and exhaust emission in indirect injection diesel engines," Applied Thermal Engineering, **23**, pp.2051–2060,2003.

[10]. Y.Cingur, *and D.* Altiparmak, " Effect of cetane number and injection pressure on a DI diesel engine performance and emissions," Energy Conversion and Management, **44**, pp. 389–397,2003.

[11]. D.T. Hountalas, D.A. Kouremenos, K.B.Binder, V. Schwarz, V. and G.C. Mavropoulos, " Effect of injection pressure on the performance and exhaust emissions of a heavy duty DI diesel engine," *SAE Technical Paper No.2003-01-0340. Warrendale, PA,2003.*

[12]. S.Jindal, B.P. Nandwana, N.S. Rathore, and V. Vashistha, "Experimental investigation of the effect ofcompression ratio and injector opening pressure in a direct injection diesel engine running on Jatropha methylester,"Applied Thermal Engineering, **30**,442–448,2010.

[13]. Avinash Kumar Agarwal, Dhananjay Kumar Srivastava, Atul Dhar, et al. "Effect of fuel injection timing andpressure on combustion, emissions and performance characteristics of a single cylinder diesel engine," Fuel, 111,pp. 374–83,2013.