RESEARCH ARTICLE OPEN ACCESS

Effect of Swirl on DI Diesel Engine Operated With Honge Biodiesel

M. N Channappagoudra[1]*, Sunil Thaned[2], N.R. Banapurmath[3], K. Ramesh[4], G.Manavendra[5]
[1]Department of Mechanical Engineering, Rural Engineering College Hulkoti-588205, Karnataka
[2]Department of Mechanical Engineering, ATS SBGI Miraj-416410, Maharashtra
[3]Department of Mechanical Engineering, B.V.B. College of Engineering and Technology, Hubli
[4]Department of Mechanical Engineering, U.B.D.T. College of Engineering, Davangere-577004
[5]Department of Mechanical Engineering, B.I.E.T, Davangere-577004

Abstract
As we know the petroleum products, diesel fuels are depleting day by day whereas energy demand is increasing day by day. The biofuel technology will provides the alternative fuels such as biodiesel, which have more prominence for IC engine applications. The objective of the present study is to enhance the swirl effect in the cylinder which causes better performance and lowers the emissions. In this experimental study the piston crown is modified by cutting number of grooves such as 3-grooves, 6grooves and 9-grooves to increase the air-fuel mixing rate. The test result revealed that 6-groove configuration has greater in brake thermal efficiency (BTE), lower in brake specific fuel consumption (BSFC), CO, UBHC, compare to the other configuration like 3-grooves, 9-grooves and normal piston, which is attributed to proper air-fuel mixing and complete combustion as with higher oxygen content in the honge oil methyl ester(HOME.)
Keywords: alternative fuel, honge oil methyl ester, Swirl, Diesel engine performance, Emissions.

I. Introduction

Biodiesel is a one promising alternative to fossil fuel for diesel engines has become increasingly important due to environmental concern and sustainable development. In few words, biodiesel is a biofuel derived from natural triglycerides such as vegetable oils or animal fats, through the transesterification process hydroxide (KOH) or sodium hydroxide (NaOH) which acts as a catalyst for the reaction. Biodiesel is usually defined as a blend of ethyl or methyl esters of fatty acids, presenting characteristics very similar to the conventional diesel oil [1]. It can be used as fuel in compression ignition motors (diesel cycle), generally in blends with conventional diesel. Biodiesel, the renewable, degradable, nontoxic liquidfuel produced from biological raw material is a good substitute for petroleum diesel. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend [2]. The fuels from non-edible oils are the promising alternative fuel to diesel due to the following reasons. [3].

i. Biodiesel can be used in the existing engine without any modification and No need to change in fuelling infrastructures and spare part inventories.
ii. Unlike fossil fuels the use of biodiesel does not cause global warming as CO_2 emitted is once again absorbed by the plants grown for non – edible oil production hence CO_2 can be balancedhence it is eco-friendly.
iii. Biodiesel is produced from renewable non - edible oil and hence improves the fuel or energy security and economy independence. Biodiesel is biodegradable, nontoxic and essentially free of sulphur and aromatics.
iv. It is renewable and is energy efficient fuel, based on oil crops or trees hence it is no effect on food or fodder source.
v. Cetane number is significantly higher than that of conventional diesel fuel and biodiesels have improved Lubricity over that of conventional diesel fuel.
vi. Less importance of oil seed residue (for fodder) and raw glycerine because these are by- products of biodiesel production.
vii. A movement towards independence of exhaustible fossil fuels and it create jobs for the people with effective cost of biofuels.

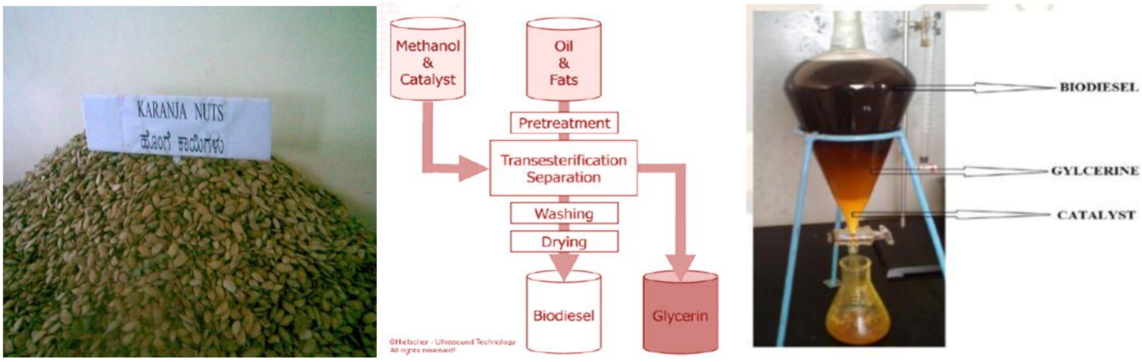
Biodiesels have low volatility and high viscosity due to long chain structure hence there is problem to use vegetable oil directly as bio diesel in CI engine applications. Again it creates the common problems such as excessive pumping power, poor atomization of fuel particles and improper combustion as lower in air-fuel mixing rate[4].

Most important function of IC engine combustion chamber is to provide proper mixing air-fuel in short possible time called swirl. The swirl will helps to enhance the turbulent kinetic energy, combustion efficiency and hence greater in combustion rate.A number of research scholar carried out the experimental work without any modification in the diesel engine. And they concluded that the use of biodiesel blends and neat biodiesel in diesel engine decreases carbon monoxide, unburnt hydrocarbons wheras increases in NOx emission levels [3]. Mingfa Yao et al. (2009) [5] observed that bowl with bump ring has more kinetic energy, high turbulence energy, enhancing mixing rate and reducing soot compared to baseline combustion chamber. R.V Ravikrishna et al. (2011) [6] studied the effect of swirl by re-entrant piston bowl geometry using Computational Fluid Dynamics (CFD) simulations. This re-entrant chamber produces the higher turbulence in the chamber. John. B Heywood (1988) [7]reported that the design with a re-entrant bowl operated with biodiesel will promote rapid fuel-air mixing at the end of compression and maintain a high swirl level. Due to greater in swirl rate particulate, CO, HC and smoke will decreases whereas NO emissions increases due to more rapid fuel-air mixing. V.V Prathiba et al (2011) [8] investigated that by cutting grooves on the piston crown will affect the swirl for better mixing and hence reduction in brake specific fuel consumption (BSFC) and smoke.C .V. Subba Reddy et al (2013) [9] reported that Combustion chamber geometry have significance influence on the engine performance,the combustion chamber with the four tangential grooves on the piston crown will effect on air flow motion in the piston bowl hence there will be improvement in combustion efficiency which is due to formation of homogeneous mixture of fuel with air and greater turbulence in the cylinder.Y Shi and R D Reitz [2008] [10]observed that optimal combustion chamber design from the high-load optimization study and varying swirl ratio, and injection timing and pressure, simultaneously minimizes emissions formation and offers improved fuel consumption.

II. Materials and Methodology

2.1 Biodiesel production.

Raw Honge oil wastransesterified to obtain Honge oil methyl ester (HOME) biodiesel by transesterification process. During this process, the waste grease is mixed with a methanol and potassium hydroxide (KOH) or sodium hydroxide (NaOH) which acts as a catalyst for the reaction. The ingredients are put into a reactor and then mixed and heated for some times. Once the reaction is complete, there are two distinct layers are formed: biodiesel (which floats to the top) and a bottom layer containing glycerineby-product. Since some methanol is still present in both the fuel and the glycerine layers at the end of the transesterification reaction, a process called methanol recovery may be conducted on both layers separately to recover the chemical. This methanol may be re-used in the next batch of fuel.During transesterification, a soapy substance forms in the fuel layer that must be washed out. This is accomplished by washing the fuel with water several times and letting the fuel dry by allowing the water to evaporate.The biodiesel can be stored in the same holding tanks as petroleum based diesel [3].



Honge nuts **Biodiesel Production Process** **Bio-diesel with three layers**

Fig.1.Honge oil methyl ester (HOME) production process.

2.2 Biodiesel and its Properties

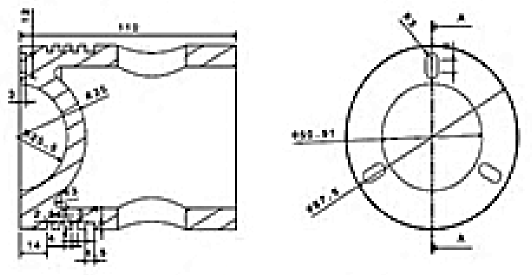
India has the potential to produce huge amount of bio diesel from non-edible oilslike Jatrophacurcus, Pongamiapinnata, Neem, Mahua, caster, linseed,and cotton. Out of these plants, India is focusing on Pongamiapinnata, because the seed contains 30-40% oiland itcan be grow in arid and wastelands.

Table 1.Properties of Honge biodiesel.

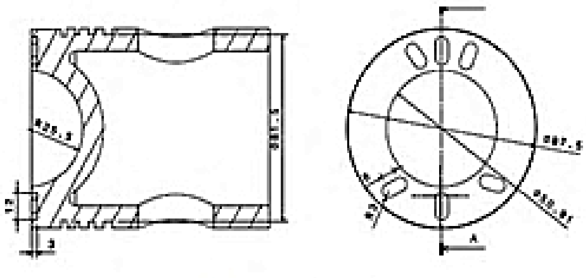
Property	**Diesel**	**B100 HOME**	**ASTM test No.**
Density (kgm^{-3})	840	870	D4052
Specific gravity	0.830	0.870	-
Kinematic Viscosity at 40^{0}C (cst)	3.5	5.84	D445
Flash point (^{0}C)	56	170	D93
Calorific value (kJ /kg)	43000	36100	-

2.3 Engine Modifications

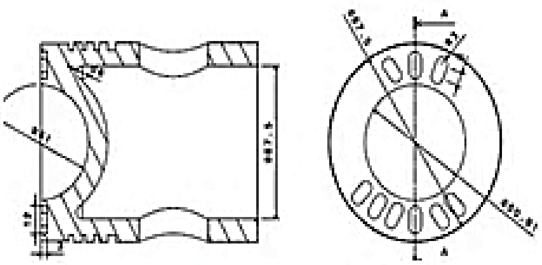
In the present work, study is carried out to know the effects of swirl by cutting grooves piston crown which effects on performance and emission characteristics of honge biodiesel fuelled direct injection diesel engine. The standard baseline hemispherical combustion chamber (HCC) bowl geometry has modifiedby cutting different number of grooves on the piston crown such as 3-Groove, 6-Groove and 9-Grooves to enhance the swirl effect in the engine cylinder.



3-Grooves Piston



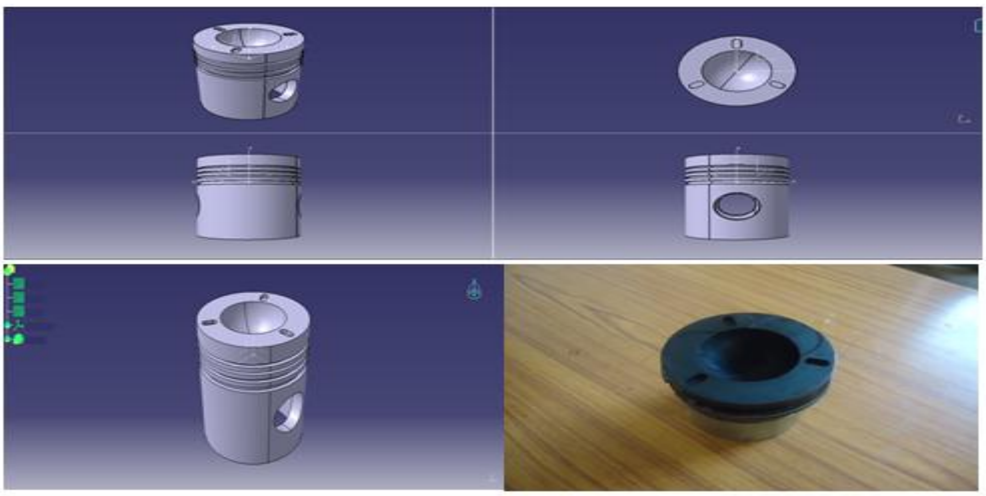
6-Grooves Piston



9-Grooves Piston

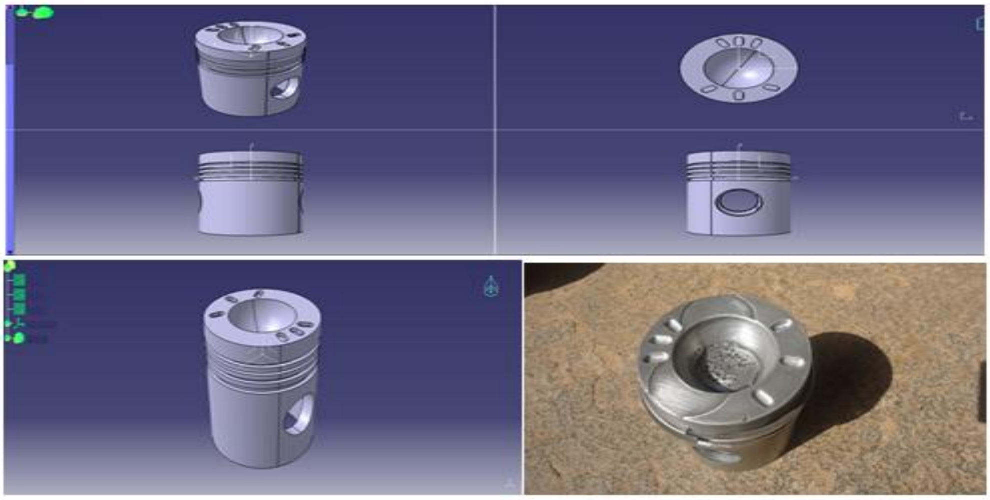
Fig.2. Schematic diagrams of grooves made on piston surface.

2.3a 3-D Modelling of different grooved Combustion Chambers:
A) 3-Grooved Combustion Chamber:



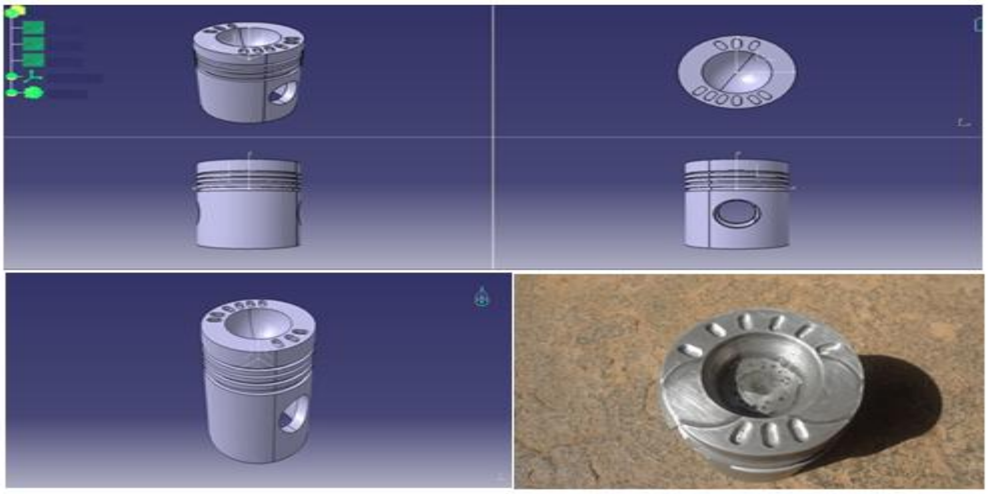
3-D Modelling **Photographic View**

B) 6-Grooved Combustion chamber:



3-D Modelling **Photographic View**

C) 9-Grovved Combustion Chamber:



3-D Modelling **Photographic View**

Fig.3 3-D Modelling of various grooves made on piston surface.

2.4 Experimental Setup

Kirloskar Company made single cylinder, 4 stroke, and water cooled diesel engine of 3.7 kW is used to conduct the experimental work. The test engine is directly coupled to an electric dynamometer. Five-gas analyser is used for emission testing.

Table 2. Specifications of the engine.

SL.NO	Parameters	Specifications
1	Machine supplier	Apex Innovations Pvt. Ltd. Sangali Maharastra State ,India.
2	Type	TV1 (Kirlosker made)
3	Software used	Engine soft
5	Nozzle opening pressure	200-225 bar
Governor type		
6	No.of cylinders	Single cylinder
7	No of strokes	foure stroke
8	Fuel	H.S Diesel
9	Rated Power	5.2 kw (7HP) at 1500 RPM
10	Cylinder diameter (Bore)	87.5 mm
11	Stroke length	110 mm
12	Compression Ratio	17.5:1
Air measurement manometer		
13	Made	MX 201
14	Type	U-Type
15	Range	100-0-100 mm
Eddy current Dynamometr		
16	Model	AG-10
17	Type	Eddy current
18	Maximum	1500-3000 RPM

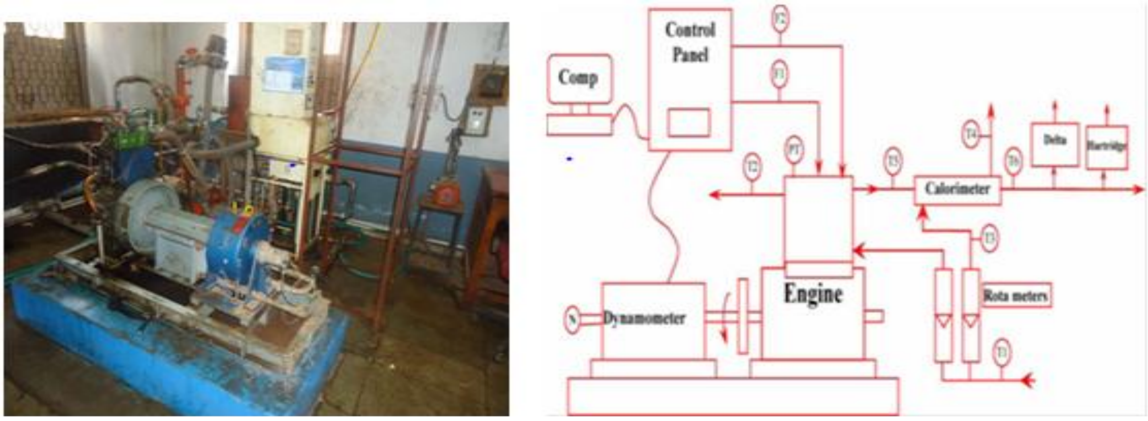


Fig.4 Engine setup.

III. Results and Discussions

In this work influence of air swirl on the performance and emission of a single cylinder diesel direct injection engine operated with honge biodiesel is done in order to achieve different swirl intensities in the cylinder.Thebaseline piston crown is modified by cutting the different number of grooves on the piston surface such as 3-grooves,6-grooves and 9-grooves to achieve better air-fuel mixing. The performance and emissions characteristics of modified piston operated with Hongebiodiesel are recorded.

3.1 Performance Analysis

3.1.1 Brake Thermal Analysis

Fig.5shows the variations of brake thermal efficiency with different configurations having different number of grooves on piston crown operated with Hongebiodiesel. It is observed that brake thermal efficiency for 6-grooved piston is found to be higher compared to other two configurations of the piston. This might be due to enhanced mixing rate in case of six grooves carried by turbulence in combustion chamber.

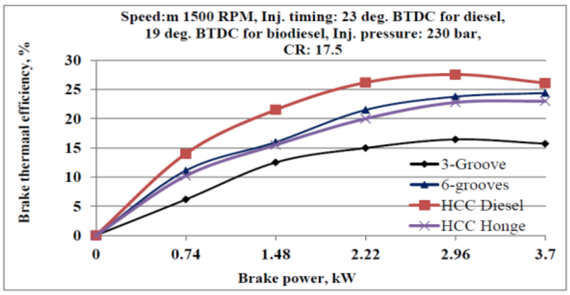


Fig.5 Comparison of BTE for 3-Grooves, 6-Grooves.

3.1.2 BSFC

Fig.6 shows the variations of brake specific fuel consumption with different configurations having different number of grooves on piston crown operated with Honge Oil Methyl Ester. It is observed that BSFC for 6-grooved piston is lower compared to other two configurations of piston. Due to poor combustion there is higher specific fuel consumption for three grooved piston as compared to 6-grooved piston and normal piston.

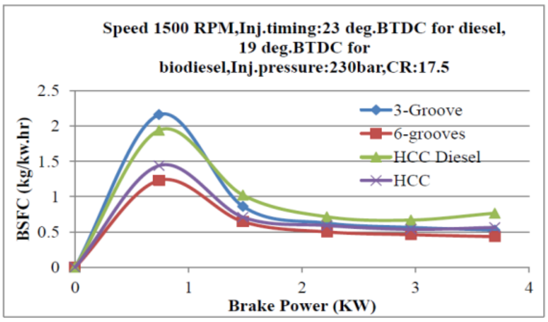


Fig.6 Comparison of BSFC (kg/Kw.hr) for 3-Grooves, 6-Grooves.

3.2 Emission Analysis

3.2.1 UBHC (ppm)

Fig.7shows the variation of hydro-carbon emission levels. Unburnt hydrocarbon emission is the result of incomplete combustion but there is decrease in hydro-carbon emission level with 6-grooved piston as compared to other two piston configurations and normal piston it is attributed to complete combustion because of proper mixing of air and fuel in 6-grooved piston. But there HC emissions are greater in 3-groove and normal piston which is due to improper air-fuel mixing rate.

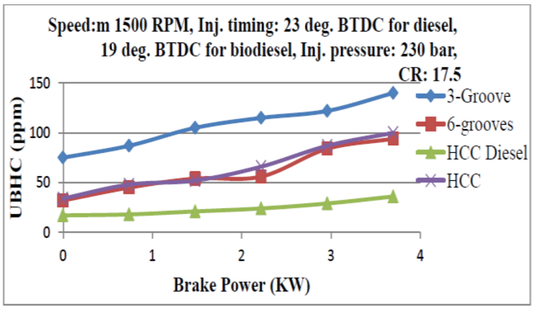


Fig. 7 Variations of UBHC (ppm) emissions.

3.2.2 CO (%)

Fig.8Shows the variations of CO emissions levels with brake power. Generally CI engines operate with lean mixtures and hence the CO emission would be low. With higher turbulence and temperature in combustion chamber the oxidation of carbonmonoxide is improved and which reduces CO emissions. With 6-grooved piston configuration emission of CO is low as compared to other two piston configurations

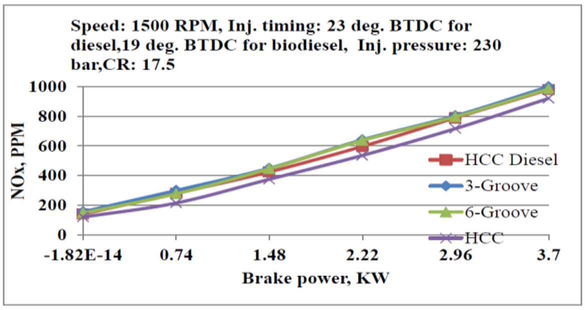


Fig. 9 Variations of NOx emission.

IV. Conclusion

In this present work a study is made to know the influence of air swirl in the cylinder on the performance and emission of a single cylinder diesel direct injection engine operated with honge biodiesel. The standard baseline piston is altered by cutting different number of grooves on the piston i.e. in the order of 3-grooves,6grooves - and 9grooves. The purpose of the study is to enhance the air-fuel mixing rate and turbulence in the cylinder.

1. Brake thermal efficiency for 6-Groove PistonConfiguration is greater compare to the other configurations which is attributed to better swirl and proper combustion.
2. There is better fuel economy for 6-Grooved Piston configuration whereas increase the Nox emission is due to better air-fuel mixing and a faster combustion process in the combustion chamber.
3. Due to high content of oxygen in the Hongebiodiesel and better air swirl the emissions CO, HC are reduced in 6-Groove Piston compared to baseline combustion chamber operated with Honge oil methyl ester.
4. It is observed that 9-Grooves piston operation stops the engine due to large change in compression ratio due to removal of more material from the piston crown as large no.of grooves in this piston.

References

[1] M. Prabhahar, R. MuraliManohar, S.Sendilvelan ,"performance and emission studies of a diesel engine with pongamia methyl ester at different load conditions" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622,Vol. 2, Issue 3, May-Jun 2012, pp.2707-2713.

[2] A. Haiter Lenin, C. R. Berlin Selva Rex, K. Thyagarajan, M. S. SenthilSaravanan, "Experimental Investigations on a Diesel Engine using Blends ofMethyl Esters of Pongamia Oil as the Fuels, European Journal of Scientific Research, ISSN 1450-216X Vol.72 No.2 (2012), pp. 273-284.

[3] C.V.Mahesh, E.T.Puttaiah, "studies on performance and emission characteristics of non-edible oil (honge oil) as alternate fuel in ci engine,International Journal of Engineering Research and Applications(IJERA) ISSN: 2248-9622. Vol. 2, Issue 3, May-Jun 2012, pp.2288-2293.

[4] S.Jaichandar a, P. Senthil Kumar , K. Annamalai, "Combined effect of injection timing and combustion chamber geometry on the performance of a biodiesel fueled diesel engine, Energy 47 (2012) 388e394.

[5] DipakPatil, Dr.Rachayya.R. Arakerimath, "Performance Analysis of Multi-cylinder C.I. Engine by using Karanja Bio-diesel",International Journal of Engineering Research andApplications (IJERA) ISSN: 2248-9622, Vol. 1, Issue 4, pp.1755-1763.

[6] Mingfa Yao, ZhaoleiZheng, Haifeng Liu, "Progress and recent trends in homogeneous charge compression ignition (HCCI) engines", Progress in Energy and Combustion Science 35 (2009) 398–437.

[7] B.V.V.S.U. Prasad, C.S. Sharma, T.N.C. Anand, R.V. Ravikrishna, "High swirl-inducing piston bowls in small diesel engines for emission reduction", Applied Energy 88 (2011) 2355–2367.

[8] John B.LHeywood, "Internal Combustion Engine Fundamentals", McGraw-Hill Series in Mechanical Engineering, 198.

[9] V.V. Prathibha Bharathi1 and G. Prasanthi, influence of in cylinder air swirl on diesel engine performance and emission. International Journal of Applied Engineering and Technology-2011 Vol. 1 (1) October-December, pp.113-118/Bharathi and Prasanthi.

[10] C .V. Subba Reddy, K. Hemachandra Reddy C. Eswar Reddy, "Effect of Tangential Grooves on Piston Crown of Diesel Engine with Preheated Cotton Seed Oil",International Journal ofEmerging Research in Management &Technology ISSN: 2278-9359 (Volume-2, Issue-4).