Effect of Turbulance Created By Internally Threaded Inlet Manifold on the Performance of the Diesel Engine with Biodiesel Blends

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Abstract: ***It is believed that crude oil and petroleum products will become very costly and scarce. Fuel economy of engines getting improved and will continue to improve. With increased use and depletion of fossil fuels, alternative fuel technology will become more common. This led to the search for an alternative fuel which should be not only environment friendly but also sustainable without compromising on the performance. Many alternative fuels gave improved performance, specifically vegetable oil present a very hopeful alternative fuel for diesel oil because they are renewable, clean burning and having properties analogous to that of diesel. Here, in this study we use waste palm cooking oil (WPCO) as a biodiesel. The main problem related with the combustion in C.I. engine is to get the homogeneous mixture of fuel and air. Air motion in Compression Ignition engine influences the distribution and atomization of fuel injected into the combustion chamber. This research includes design and orientation of the inlet manifold, which is a major factor effecting the emissions and performance of the engine. Swirl greatly enhances the mixing of diesel and fuel to give better homogenous mixture within a short time. This paper aims at studying the performance and emission characteristics of a water cooled engine by directing the air flow with buttress threads in the intake manifold with waste cooking oil biodiesel blended with diesel in varying proportions on volume basis. Tests were carried out for pure diesel and biodiesel blends and various parameters such as brake power, fuel consumption and mean effective pressures are calculated. The test results indicate that blend B20 (20% waste cooking oil & 80% diesel) gives better performance and emission results compared to all fuel mixtures and diesel under this study.***

Keywords: Waste Palm Cooking Oil (WPCO), buttress internal threads, swirl, single cylinder 4-stroke diesel engine, exhausts emissions.

1. Introduction

Heat (thermal energy) is oldest form of energy. Thermal energy is usually released from energies such as electrical energy and chemical energy. The device for converting one useful form of energy to another useful form is termed as engine. The conversion of energy plays a major role in an energy conversion process and it determines the efficient use of the energy which is supplied. Heat engine is a system or device that converts heat or thermal energy of a fuel to mechanical energy. [1]

Heat engine typically uses energy provided in the form of heat to do work and then exhaust the heat which cannot be used to do the work. Heat engines may be of internal combustion engines or external combustion engines. In which, there are two major types of internal combustion engines are in use today: (1) the spark ignition engine, which is used primarily in automobiles; (2) the diesel engine, which is used in large vehicles and industrial systems where the improvements in cycle efficiency of these engines make them advantageous over the more compact and lighter-weight spark ignition engine. Each of these engines is an important source of atmospheric pollutants. Automobiles are major sources of carbon monoxide, unburned hydrocarbons, and nitrogen oxides. The automobile engines have been designed based on the criteria of to reduce emissions of these pollutants. Even though, substantial progress has been made in emission reduction, automobiles remain important sources of air pollutants.

Swirl creates during the induction process by two general approaches. In one, flow is discharged tangentially toward the cylinder wall,, where it is deflected sideways and downward in swirling motion. In the other, the swirl is generated within the inlet port; the flow is forced to rotate about the valve axis. Several research studies about swirl enhancement in Internal Combustion engines reported that swirl creation facilitates the mixing of the fuel-air mixture and increases the combustion rate respectively. [2]

In Direct injection engines like compressed ignition engines fuel is injected directly into the combustion chamber and gets mixed with air depending upon the air motion in the combustion chamber. Supplied air into the cylinder through the inlet manifold is a major factor controlling the combustion process of engine. It governs the fuel-air mixing, burning rates and turbulence creation in diesel engines. Air enters the cylinder or combustion chamber of an internal combustion engine (I.C) through the intake manifold runner with high velocity. Then the kinetic energy of the fluid having high velocity is transformed into turbulent energy and causes rapid and proper mixing of fuel and air inside the combustion chamber. [3][4].

Biodiesel has been used in compression ignition or diesel engines from past few decades with a better substitute for diesel fuel. It is mainly due to their properties analogous to those of diesel, environmental friendly, and energy security. Promotions to use alternative fuels such as bio-fuels or biodiesels even in transportation and environmental concerns on carbon dioxide (CO_2) emissions are the main reasons for investigating the use of biodiesel as an alternative fuel for diesel (CI) engines. Nowadays, in Europe and other countries vehicles are fuelling with low percentage of biodiesel without problem, due to a consequence of technological advances. [4].

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2. Literature Survey

V.CVS Phanendra, et al. [1] in his experiment, modified the design of the inlet manifold by providing helical threads of variable pitches inside the inlet manifold, which is a important factor affecting the performance of the engine. He stated that, due to the helical threads in the manifold, swirl is created around the valve axis which leads to turbulence and consequently better air-fuel mixing. The performance characteristics with helical threaded manifold and normal inlet manifold were calculated and compared. The experiment was carried out with various configurations by changing helical threads by varying the pitch of the thread from 10mm to 25mm in additions of 5mm. It was found from the experimental results that the 10mm pitch manifold showed better performance results. The performance parameters presented below at 80% of rated load. Brake power was increased by 2.38%. Total fuel consumption was reduced by 2.91%. Brake specific fuel consumption was reduced by 5.55%. Indicated power was increased by 4.27%. Mechanical efficiency was reduced by 1.81%. Brake thermal efficiency was increased by 11.3%. Exhaust gas temperature was reduced by 1.81%. Volumetric efficiency was reduced by 11.3%. Hydro Carbon emissions were reduced by 12.5%. Carbon monoxide emission was reduced by 0.3%.

Dr. Rajesh Kumar U. Sambhe, and Dr. Pankaj N.Shrirao, et al [2] investigated with various types of inlet manifolds for compression ignition, direct injection (DI) single cylinder engine in order to create the swirl. Here they used three types of threads namely Acme, Knuckle and Buttress threads of constant pitch inside the inlet manifold. It is stated that, the inlet manifold with buttress threads gives better emissions and performance results compared to the inlet manifolds with knuckle and acme threads. This is because, with buttress threaded inlet manifold a higher swirl coefficient and swirl ratio is achieved compared with inlet manifolds having knuckle and acme threads. The Configuration of inlet manifold with buttress internal threads increases the turbulence and gives better fuel-air mixing process among all the configurations of inlet manifolds. As a result, BSFC is reduced; the thermal efficiency increases and exhaust emissions are reduced for buttress threaded inlet manifold. 11.62% of reduction in Brake Specific Fuel Consumption at 2.5kW load for engine with buttress threaded inlet manifold compared to engine with normal inlet manifold. It can be concluded that 26.66%, 12.32%, and 3.6% of reduction in CO, HC and NOx emissions respectively at 4/5 of rated load for engine with inlet manifold having buttress internal threads compared to the engine with normal manifold.

Suvendu Mohanty, Dr. Om Prakash, et al [3] studied the effect of various blends of an environmental friendly alternative fuel such as Waste Cooking Oil (WCO) on the performance of diesel engine. Experimental work has been carried out on the engine to analyze the performance and exhaust emission characteristics of a single cylinder compression ignition engine fuelled with biodiesel blends at various loads. The biodiesel used here is waste cooking oil (WCO) biodiesel. A test was conducted on an engine which was fueled with diesel and seven different blends of biodiesel made from waste cooking oil and diesel and the results were analyzed. Compared with conventional diesel, exhaust emissions like CO and HC are reduced while NOx emissions are increased with biodiesel blends with diesel in an internal combustion engine.

Based on the literature survey, it can be analyses that the design and configuration of the inlet manifold is very important in an IC engine. Swirl created by taking the intake flow into the cylinder with an initial angular momentum. In general, swirl is used in diesels and some stratified charge engines to promote more rapid mixing between the inducted air charge and the injected fuel. In order to produce high turbulence before combustion swirl generated in the inlet manifold is more helpful for rapid mixing of air and fuel. And also, there is a great need for the alternative fuels which are renewable and low cost. The aim of this work is to analyze the creation of swirl on the performance and emission characteristics of diesel engine, by inducing swirl in inlet manifolds with buttress internal threads inside the inlet manifold when fuel with blends of biodiesel (WPCO) and diesel in different proportions on basis of volume.

3. Waste Palm Cooking Oil (WPCO)

The idea of using alternative fuel and its derivatives as fuel is becomes interesting, due to variations in the prices of oil in the market and the increasing impact on the world environment, mainly the effects of exhaust emissions on the world. The possible different sources for alternative fuels are non-edible and edible vegetable oils and waste oil (triglycerides). Now days the cost of the biodiesel is more as compared to petroleum products because most of the biodiesel is produced from refined edible oils. The possible way of reducing the biodiesel cost is to use less cost and easily available feedstock such as waste vegetable oils. Waste cooking oil is the most economical vegetable oil and it can available at cheap. Hence, if the waste palm cooking oil is used as biodiesel, the economics of biodiesel can be improved significantly. [3]

Biodiesel can be created from virtually any type of vegetable oil or animal fat. The primary constituent of vegetable oil is triglyceride -- a long-chain hydro-carbon. Catalyzing triglyceride using anhydrous methyl alcohol in the presence of a strong base (sodium hydroxide) yields large amount of biodiesel and small amounts of glycerin as by-product. Depending on the free fatty acid (FFA) content of oil, conversion of any vegetable oil into biodiesel can be carried out using the method of Alkaline Transesterfication process. 1. Add one liter oil into a three neck fitted with condenser, thermometer and methanol dozer.. 2. Heat the vegetable oil to about 60° C. 3. Prepare Sodium methoxide by dissolving required amount of sodium hydroxide (as per titration test) in 200ml methanol. 4. Add Sodium methoxide to the preheated oil and constantly mix the contents for 1.0-1.5 hrs using mechanical stirrer. 5. Allow the mixture to settle for about 1-2 hrs in a separating funnel. 6. Drain out glycerin that settles at the bottom as a thick, cloudy liquid. 7. Translucent liquid that remains on top is methyl ester or biodiesel. Washing of Biodiesel is necessary to remove the soluble components using hot water. Hot water is sprayed on top of the biodiesel. Then it is allowed to settle down and waste water is drained off. The washing is carried out 3-4 times to get pure

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biodiesel. The process flow chart for biodiesel was shown in figure 1.

Figure 1: waste palm cooking oil

Table 1: Biodiesel (WPCO) Properties

Property	Diesel	WPCO Biodiesel
Density (Kg/m^3)	850	886
Colour	-	Yellowish
Kinematic viscosity at 40^{0}c (m^2/sec)	(2.5-6)×10^{-6}	(4.3-6)×10^{-6}
Flash point (^{o}c)	51	>210
Calorific value (MJ/Kg)	42	37
Specific gravity	0.85	0.86

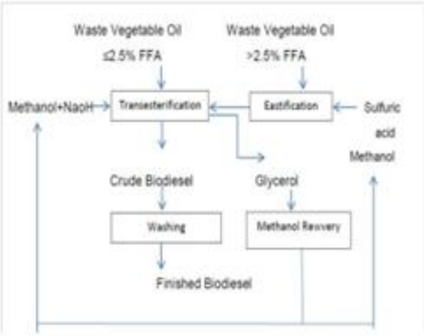

Figure 2: Process Flow for Biodiesel Process

4. Experimental Work

In order to analyze the performance and exhaust emissions of internal combustion engine an experimental set-up was developed. In the present work the effect of turbulence created by inducing swirl in the inlet manifold with buttress internal threads of 2mm pitch by fueling with biodiesel blends of WPCO on volume basis. Buttress threads are shown in fig 2.The experiment was carried out on a single cylinder, water cooled, direct injection diesel engine. Eddy current dynamometer is used for loading i.e. electrical loading. Properties of WPCO are in Table-1. The engine Specifications are given in Table-2.

Table 2: Test engine specifications

Particulates	Specifications
Model	AVI
Make	Kirloskar Oil Engine Ltd.
Arrangement of cylinders	Vertical
Lubricant	SAE 20/SAE40
No of cylinders	1
Bore	85mm
Stroke length	110mm
Rated speed	1500 rpm
Rated power	3.68 Kw (5HP)
Compression ratio	17.5:1
Starting	Hand start with crank handling
Fuel oil	High Speed Diesel (HSD)
Type of cooling	Water cooled

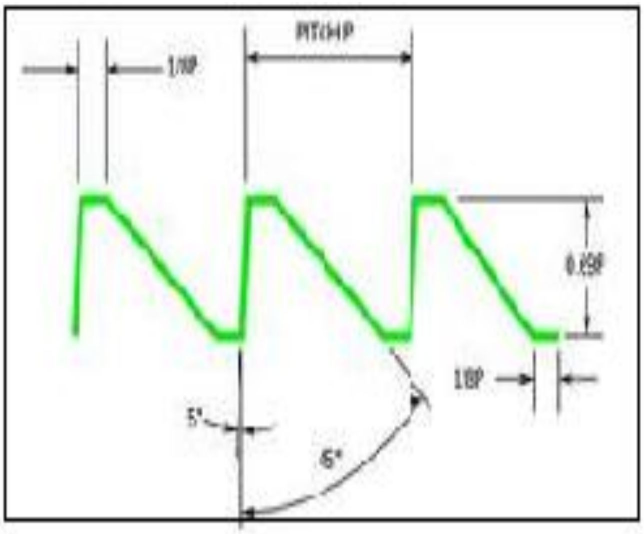

Figure 3: Profile of Buttress Thread [2]

If P= Pitch of the thread, d= depth of the thread

Figure 4: Internally Buttress Threaded Inlet Manifold

5. Results and Discussion

5.1 Brake Specific Fuel Consumption (BSFC)

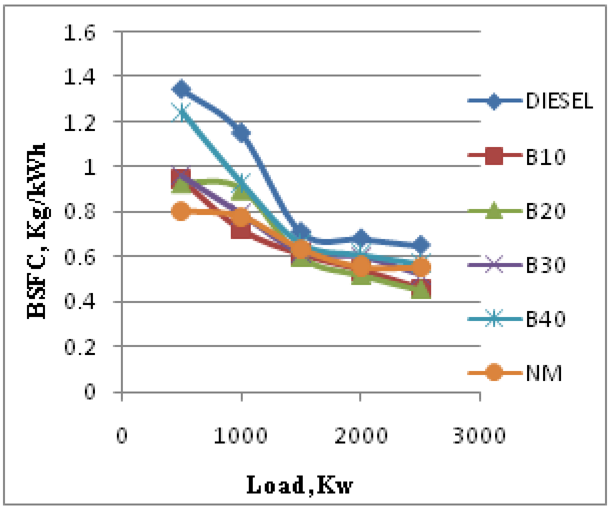

Figure 5: load vs. brake specific fuel consumption

Figure 5 shows variation of Brake Specific Fuel Consumption (BSFC) with load on the engine with various

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biodiesel (WPCO) blends on the engine with buttress internal threads. Lower BSFC is desirable because it is the measure of the engine's efficiency indirectly. BSFC and engine efficiency are inversely proportional. In general, BSFC is used rather than the thermal efficiency because more or less perfect definition of thermal efficiency does not exist. It is observed from the graph the brake specific fuel is decreasing for all the blends with increasing the load on the engine. For the blend B20 the decrease in BSFC is very precise at loads of 2 kW and 2.5kW with buttress threads, compared to the normal aspirated engine i.e. with normal inlet manifold as well as with buttress threads. The decrease is about 6.8 % at 2Kw load. This may be due to high swirl generation in the inlet manifold with buttress threads; possibly due to increased temperature and efficiency. And for the blend B10 also has significant decrease compared to the diesel.

5.2 Brake Thermal Efficiency

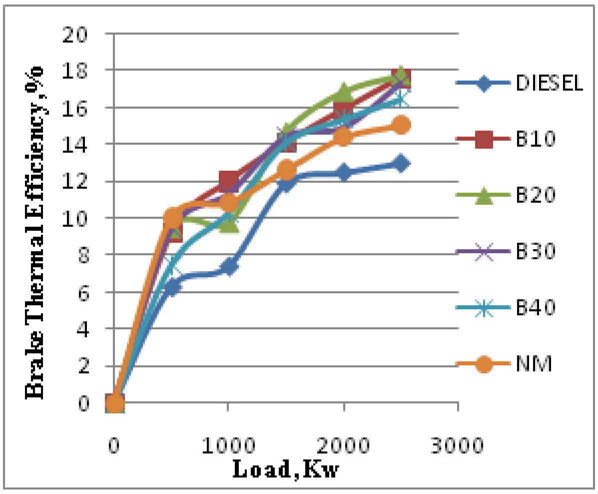

Figure 6: load vs. brake thermal efficiency

Figure 6 shows variation of brake thermal efficiency with different blends of Waste palm Cooking Oil (WPCO) and diesel. The brake thermal efficiency of all the blends is more compared to the diesel with buttress internal threads and normal inlet manifold. Blend B20 gives better performance results at the rated loads of 2 kW and 2.5 kW compared to all the blends. In-cylinder flow field structure is greatly influenced by providing threads in the intake manifold design. Air motion in Compression Ignition engine influences the distribution and atomization of fuel injected into the combustion chamber. With optimal turbulence, better mixing of air and fuel is possible which leads to complete and effective combustion so that thermal efficiency increases. Brake thermal efficiency increases with the load for the reason that as the load increases relatively less portion of power is lost.

5.3 Exhaust Gas Emissions of Carbon Monoxide

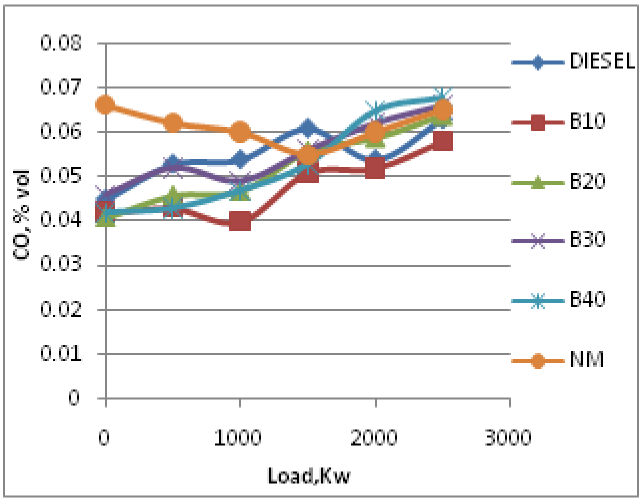

Figure 7: load vs. carbon monoxide

Figure 7 shows the variation of CO emission with engine loading. Carbon monoxide forms during the combustion process. It was observed from the graph that CO emissions are increased with increase in engine load. CO emission of biodiesel is less compared to diesel it is likely due to oxygen content present in the biodiesel is more which helps in more complete and rapid oxidation of fuel. Generally, Compression Ignition engines operate with lean mixtures and hence the CO emission would be low. With the higher swirl of air in the inlet manifolds with internal threads, the oxidation of carbon monoxide in the engine is improved and subsequently reduces the CO emissions. With rich fuel-air mixtures, there is insufficient oxygen to burn fully all the carbon in the fuel to CO_2; also, in high temperature products, even with lean mixtures, dissociation ensures there is a significant CO level. CO emission of all the blends less compare to diesel with normal inlet manifold and buttress threaded inlet manifold. Significantly, blend B10 gives less CO emission compare to all the blends and diesel.

5.4 Exhaust Emissions of Hydro Carbons

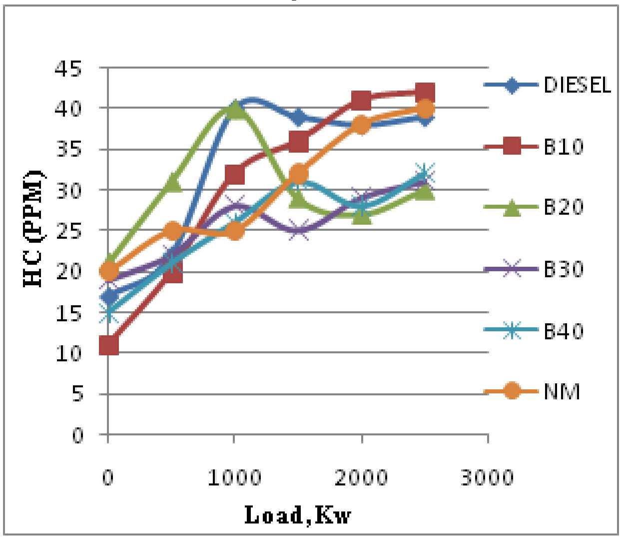

Figure 8: load vs. hydro carbons

Figure 8 variation of HC emission with various loads on normal inlet manifold engine and buttress threaded inlet manifold engine with biodiesel blends. The possible sources of HC emission in an I.C engine is during compression and

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combustion, the increasing cylinder pressure forces some of the gas in the cylinder into crevices, or narrow volumes connected to the combustion chamber. Most of this gas is unburned fuel-air mixture. As the engine is fitted with manifold of buttress threads, the increasing turbulence causes better mixing of fuel and air so that hydro carbon emission is decreasing. It is apparent that B20 blend gives less hydrocarbon emission at rated load of 2kW and 2.5kW compare to all blends and diesel chamber. Most of this gas is unburned fuel-air mixture. As the engine is fitted with manifold of buttress threads, the increasing turbulence causes better mixing of fuel and air so that hydro carbon emission is decreasing. It is apparent that B20 blend gives less hydrocarbon emission at rated load of 2kW and 2.5kW compare to all blends and diesel.

5.5 Exhaust Emissions of Nitrogen Oxides

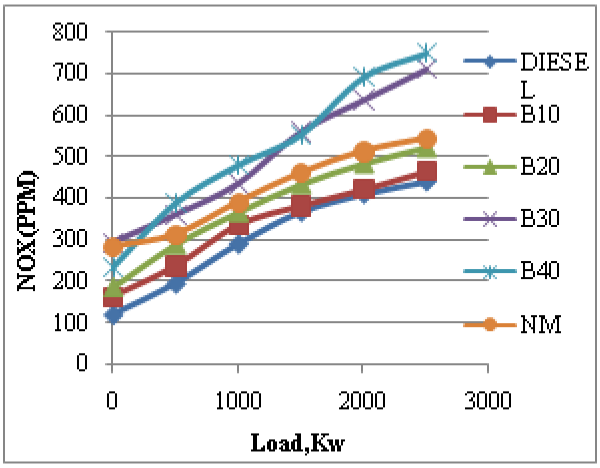

Figure 9: load vs. nitrogen oxides

Fig shows 9 variation of NO_X emission with various loads on normal inlet manifold engine and buttress threaded inlet manifold engine with various biodiesel blends. It is observed that blends B10 and B20 gives less NO_X emission with normal inlet manifold but more for buttress threaded manifold. The NO_X for diesel engine with buttress internal threads is 440ppm and for blends B10 and B20 is 465ppm, 524ppm respectively at 2.5Kw rated load. The increase in NO_X is may be due to higher oxygen content present in the waste palm cooking oil and my be due to less operating temperature in the cylinder by creating more swirl which leads to less NO_X emission at lower blends.

6. Conclusion

Performance and emission characteristics of diesel (C.I) engine with blends of biodiesel of waste palm cooking oil with diesel and buttress threads inside the inlet manifold are compared with the normal inlet manifold in this experimental investigation. From this investigation, it can be concluded that blend B20 gives better performance and emission results compared to the all blends and diesel. The results of this study may be summarized as follows.

- It is observed that reduction of BSFC for engine with buttress internal threads using waste palm cooking oil blends as compared to the engine of buttress internal threads with diesel at all load conditions. It is significant to note that a 6.8% of reduction BSFC for blend B20 with buttress threads against normal inlet manifold at 2Kw load.
- Thermal efficiency is more for all the blends compared to the diesel at all the loads because a better mixing of fuel and air due to the creation of turbulence by inlet manifold.
- The emissions of un-burnt hydrocarbon (HC) for biodiesel with buttress internal threads are less this is because of increased turbulence by creating the swirl. Blends B10 and B20 give lesser emissions at rated loads of 2Kw and 2.5Kw.
- CO emission of biodiesel is less compared to diesel it is likely due to oxygen content present in the biodiesel. Blend B10 gives less CO emission compare to all the blends and diesel.
- It is observed that blends B10 and B20 gives less NO_X emission with normal inlet manifold but more for buttress threaded manifold.

7. Scope of Future Work

The present work can be extended by varying the pitch, width and depth of the buttress threads in the inlet manifold. The engine can be tested for better performance with the buttress threaded manifold for various alternative fuels also.

References

[1] V. Pandurangadu& M. Chandramouli, V.CS phaneendra, "Evaluation of Performance of a Four Stroke Compression Ignition Engine with Various Helical Threaded Intake Manifolds", International Journal of Applied Research in Mechanical Engineering (IJARME), ISSN: 233-5950, Volume-2, Issue, 2012.

[2] Dr.Pankaj N.Shrirao & Dr.Rajeskumar U.Sambe. "Effect of Swirl creation by Internally Threaded Inlet Manifold on Exhaust Emissions of a Direction Injection Diesel Engine. International Journal of Science and Research (IJSR). Volume 3 Issue 7, July 2014.

[3] Dr. Om Prakash& Suvendu Mohanty "Analysis Of Exhaust Emissions of Internal Combustion Engine Using Biodiesel Blends". International Journal of Engineering Technology and Advanced Engineering (IJETAE). Volume 3, Issue 5, May 2013.

[4] A Bijucherian, Mallikarjuna J.M& Murali Krishna B (2010). "Effect of Intake Manifold Inclination on the Intake Valve Characteristics of a Single Cylinder Diesel Engine Using Particle Image Velocimetry. International Journal of Research and Applied Sciences 6(2) Pp. 119-125.

[5] Ridvan Arsian. "Emission Characteristics of A Diesel Engine Using Waste Cooking Oil as Biodiesel Fuel". African Journal of Biotechnology Volume. 10(9), pp. 3790-3794, 9 May, 2011.

[6] Internal Combustion Engine Fundamentals by John B.Heywood. McGraw-Hill Series in Mechanical Engineering.

[7] Internal Combustion Engines by V.Ganesan, Tata McGraw-Hill Publishing Company Limited.

[8] Mohamad Azmi Bustam, Zahoor Ullah and Zakaria Man "Characterization of Waste Palm Cooking Oil for

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Biodiesel Production "International Journal of Chemical Engineering and Applications, Vol. 5, No. 2, April 2014.

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