International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

Experimental Investigation on CI Engine for Performance, Emission and Combustion Characteristics of Dual Biodiesel Blended in Diesel

Md. Fakhruddin H.N[a,*], Dr. Mohammed Yousuf Ali[b], Dr. M.Manzoor Hussain[c]
[a]*Methodist College of Engg. & Tech., Osmania University – Hyderabad, Telangana – 500001, India*
[b]*Avanthi Institute of Engineering & Technology, Hyderabad, Ranga Reddy, India*
[c]*JNT University H, College of Engineering Kukatpally, Hyderabad, Telagana, 500085, India*

Abstract— ***Need for alternate fuel in CI engine for which a lot of experimental research is being done worldwide. Intense research is already done with biodiesel blended in diesel. And Dual biodiesel blended in diesel research is underway, which gain importance because feasibility to materialize locally available feed stock. In this contest the experimental research is being carried out to examine the performance and combustion of Waste Cooking Oil biodiesel (WCOBD) and Palm Stearin biodiesel (PSBD) blended in diesel. Result shows that B20 mixture stand close to pure diesel without much engine modification. Brake thermal efficiency and brake specific fuel consumption differ by 12.99percent and 23.5percent. CO differs by 16.5% and HC differ by 3.09% that of pure diesel mode. Whereas NOx increased by 8.9% for optimal load and blend ratio. Peak in-cylinder pressure and net heat release rate differ by 2.05% and 3.1% respectively. Properties for pure diesel and dual biodiesel blends of diesel are also enclosed.***
Keywords: Dual Biodiesel, WCOBD, Palm Stearin Bio-diesel, Combustion

I. INTRODUCTION

Biodiesel is known to be biodegradable, so it is considered to be much less damaging to the environment if divulge. The advantage about biodiesel is that it is made from plants and animals resources which are not depleted when used. The non renewable of world petroleum and increased environmental impact has reviving interest in another possible sources for petroleum based fuels. Biodiesel extracted from vegetable oil or animal fats by transesterification (with alcohol like methanol and ethanol) is advised for use in place of petroleum-based diesel, because biodiesel has more oxygen , not depleted when used, biodegradable and environmental amiable. The used cooking oil is considered as waste, while it has potential as a liquid fuel by physical and chemical conversion remains same.

Waste Cooking Oil as biodiesel

Biodiesel fuel produced successfully from waste cooking oils by an alkali-catalyzed transesterification process and can be considered as alternative fuel in diesel engines and various utilities. Need only to convert waste cooking oil from kitchen waste into biodiesel and transesterification is the most appropriate process for this conversion [1].

Palm Stearin as biodiesel

Palm stearin is the solid fraction of palm oil that is produced by partial crystallization at controlled temperature [2]. After fractionation the liquid portion is known as palm olefin, which is commonly bottled and sold as cooking oils. The solid fat portion is known as palm stearin and is normally used to formulate trans-free fats such as margarine, shortening and vegetable ghee [3] and soap industry. Palm oil is mainly used for edible purposes while palm kernel oil is used for non-edible purposes such as making soaps, cosmetics and detergents as it contain cholesterol.

II. MATERIALS AND METHODS

Engine Specification

Performance test is carried out in a research engine test rig having the specification as mention here, kirlosker make single cylinder four stroke diesel engine. This has stroke length and bore diameter of 110mm, and 87.5mm respectively. Power 3.5kw speed 1500rpm compression ratio 17.5 injection opening pressure 225bar and eddy current loading unit.

Experimental Procedure

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

Experimental work is carried out first with pure diesel at four different loading and performance parameters are evaluated. Next pure diesel is blended with dual biodiesel of WCO and PS at three different proportions. i.e. 5WCOBD5PSBD90D, 10WCOBD10PSBD80D & 15WCOBD15PSBD70D and experimented for different loadings.

III. TABLES

Table1.1 Fuel Properties for Pure Diesel, Biodiesels and Diesel Blends

Property	Diesel	WCOBD	PSBD	B10(5WCOBD+5PSBD+90D)
Density (kg/m^3)	832	878	898	837.6
Viscosity at 40˚C (mm^2/s)	2.6	3.35	4.12	2.71
Calorific value (MJ/Kg)	46.049	45.080	39.507	45.673

Fuel Properties for Pure Diesel, Biodiesels and Diesel Blends Contd…

Property	**B20 (10WCOBD+10PSBD+80D)***		B30 (15WCOBD+15PSBD+70D)
Density (kg/m^3)	841.6	**842.12***	841.6
scosity at 40˚C (mm^2/s)	2.827	**2.84***	2.827
alorific value (MJ/Kg)	45.297	**45.505***	45.297

*Properties are test verified at Vimta Labs Ltd.

IV. RESULTS AND DISCUSSION

Brake Thermal Efficiency

Brake thermal efficiency is the measure of performance of the engine calculated as the ratio of brake power generated to the heat input. It is the indication of the ability of engine to transform energy input to useful work.

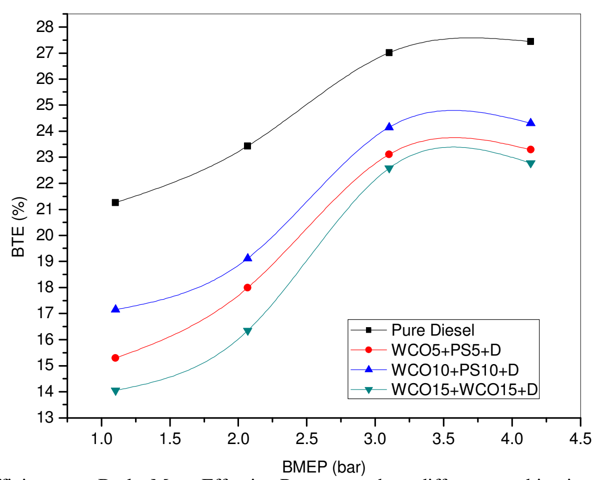

Fig.1. Brake Thermal Efficiency vs. Brake Mean Effective Pressure at three different combinations compared with pure diesel

BTE for conventional diesel is greater than its blends. The variations in the thermal efficiency of the biodiesel blends are due to the lower calorific value of WCOBD & PSBD when compared to diesel. Further, higher viscosity and slow vaporization of biodiesel present in these blends leads to inferior combustion of biodiesel which causes reduction in brake thermal efficiency [4, 5, 6].

It is noticed that as the biodiesel is blended with diesel for all proportions, brake thermal efficiency decreases.
Under full load condition for WCOBD5+PSBD5+D(B10), WCOBD10+PSBD10+D(B20) and WCOBD15+PSBD15+D(B30) percentage of substitution, brake thermal efficiency is found to be 16.6%, 12.99% and 18.4% lower than that of pure diesel mode respectively.
It is further to note that for all the fuels used BTE increases with increasing load steeply except at full load.
BTE is lower for B10 and increase with the blending ratio of B20 thereafter falls with further increase to B30, B20 being optimum blending ratio. This trend is also experienced by previous researchers [8].
The lowest value of brake thermal efficiency was noted may be due to the large amount of bio diesel supplied to the engine when compared to diesel in order to maintain the equal energy input to the engine[9,10]. The high viscosity of the blended fuels inhibits the proper atomization, fuel vaporization, and combustion. This tendency is due to the combined effect of lower calorific value, higher density, and viscosity of the blended fuel. These results are in accordance with experimental work done by the previous researchers[11,12].

Brake Specific Fuel Consumption

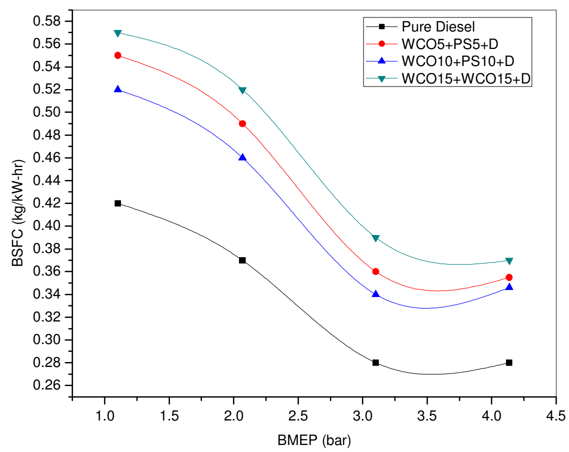

Fig.2. Brake Specific Fuel Consumption vs. Brake Mean Effective Pressure at three different combinations compared with pure diesel

The reason for the higher BSFC of biodiesel can be due to the effects of the relative fuel density, viscosity and heating value of blends.Biodiesel fuel is delivered into the engine on a volumetric basis per stroke, thus, larger quantity of biodiesel is supplied into the engine. Therefore, to produce the equal power, more biodiesel fuel is needed.
It is observed that BSFC decreases as the load increases for all the test fuels and is lowest for diesel fuel mode, since brake thermal efficiency was more than that of any percentage of biodiesel substitution; hence brake specific fuel consumption has minimum value for pure diesel operation at all loading conditions compared to different biodiesel substitution. Minimum BSFC is observed for pure diesel at full load is 0.28kg/kW-hr and for blended diesel at full load for WCOBD10+PSBD10+D(B20) is 0.346kg/kW-hr.
BSFC is the ratio between mass flow of the tested fuel and effective power[13]. The BSFC of diesel engine depends on the relationship among volumetric fuel injection system, fuel density, viscosity and lower heating value[14].

Carbon Monoxide Emission

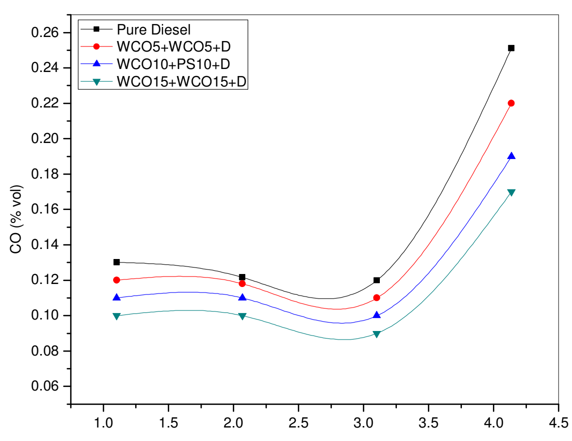

Fig.3. Variation of Carbon Monoxide Emission with Brake Mean Effective Pressure at three different combinations compared with pure diesel

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

It is observed that as the load increase up to 75%, the formation of CO decrease at any proportion of biodiesel blend in a dual fuel mode. In a pure diesel mode operation, due to the presence of more excess air, the carbon oxidation reaction is almost completed the considerable amount of CO is not produced until the smoke limit is reached. But as the load was increased from 75% to full load, CO formation increases rapidly, because CO is a product of incomplete combustion due to insufficient amount of air in Air Fuel mixture or insufficient time in the cycle for completion of combustion, at full load. The optimum CO content is observed for B20 at 75% load is 0.1% by volume and for diesel 0.1199% by volume.

Hydrocarbons Emission

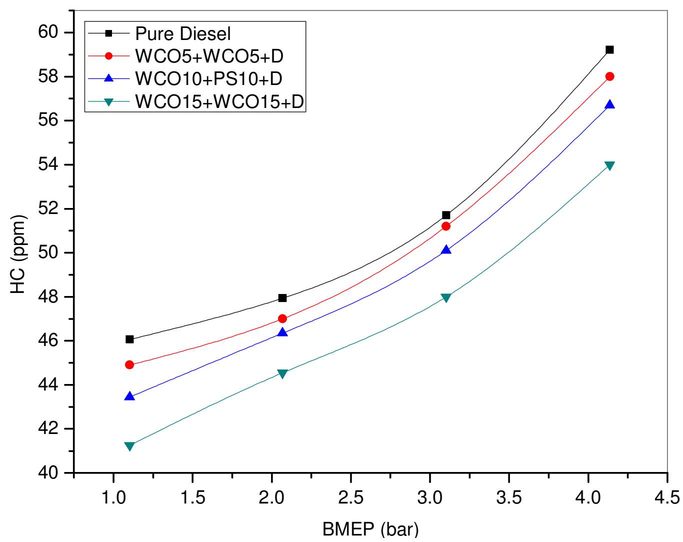

Fig.4. Variation of HC with BMEP using three different combinations is compared with pure diesel

As depicted in figure that there is a continuous increment in HC content as the load increases. HC content will be low for B30 at full load i.e. 54.01ppm, formation of HC contents will be low because of proper mixing of fuel droplets with air. But since maximum brake thermal efficiency is for B20 i.e. for 20% bio diesel substitution, an optimum blending ratio its HC content at optimal loading is found to be 50.1ppm, and for pure diesel it is 51.7ppm. Hydrocarbon emission dropped further due To the increased wall temperature[15].

NOx Emission

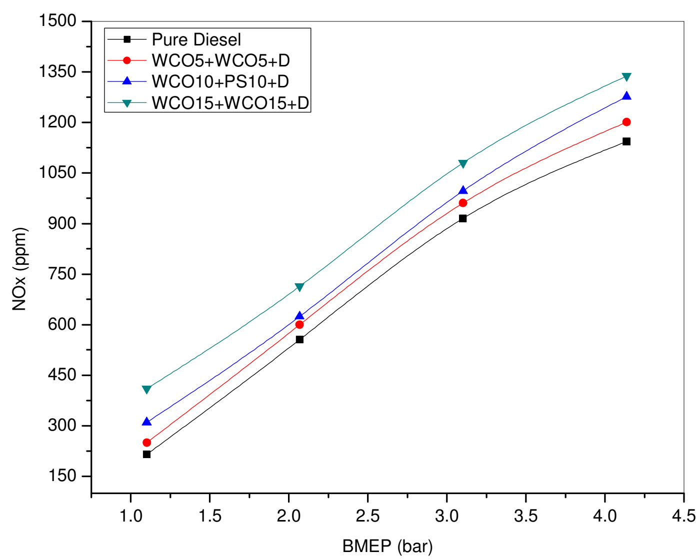

Fig.5. Variation of NOx with BMEP using three different combinations is compared with pure diesel

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

NOx concentration varies linearly with the load of the engine. As the load increases, the overall fuel-air ratio increases, resulting in an increase in the average gas temperature in the combustion chamber and this increases the NOx. The in-cylinder temperature was very high which leads to the formation of NOx due to the presence of excess of oxygen. High biodiesel blends substantially increased the NOx emissions. Maximum amount of NOx were found B30 i.e. 1338ppm, which is 17.06% more than that of pure diesel mode. And for optimum blend it is 1276.6ppm at full load. And for optimal load it is 996.6ppm for B20 and 915ppm for pure diesel.
The oxides of nitrogen in the exhaust emission are the combination of nitric oxide (NO) and nitrogen dioxide (NO2). The formation of NOx is highly dependent on in-cylinder temperature, oxygen concentration in the cylinder[16].

Cylinder Pressure

Peak in-cylinder pressure is higher for diesel fuel at all tests. This result can be related to the differences in the heat release pattern. The peak in- cylinder pressure mainly depends on the combustion rate in initial stages, which is influenced by the fuel taking part in uncontrolled heat release phase. High viscosity and low volatility of the biodiesel lead to poor atomization and mixture preparation with air during the ignition delay period. The peak in- cylinder pressure of biodiesel blends are lower due to the deterioration during the preparation process of air–fuel mixture as a result of high fuel viscosity. Peak in- cylinder pressure slightly decreases with the addition of biodiesel content in the blend. With the addition of biodiesel content in the blend, the peak cylinder gas pressure slightly goes away from top dead center (TDC) due to poor atomization, mixture preparation and combustion process [7]. For optimal blend and loading peak pressures ate 57.84bar and 56.65bar for pure diesel and B20 respectively.

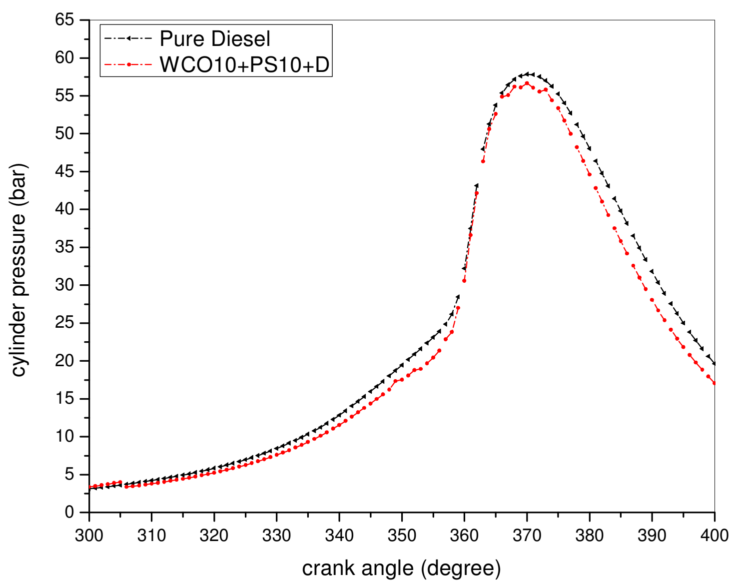

Fig.5. Cylinder pressure with crank angle compared for pure diesel and optimum blend of diesel

The peak Cylinder gas pressure of biodiesel and its blends were lower due to the deterioration during the preparation process of air–fuel mixture as a result of high fuel viscosity[17].

Net Heat Release Rate

It is one of the most important parameter to characterize the combustion process in CI engine. Using the net heat release rate it is possible to determine ignition delay, start of combustion and peak set heat release rate, because of the vaporization of the fuel accumulated during ignition delay, at the beginning a negative HR is observed and after combustion, this behavior becomes positive. After the ignition delay, premixed fuel air mixture burns rapidly, followed by diffusion combustion, where the burn rate is controlled by fuel–air mixture.

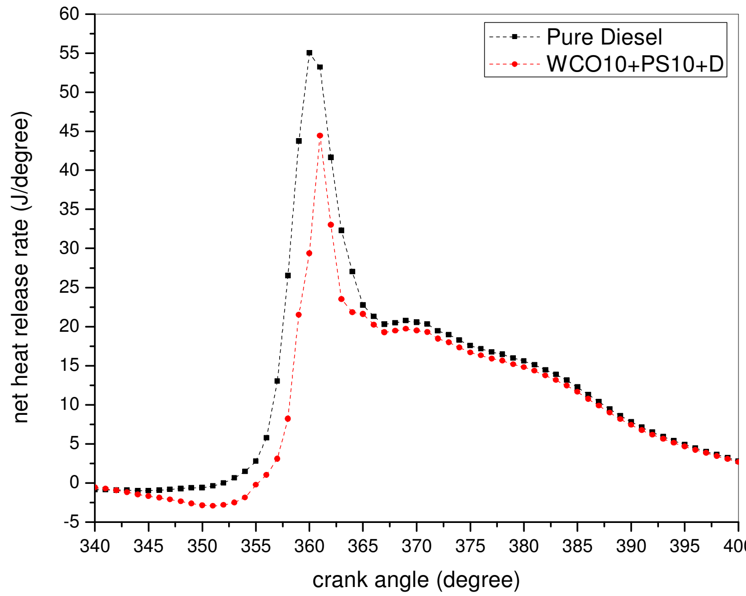

Fig.6. Net heat release rate with crank angle compared for pure diesel and optimum blends of diesel

Combustion starts earlier for biodiesel blends under all engine operating conditions (not shown in figure) and it becomes more prominent with higher biodiesel addition in the blends. The premixed combustion heat release is higher for diesel owing to higher volatility and better mixing of diesel with air [7]. Another reason may possibly be the longer ignition delay of diesel, which leads to a larger amount of fuel accumulation in the combustion chamber at the time of the premixed combustion stage, leading to a higher Net Heat Release Rate. Heat release rate for pure diesel is 53.32J/deg and for B20 is 55.00J/deg.
longer ignition delay of diesel, which leads to a larger amount of fuel accumulation in the combustion chamber at the time of the premixed combustion stage, leading to a higher rate of heat release[18].

V. CONCLUSION

- Brake thermal efficiencies for diesel, B10, B20 and B30 are 26.01%, 21.32%, 22.13% and 20.68574% respectively.
- Brake specific fuel consumption is 0.28kg/kW-hr for diesel, 0.36 kg/kW-hr for B10, 0.34 kg/kW- hr for B20 and 0.39 kg/kW-hr for B30
- It is noticed that WCOBD10+PSBD10+D(B20) blend is having higher brake thermal efficiency when compared to the other two blends and the same blend is having minimum brake specific fuel consumption, therefore it is selected as an optimum blending ratio of biodiesel in pure diesel.
- CO content for B20 at full load i.e. 0.19% by volume and HC content at full load was found to be 56.7ppm, which is 11.8% less than that of pure diesel mode.
- Maximum B30 NOx was found to be 1338ppm, which is 17.06% more than that of pure diesel mode. And for optimum blend shows 1276.6ppm.
- The peak in-cylinder pressure conditions when engine is operating under pure diesel and B20 are found to be 57.8468, 56.6573bars respectively.
- Maximum heat release for diesel which is 55.00J/deg and for biodiesel 53.3J/deg.
- Net heat release rate slightly goes away from top dead center (TDC). For diesel 360degree and for biodiesel it is 361 degree.

REFRENCES

[1] Tomasevic AV, Siler-Marinkovic SS. Methanolysis of used frying oil. Fuel Process Technol 2006;81:1–6 .www.sciencedirect.com/science/journal /03783820/81/1
[2] Narayana Reddy, J. and Ramesh A., 2006, “Parametric studies for improving the performance of a Jatropha oil-fuelled compression ignition engine”, Renewable Energy, Vol.31, No.12, pp.1994-2016.
[3] Tsolakis A, Megaritis A, Wyszynski ML, Theinnoi K. Engine performance and emissions of a diesel engine operating on diesel-RME (rapeseed methyl ester) blends with EGR (exhaust gas recirculation). Energy 2007; 32:2072-80.

[4] R. Anand, G.R.kannanb, P.karthikeyan, A study of the performance emission and combustion characteristics of a DI diesel engine using waste cooking oil methyl ester-ethanol blends, proceedings of the ASME 2012 international mechanical engineering congress & exposition imece2012 november 9-15, 2012, houston, texas, USA.
[5] Narayana Reddy, J. and Ramesh A., 2006, “Parametric studies for improving the performance of a Jatropha oil-fuelled compression ignition engine”, Renewable Energy, Vol.31, No.12, pp.1994-2016.
[6] Huseyin Aydin, Cumali IlKilic, 2010, “Effect of ethanol blending with biodiesel on engine performance and exhaust emissions in a CI engine”, Applied Thermal Engineering, Vol.30, pp.1199-1204.
[7] Gumus *Automotive Division, Department of Mechanical Education, Marmara University, Ziverbey 34722, Istanbul, Turkey]
[8] Jegadheesan.C, Somasundaram.P, Meenakshipriya.B,Vignesh.U.P. “Effect of DEE Injection in Pongamia Pinnata Biodiesel Fulled CI Engine using Hydrogen as Secondary Fuel” Advanced Materials Research Vol. 768 (2013) pp 188-194 Online: 2013-09-04 © (2013) Trans Tech Publications, Switzerland
[9] Senthilkumar M, Remesh A, Nagalingam B. Complete vegetable oil fueled dual fuel compression ignition engine. SAE technical paper 2001-28-0067.
[10] Nazar J, Ramesh A, Sharma RP, Performance and emission Studies of use SVO and bio diesel from different Indian feed stock, SAE technical paper 2004-28-071.
[11] Sukumar Puhan N, Vedaraman G, Sankaranarayanan Boppana V, Bharat Ram. Performance and emission study of Mahua oil (Madhuca Indica oil) Ethyl ester in a 4-stroke natural aspirated direct injection diesel engine. Renew Energy 2005; 30:1269-78.
[12] Suresh Kumar K, Velraj R, Ganesan R. Performance and exhaust emission characteristics of a C.I engine fueled with Pungamia Pinnata Methyl Ester (PPME) and its blends with diesel, International Journal of Renew Energy 2008; 33: 2294.
[13] M. Mofijur, H.H. Masjuki, M.A. Kalam, A.E. Atabani, Department of Mechanical Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia. Energy 55 (2013) 879e887
[14] Qi DH, Chen H, Geng LM, Bian YZ. Experimental studies on the combustion characteristics and performance of a direct injection engine fueled with biodiesel/diesel blends. Energy Convers Manag 2010;51:2985e92.
[15] http://www.palmoilworld.org/about_palmoil.html
[16] American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-02, pp-184-190 www.ajer.org
[17] Kumar MS, Ramesh A, Nagalingam B. An experimental comparison of methods to use methanol and Jatropha oil in a compression ignition engine. Biomass Bioenergy 2003;25:309–18.
[18] M. Gumus, Automotive Division, Department of Mechanical Education, Marmara University, Ziverbey 34722, Istanbul, Turkey, Fuel 89 (2010) 2802–2814