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Effect of Injection Timing on Performance and Emission Analysis of Single Cylinder Diesel Engine Fuelled with Dual Bio-fuels

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Abstract

In this experimental study, the performance and emission characteristics were investigated for dual bio fuel (Jatropha oil and Rubber seed oil) in a single cylinder diesel engine by retarding the injection timing to 21º from standard injection timing of 24º. The blends used in this are B20 (Biodiesel-20%), B40 (Biodiesel-40%), B60 (Biodiesel-60%) with pure diesel fuel. This paper reveals about the influence of injection timing variation in diesel engine by using this dual bio fuel. The performance and emission parameters considered for the tests are BSFC (Brake Specific Fuel Consumption) ,CO (carbon monoxide), NOX (nitrogen oxide)and UHC (unburned hydro carbon) . These parameters were analyzed for different load conditions varying from zero to 100 % load. From the test results, it is observed that SFC is lower for B20 blend compared to that of pure diesel fuel whereas B40 and B60 blends have slightly higher values but are closer to B20 blend. It is also found that the emissions of CO, UHC were reduced with increase in blends of biodiesel in the fuel mixture but NO_x emission is increased with increase in blends of biodiesel in the fuel mixture.

Keywords: Diesel Engine, Bio Fuel, Injection Timing, Performance, Emission.

1. Introduction

The renewable liquid or gaseous transport fuels produced from plant or animal material have emerged as one of a number of possible alternatives to fossil fuels that might help meet our energy needs in an environmentally sustainable method. However, bio fuels production, which mainly uses food crops, has been controversial because in some cases it has led to deforestation and to disputes over rising food prices and land use. New types of bio fuels, such as those using non-food crops and algae, are being developed with the aim of meeting our energy demands while avoiding the problems of the past. Jatrophacurcas is a species of flowering plant in the genus Jatropha in spurge family. Euphorbiaceae, that is native to the American tropics, most likely Mexico and Central America. It is cultivated in tropical and subtropical regions around the world, becoming naturalized in some areas. Jatropha plants also cultivated in central and southern parts of India, the Jatropha seeds contain 27-40% oil that can be processed to produce a high–quality bio diesel fuel, usable in a standard diesel engine. The seeds are also a source of the highly poisonous toxalbumincurcin. When Jatropha seeds are crushed, the resulting jatropha oil can be processed to produce a high-quality biofuel or biodiesel that can be used in a standard diesel car. Rubber seed oil is oil extracted from the seeds of rubber trees. In the latex manufacturing process, rubber seeds are not historically collected and commercialized. Recent analysis shows that rubber seed oil contained the fatty acids of Palmitic (C16:0)-0.2%, Stearic(C18:0)-8.7%,Oleic(C18:1)-24.6%,Linoleic(C18:2)-39.6% and Linolenic (C18:3)-16.3%. [1] CenkSayin et al. Studied the influence of injection timing on the engine performance and exhaust emissions by using ethanol blended diesel fuel from 0% to 15%. The different injection timing was used are 21˚, 24˚, 27˚, 30˚ and 33˚, the experimental results showed that the BSFC and emissions of CO and NO_xincreased as BTE and emissions of CO and HC decreased with increasing amount of ethanol in the fuel mixture. When compared to the results of original injection timing (27˚ CA BTDC),NOx and CO2 emissions increased, and unburned HC and CO emissions decreased for the retarded injection timings (21˚ and 24˚ CA BTDC) at the all test conditions. On the other side, with the advanced injection timings (30˚ and 33˚ CA BTDC), decreasing HC and CO emissions diminished, and NOx and CO2emissions boosted. In terms of BSFC and BTE, retarded and advanced injection timings compared tothe original injection timing in the all fuel blends gave negative results for all engine speeds and loads. [2] Hyungjun Kim et al Investigated the combustion and emission characteristics as well as engine performance according to the narrow spray angle and advanced injection timing for homogeneous charge compression ignition (HCCI) combustion in dimethyl ether (DME) fueled diesel engine. The bowl shape of the piston head was modified to apply the narrow spray angle and advanced injection timing. The injection timing ranging from BTDC 80° to BTDC 10° and two fuel masses were selected to evaluate the combustion, emission and engine performance. The calculated results were in good accordance with the experimental results of the combustion and emissions of the engine. Nitrogen oxide (NOx) emissions at injection timing BTDC 30° remarkably decreased, while hydrocarbon (HC) and carbon monoxide (CO) emissions at an injection timing of BTDC 70° showed high levels. Also, the IMEP and ISFC have decreasing and increasing patterns respectively as the injection timing was advanced. [3] Z. Zhu et al. Studied about a two-cylinder, direct injection compression ignition engine was retrofitted to run on dimethyl ether (DME) fuel. Under different fuel delivery timing, total hydrocarbon (THC), carbon monoxide (CO), nitrogen oxides (NO_x), smoke, DME and formaldehyde (CH_2O) emission characteristics of DME engine were investigated and compared with diesel engine. Compared with diesel engine, DME engine can achieve smoke-free and significant lower THC and NO_x emissions. CO emission of DME engine is decreased at low and middle engine speed conditions as well. CH2O emissions for both fuels are approximately equal. Retarding DME injection timing, NO_xemission can be further reduced, while the increase of CO, THC, DME and CH_2O emission are observed. [4] R. Chandra et al. have analyzed the performance results of a 5.9 kW stationary diesel engine which was converted into spark ignition mode and run on compressed natural gas (CNG), methane enriched biogas (Bio-CNG) and biogas produced from biomethanation of jatropha and pongamia oil seed cakes. The performanceof the engine with 12.65 compression ratio was evaluated at 30˚, 35˚ and 40˚ ignition advanceof TDC. The maximum brake power produced by the engine was found at ignition advance of 35˚ TDC for all the tested fuels. In comparison to diesel as original fuel, the power deteriorations of the engine was observed to be 31.8%, 35.6% and 46.3% on compressed natural gas, methane enriched biogas and raw biogas, respectively, due to its conversion from CI to SI mode. The methane enriched biogas showed almost similar engine performance as compared to compressed natural gas in terms of brake power output, specific gas consumption and thermal efficiency. [5] Ruijun Zhu et al. studied The effects of DMM addition and fuel injection timing on combustion characteristics, fuel efficiency and emissions of a compression-ignition engine fueled with diesel-dimethoxymethane (DMM) blends are investigated experimentally in this study. Three diesel-DMM blends with 15%, 30% and 50% volume fraction of DMM addition respectively are tested at different engine loads and engine speeds. It was found that NOx is slightly increased, when advancing fuel injection from 20 to 23 CA BTDC, the number of nanoparticles is reduced; the further advanced fuel injection timing from 23 to 26 CA BTDC producesmore nanoparticles. In this study, the lowest nanoparticle number in exhaust gas was achieved by injectingdiesel-DMM blends with 50% DMM addition at 23 CA BTDC. [7] M. Mani et al. analyzed the influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil. Tests were performed at four injection timings (23˚, 20˚, 17˚ and 14˚ BTDC). When compared to the standard injection timing of 23_ BTDC the retarded injection timing of 14˚ BTDC resulted in decreased oxides of nitrogen, carbon monoxide and unburned hydrocarbon while the brake thermal efficiency, carbon dioxide and smoke increased under all the test conditions.

In this study, the esterified rubber seed oil and jatropha oil blended with pure diesel fuel was used with different blends such as B20, B40 and B60 to obtain the performance such as brake specific fuel consumption (BSFC) and emission characteristics of CO, UHC and $NO_x$of a single cylinder constant speed diesel engine running at 1500 rpm and retardation of injection timing (21˚) from standard injection timing (24˚) at constant injection pressure and mass flow rate. The diesel engine was performed change of rated power to measure the performance and emission characteristics with some engine modification. Table 1 gives the properties of the fuels considered for the study.

Table 1: Properties of Fuels.

Property	**Diesel**	**Rubber seed oil (RSO)**	**Jatropha oil (JO)**	**Bio-diesel (RSO & JO)**
Sp. Gravity	0.74	0.82	0.96	0.90
Viscosity at 40˚C (mm^2/s)	4.15	70.2	4.4	4.2
Calorific value (KJ/Kg)	42000	37000	38500	39500
Carbon residues%	0.12	0.19	0.61	0.26
Iodine Value	0.067	133.46	120.5	133.32

2. Experimental Setup and Procedure

The single cylinder constant speed DI engine was used to evaluate the engine performance and emission characteristics with biodiesel. The diesel runs under different load conditions at a constant speed of 1500 rpm with the different biodiesel proportions. The diesel engine (Kirloskar brand) was directly attached with an eddy current dynamometer for changing the different loads. The different type of measuring device was attached in the test engine such as orifice meter with U tube manometer for measuring air consumption, the one liter burette for fuel consumption and the separate biofuel tank an AVL415 smoke meter was provided for measuring the smoke opacity and exhaust temperatures. The test rig was installed with AVL software for obtain various curves and results during operation. A five gas analyzer was used measured the emission characteristics such as UHC, CO and NO_xvalues from exhaust gas. The performance and emission test was conducted for the compression ratio of 17.5 at injection timing of 21˚C retardation from 24˚ standard injection timing at rated power of 4.4 KW. The test was carried out at different proportions such as biodiesel 20%, 40% and 60% blended with diesel fuel. The performance analysis of the engine at different rated power was evaluated in terms of brake specific fuel consumption (BSFC) and emission characteristics such as carbon monoxide (CO), un-burnt hydrocarbon (UHC) and Nitric oxide (NO_x). The engine layout is given in Fig. 1 and the specifications of the test engine are described in table 2.

Table 2: The Test Engine Specifications.

Bore	**87.5 mm**
Stroke	110.0 mm
Speed	1500 (constant speed)
Compression Ratio	17.5:1
Rated Power	4.4 KW

Number of Cylinders	1
Type of Cooling	Air cooled-Eddy current dynamometer
Injection Opening	24˚ BTDC
Pressure	220 Bar
Number of Stroke	4 Stroke

3. Results and Discussions

3.1 Brake Specific Fuel Consumption (BSFC)

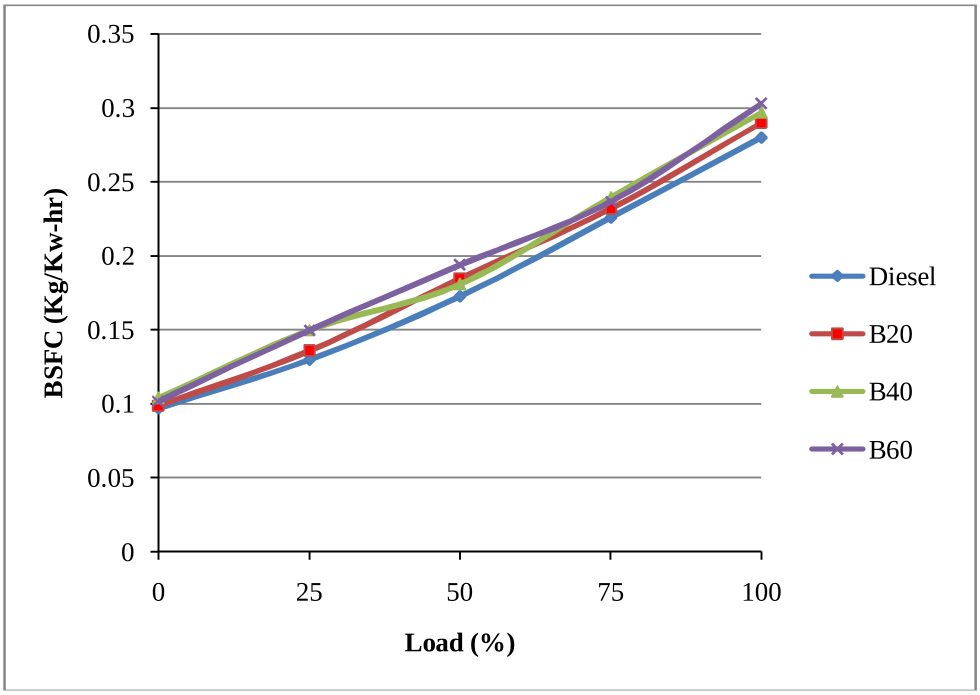

Fig. 1: Variation of load and BSFC.

Fig 1. shows the variation of brake specific fuel consumption (BSFC) for retardation timing (21˚) from standard timing (24˚) with the different proportions of B20, B40 and B60. The BSFC was increased at 0% load to 100% load condition. It indicates that the blends B20, B40 and B60 were increased from 0.1 Kg/KW-hr at no load to 0.28, 0.29 and 0.3 Kg/KW-hr respectively. The Diesel gave better result when compared to other 3 blendsthat is the fuel consumption of diesel is less due to higher calorific value. This also may be due to increase of ignition delay and the fuel may take longer time to burn completely to produce large amount of heat energy as a result there is an increase of fuel consumption. This BSFC graph reported that by changing the injection timing (retardation) from standard timing of this Jatropha oil and Rubber seed oil bio dual fuel blends with diesel results in higher brake specific fuel consumption.

3.2 Carbon Monoxide (CO) Emissions

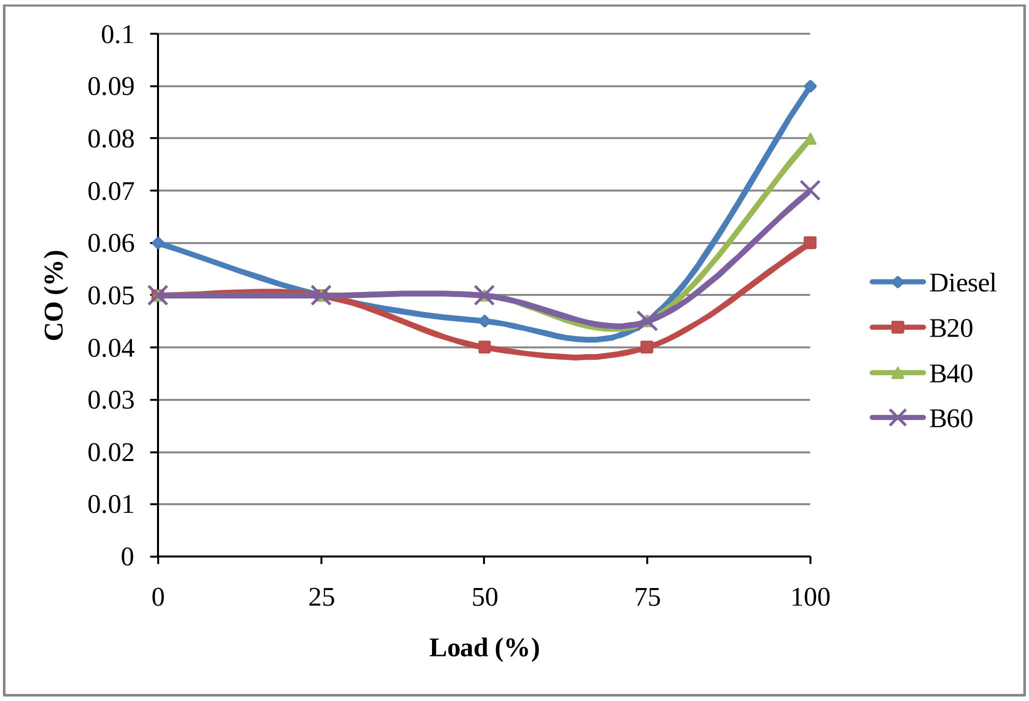

Fig. 2: Variation of load and CO emission.

CO emissions are mainly due to incomplete combustion of fuel and it is produced most readily from petroleum oils, which contain no oxygen in their molecular structure. Generally Co emissions are affected by start of injection timing, injection pressure, engine load, speed and improper air fuel mixing. Fig 2. shows the variation of carbon monoxide with changing the load conditions. In single cylinder constant speed engine with change of injection timing from standard timing the CO was analyzed using the exhaust gas analyzer and smoke meter. The CO emission of diesel is increased from 0.06% at no load to 0.09% at full load. The B40 is increased from 0.05% at no load to 0.08% of full load. The B60 is increased from 0.05% at no load to 0.07% at full load and B20 increased from 0.05% at 0% load to 0.06 at 100% load thus gives an optimum value and better result when compared to diesel. The CO emission of diesel is increased by 0.03% and B20 is increased by 0.01%.

3.3 Un-Burned Hydrocarbon Emissions (UHC)

UHC emission is mainly due to incomplete combustion and partially burning of fuel this may be due to improper air fuel ratio, higher density and viscosity of fuel. Fig 3. shows the variation of hydrocarbons at different loads with respect to injection timing, the Diesel is increased from 18 ppm at no load to 18.5 ppm at full load, B40 is increased from 12 ppm at no load to 18.5 ppm at full load, B20 increases from 18 ppm at no load to 18.5 ppm at full load and B60 increases from 156 ppm at no load to 17 ppm at full load thus giving a better result when compare to diesel. It is reported that the retardation injection timing is not suitable parameter for diesel fuel for reducing HC emission by using this dual bio fuel and the lower cetane number of biodiesel increases the combustion delay, by reducing the injection timing.

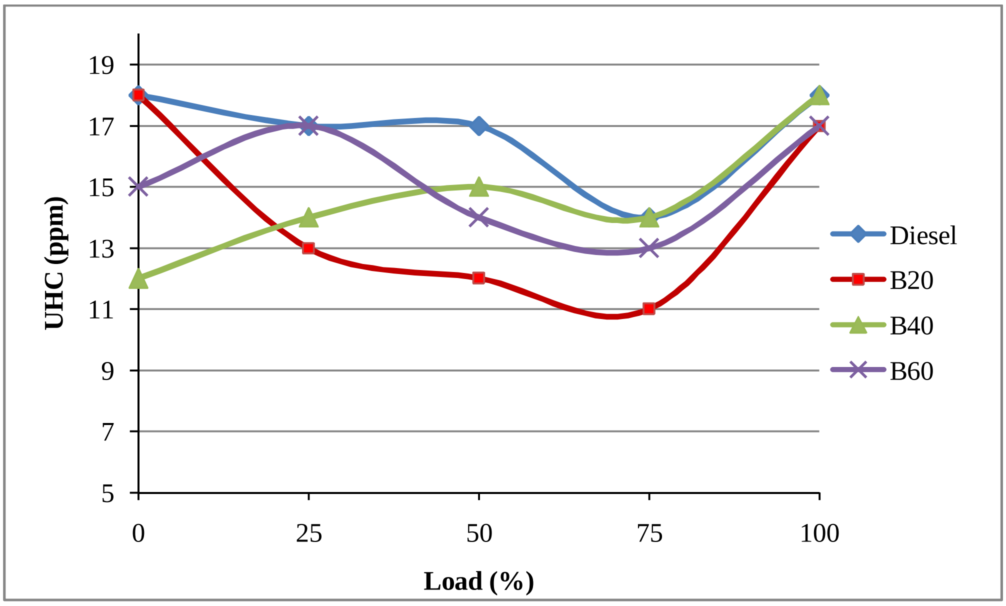

Fig. 3: Variation of load and UHC emission

3.4 Nitric Oxide (NO_x) Emissions

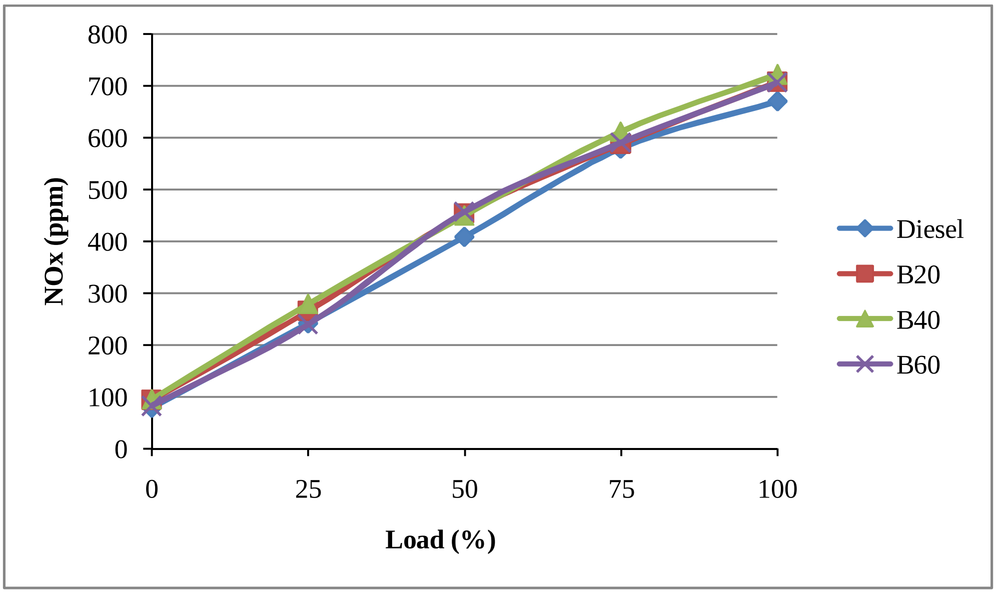

Fig. 4: Variation of load and NOx emission.

NO_xemission is an important emission characteristic from diesel engine point of view; this is formed inside the combustion chamber during the combustion process due to the effect of atomic oxygen and nitrogen. When the exhaust temperatures increase the NO_xemissions is also simultaneously increased. By retarding the injection timing the NO_xemission of the two fuels continuously increased with the various engine load conditions. At retardation of injection timing 21˚ from 24˚C and with B20, B40 and B60 gradually increased from 0% load to 100% load. In the blend B40 gave the higher value of nitric oxide emission from 99 ppm to 700 ppm at no load to full load and diesel fuel slightly increases the NO_xemission from 95 ppm to 660 ppm at no load to full load and giving the optimum value this may be due to higher calorific value. At variation of different loads the exhaust temperature increases gradually and this causes NO_xemission. This graph indicates clearly that the Nitric Oxide emission increases by retarding the injection timing and type of bio diesels (Dual fuel, Jatropha oil and Rubber seed oil blends with diesel.

4. Conclusions

Primarily the Diesel Engine was able to run by using bio dual fuels Jatropha oil and Rubber seed oil blends with Diesel at various loads and constant speed of 1500 rpm by retarding the injection timing from 21˚ from 24˚ standard injection timing. The injection timing was changed for 3 proportions of B20, B40, B60 and pure diesel fuel. The following conclusions were made from the experimental study.

- The retardation timing of 21˚ the brake specific fuel consumption (BSFC) of diesel is optimally increased when compared to other bio diesel blends which increases higher than that of diesel. It can be stated that the diesel which has higher calorific value of 42000 KJ/Kg the BSFC will be less while the calorific value of dual bio fuel (RSP & JO) is 39500 KJ/Kg the BSFC will be higher since the energy and heat release will be higher and consumes more time.
- The CO emission of diesel is gradually increasing from 0.06% at no load to 0.09% at full load by retarding the injection timing. The B20 gave the better result which increases 0.05% to 0.06% at 0% load to 100% load by retardation of injection timing to 21˚ from 24˚. It is inferred that at retardation of injection timing of this dual bio fuel the CO emission of diesel will be more.
- By retarding the injection of timing of this dual bio fuel, the unburned hydrocarbon emission (UHC) of B60 is from 15 ppm to 17 ppm while the UHC emission of diesel fuel is from 18 ppm to 18.5 ppm. Thus B20 gives the better result. The increase of diesel fuel may be due to change in density of fuel at different stages .
- The NO_xemission is seems to be increased for all the three blends B20, B40 and B60 and also with diesel fuel this mainly due to increase of exhaust gas temperatures from 0% load to 100 % load. The B40 gave the higher value of 710 ppm at 100% load while the diesel fuel gave 660 ppm at full load which is optimum for this dual bio fuel and lower than that of the B40 blend.

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References

[1] CenkSayain, Mustafa Canakci," Effect of Injection Timing on the engine performance and exhaust emissions of a dual-fuel diesel engine". Energy Conversion and Mangament 50(2009) 203-213.
[2] Hyung Jun Kim, Kwan Soo Lee, Chang Sik Lee, "A Study on the reduction of exhaust emissions through HCCI combustion by using a narrow spray angle and advanced injection timing in a DME engine",Fuel Processing Technology 92 (2011) 1756-1763.
[3] Z. Zhu, D.K .Li , J. Liu, Y.J. Wei, S.H. Liu, " Investigation on the regulated and unregulated emissions of a DME engine under different injection timing", Applied Thermal Engineering 35 (2012) 9-14.
[4] R. Chandra, V.K. Vijay, P.M.V. Subbarao, T.K. Khura," Performance evaluation of a constant speed IC engine on CNG, methane enriched biogas and biogas". Applied Energy 88 (2011) 3969-3977.
[5] Ruijun Zhu, Haiyan Miao, Xibin Wang, Zuohua Huang," Effects of fuel constituents and injection timing on combustion and emission characteristics of a compression–ignition engine fueled with diesel –DMM blends". Proc of Combustion Institiute, SciVerse Science Direct 34 (2013) 3013-3020.
[6] Biplab K. Debnath, NiranjanSahoo, Ujjwal K. Saha, " Thermodynamics analysis of a variable compression ratio diesel engine running with palm oil methyl ester". Energy Conversion and Mangament 65 (2013) 147-154.
[7] M. Mani, G. Nagarajan, "Influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil". Energy 34 (2009) 1617-1623.
[8] Kanter, James (December 30, 2008). "Air New Zealand Flies on Engine with Jatropha Biofuel Blend". The New York Times.
[9] Shankaransh Srivastava, "Effects of Blends of Rubber Seed Oil on Engine performance and Emissions".