Experimental Investigation of Performance and Emission Characteristics of DI Diesel Engine with Rapeseed Methyl Ester.

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Abstract

Plant oils and Diesel fuel have similar combustion characteristics and ignitions qualities. But the viscosities of plant oils are higher than the diesel fuel. This problem can be overcome by transesterification process. These plant oils became as used alternate to the diesel fuel due to increase in prices and scarcity in supply of liquid fuels. This article represents the investigation of 4 stroke, single cylinder, Direct Injection, Variable Compression ratio diesel engine operating with Rapeseed methyl Ester (RME). The main purpose this study is to evaluate the Performance and Emission Characteristics RME blends with the diesel fuel. The detailed comparisons were made for RME and its blends with the diesel fuel at different loads (no load, 25%, 50%, 100%). Similar trends are observed for Brake specific fuel consumption of Diesel fuel and RME blends. Brake thermal efficiency of RME B20 is 42.38%, which is very near to the Diesel fuel. NOx emissions for RME B20 are higher than the diesel due to higher oxygen content of the RME. CO and CO_2 emissions are compared with the Diesel fuel and RME blends (RME B20, RME B40, and RME B100). The exhaust temperature differences were low for RME and its blends with the diesel fuel. Hydrocarbon emissions are low for all RME blends and ranges between 4 and 16ppm.

Keywords — *Rapeseed Methyl Ester, Diesel Engine, Performance, Emissions, Smoke.*

I. INTRODUCTION

G Labeckas,S Slavinskas [1] presented performance and emissions results of the four stroke, four cylinder, naturally aspirated DI Diesel engine when operating with RME and its blends with Diesel fuel(5%, 10%, 20%,35%). They found that the brake thermal efficiencies of diesel fuel ranges between 0.373 and 0.383 and from 0.356 to 0.398 for RME. B10 has higher fuel energy content than the B35. They also found that the Carbon monoxide and smoke opacity are lower by 51.6% and 13.5 to 60.3% when compared with the diesel fuel. 5-21 ppm HC levels were observed in the Biodiesel blends.

O.M.I Nwafor and G.Rice [2] reported the RME is good alternate fuel for diesel fuel and used in the Diesel engine without modifications. They found that performance of RME is more than the diesel fuel. The power output of the diesel fuel is slightly higher than the biodiesel due to low heating value of plant oils. Although, HC emissions of RME are lower, frictional power is high. Even though, lubricating oil showed reduction in viscosity, the performance of the engine does not lost by supporting dilution in the lubricating oil.

O.M.I Nwafor [3]. Investigations were performed to evaluate the emissions characteristics like CO, CO_2, HC with pure RME, 25/75 Diesel Fuel/ RME, 50/50, 75/25 and diesel. CO emission levels were almost similar with the diesel fuel and CO_2 emissions were to some extent higher than the diesel fuel. At higher loads, HC emissions were slower for RME and its blends. O.M.I Nwafor observed that the HC emissions are reduces with increase in percentage of bio fuel and also observed that there is no marked difference in exhaust temperatures. Due to less energy content in the RME, fuel economy is poor.

Sandeep Kumar Duran, Maninder Singh, Hardeep Singh [4] investigated the performance and combustion of Diesel engine operating with Karanja and Rapeseed Biodiesel. They observed that the rate of pressure rise is low for KB50 (Karanja Biodiesel). They also observed that at all loads; KB20 has higher Brake thermal efficiency (31.072%) due to oxygen content and lower B.S.F.C. KB20 showed to be good substitute when compared with other blends.

G Labeckas , S Slavinskas [5] studied the effects of Rapeseed Oil RO25 (1:4 by volume) and RME20 (1:5 by volume) on four stroke four cylinder diesel engine. They observed that, at low to medium loads B.S.F.C for does not showed marked difference, but at rated speed & full load RO25 and RME20 has 4.7%,11.9% high when compared with the diesel fuel. CO_2, CO, Smoke Opacity, HC emissions of RO25 follows the similar trends of Diesel fuel at fully opened throttle. RME 20 has smoke opacity 42.6% at fully opened throttle.

The main aim of this research is to perform the experimental investigations of Diesel fuel, rapeseed methyl ester and its blends with diesel fuel (RME B20, RME B40, RME B100) on direct injection (DI) diesel engine when operating with different loads. This paper studies the Performance characteristics (i.e, B.S.F.C., Break Thermal Efficiency, Exhaust gas Temperature) on the DI Diesel engine. The blends used for the analysis by volume are listed below:

Diesel Fuel
20% RME 80% Diesel fuel (RME B20)
40% RME 60% Diesel fuel (RME B40)
100% RME (RME B100)

The exhaust emissions like NO_X, CO, CO_2, HC, Smoke number of the above biodiesel blends are also measured and comparisons were made at 100% percentage of load.

Experimental Set up

Experiments were carried out on a Kirloskar, TV1, four stroke, single cylinder, water cooled, variable compression ratio, direct injection diesel engine. Diesel engine technical specifications are showed in Table 1.

Table 1: Diesel Engine specifications

No. of cylinders	1
No. of strokes	4
Fuel	H.S. diesel
Rated Power	3.5 KW @ 1500rpm
Cylinder diameter	87.5 mm
Stroke length	110 mm
Connecting Rod Length	234 mm
Compression ratio	12 to 18:1

The experimental set up is shown in Fig 1. The exhaust gas temperature sensor, INDUS smoke meter (Model: OMS 103), INDUS 5 gas analyzer (Model: PEA 205) were connected at the exhaust side of the engine.

The engine is provided with airflow measurements with orifice and fuel flow measurements. Eddy current dynamometer coupled to the engine shaft is used to vary the loads. The engine was operated with 18:1 compressor ratio, at 4 loads (no load, 25%, 50%, 100%) by maintaining speed 1500 rpm. The performance and emission characteristics are measured for Diesel fuel, RME B 20, RME B40, RME B100 at different loads.

II. Test Results and Analysis

A. Performance Tests

The Brake Thermal Efficiency with load is presented in the Fig. 2. Brake Thermal Efficiency is higher at high percentage of loads operating with RME and Diesel fuel blends. The brake thermal efficiency values at 100% of load reaches to 48.96, 42.38, 33.64 and 33.19 for Diesel fuel, RME B20,

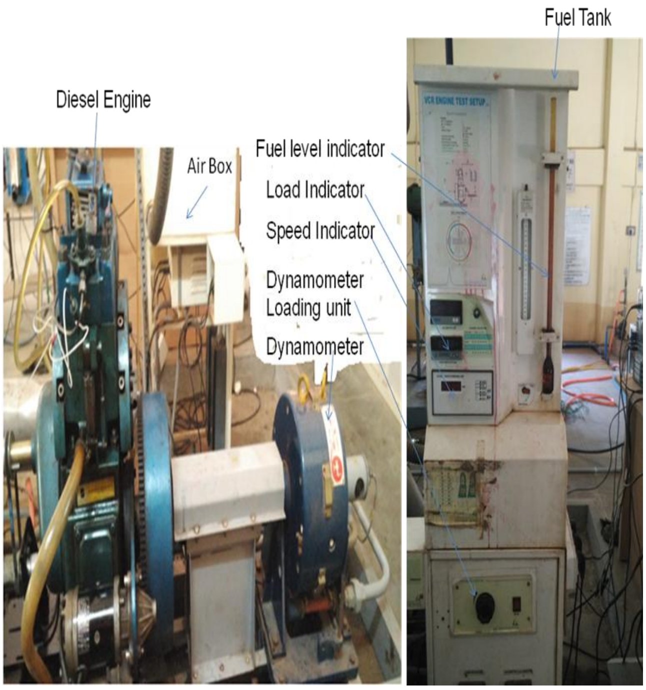

Fig 1: Experimental setup

RME B40, RME B100 respectively. Similar trend was observed in [1]. This is due the lower heating value of RME and its blends with diesel fuel. It is also observed that the diesel fuel having higher power output than RME [2].

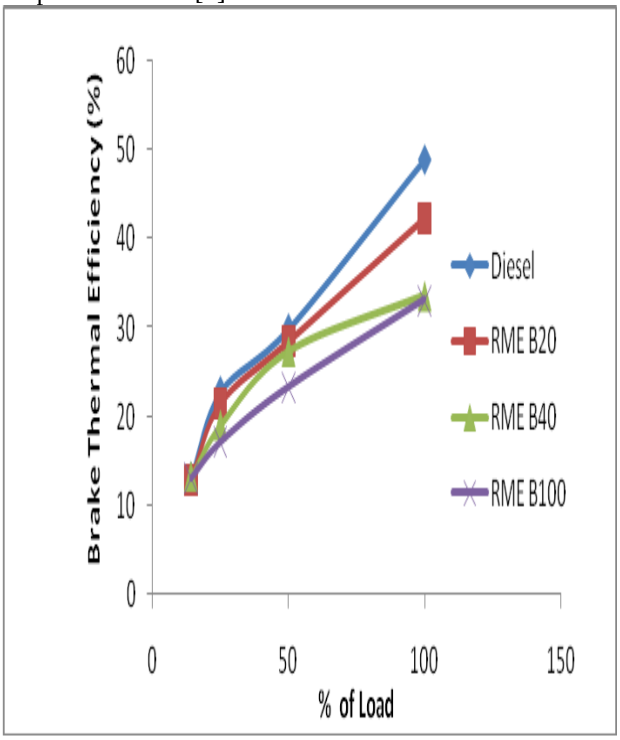

Fig 2: Comparisons of Brake Thermal Efficiency at 1500 rev/min

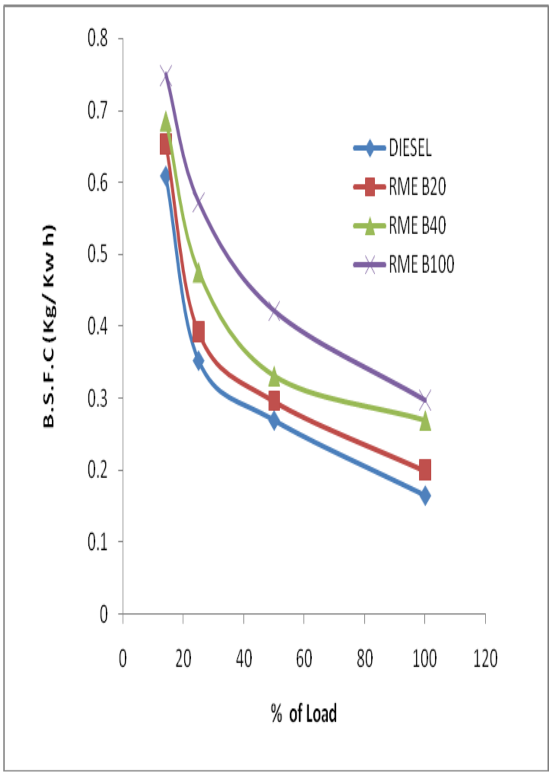

Fig 3: Comparisons of B.S.F.C at 1500 rev/min

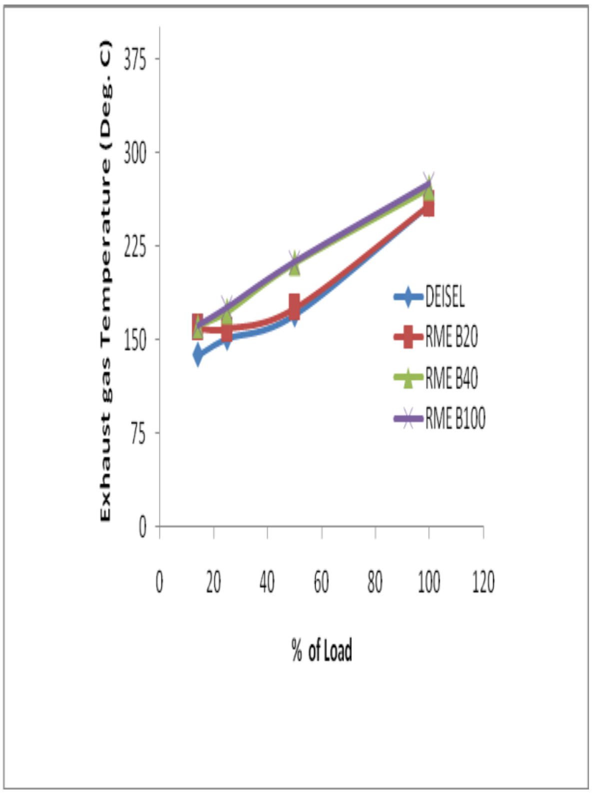

Fig 4: Comparisons of Exhaust gas temperature at 1500 rev/min

Brake specific fuel consumption (BSFC) in Kg / Kw h with different engine loads in %, operation on Diesel fuel and RME blends were showed in Fig.3. BSFC decreased with increased percentage of load as shown in Fig. 3. It is due to its original properties, rate of increasing with brake power with percentage of load. BSFC at no load was recorded as 0.749 kg/ kw. h, 0.686 kg/ kw. h, 0.653 kg/ kw. h, 0.609 kg/ kw. h for RME B100, RME B40, RME B20 and Diesel fuel respectively. This type of behavior is due variations in calorific value, oxygen content, rich fuel spray patterns [1] in the RME blends.

Fig. 4 shows the effect of RME blending on Exhaust gas temperature with percentage of load. Exhaust temperatures RME and its blends with diesel fuel follow the similar trend with diesel fuel [3]. This is mainly due to fact that, higher amount of fuel is burned at higher loads [4].

B. Emission Tests.

Fig 5 shows the NOx emissions of Diesel fuel, RME B20, RME B40, RME B100. It is observed from the Fig. 5 that the RME B20 has higher NOx emissions when related to Diesel fuel because of higher oxygen content in the RME B20. As rate of NOx emission increases due the fact the increase of temperature of burnt gases. The other reason is due to earlier start of combustion [5]. The NOx values at 100% load and 1500 rpm for Diesel and its blends with RME are found to be below 1128 PPM.

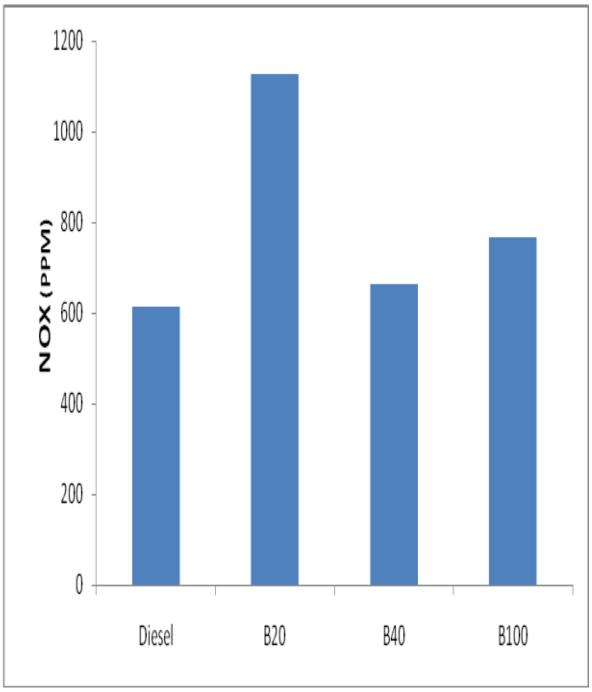

Fig 5: Comparisons of NOx emissions at 1500 rev/min, 100% of Load

The carbon monoxide emissions of Diesel fuel and RME blends at 1400 rev/min are shown in Fig. 6. CO emissions are increased with increasing percentage of RME at full load due to oxygen content. CO emission values are found to be 0.025% and 0.036%for Diesel and RME B20 respectively.

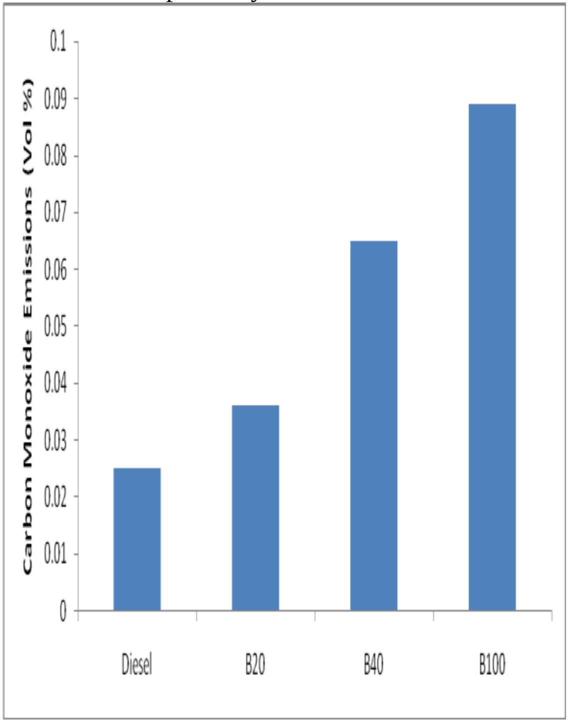

Fig 6: Comparisons of CO emissions at 1500 rev/min, 100% of Load

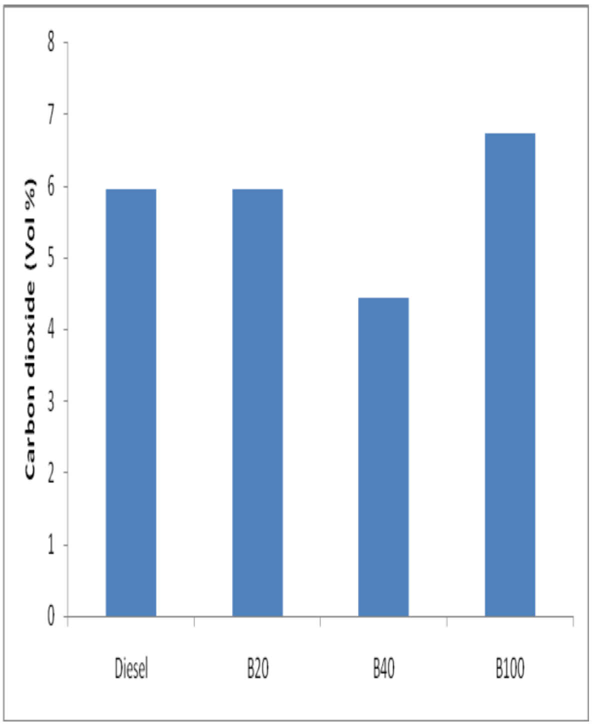

Fig 7: Comparisons of CO_2 emissions at 1500 rev/min, 100% of Load

Fig. 7 represents the carbon dioxide emissions (Vol%) with RME and blends with Diesel fuel. From the Fig 7, it is observed that there is no much marked difference between RME blends and Diesel fuel. Carbon dioxide emissions are decreases initially and then increases with percentage of RME. Due effective combustion, the Carbon monoxide emissions of RME B100 showed the slightly higher than Diesel [3].

Hydro carbon emissions of RME and Diesel fuel in the blend are showed in Fig. 8. It is observed from the Fig. 8 that RME B20 has lower Hydro carbon emissions than the Diesel fuel. This type of behavior is due to higher viscosity of biodiesel, which causes good fuel penetration. Poor mixture penetration, lean combustion, quenched flame are the reasons for increasing the Hydrocarbon emissions [3]. HC emissions for all biodiesel blends are low, ranges between 4 and 16 ppm [1].

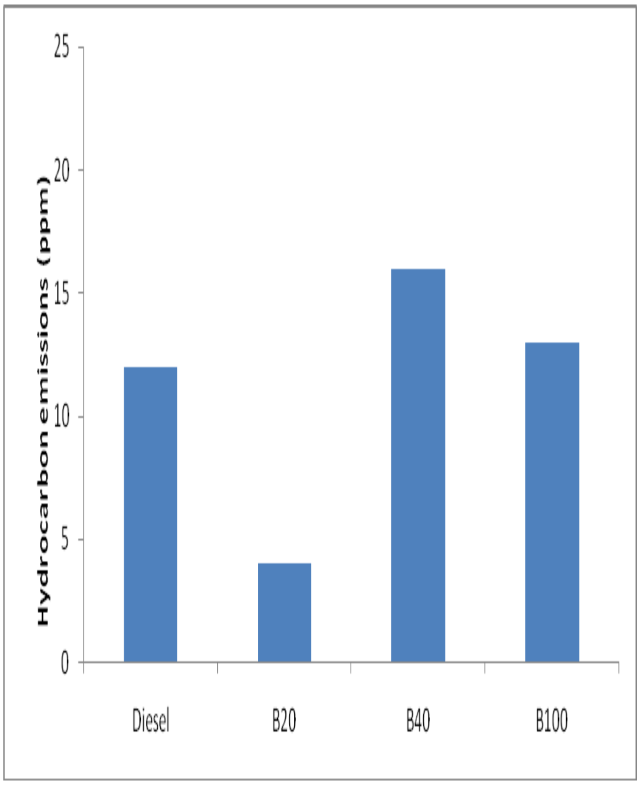

Fig 8: Comparisons of Hydrocarbon emissions at 1500 rev/min, 100% of Load

Smoke number of Diesel fuel and its blends with RME at full load are showed in Fig.9. Combustion peculiarities at full load are the reasons for Smoke number of RME B20 higher than the Diesel fuel [5]. Smoke number for the Diesel fuel is 76%, RME and its blends with diesel ranges between 80% and 82%.

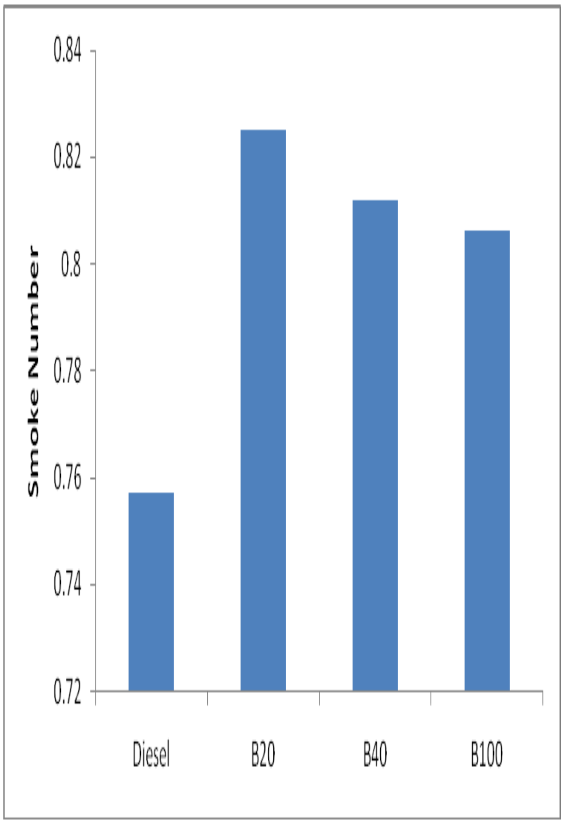

Fig 9: Comparisons of Hydrocarbon emissions at 1500 rev/min, 100% of Load

III. Conclusions

The following are the conclusions from the experimental investigations:

Experimental investigations are performed on RME and its blends with diesel fuel. An investigation reveals that the RME blends are the good alternate for Diesel fuel without modifications in the diesel engine. RME and its blends of B.S.F.C follow the similar trend of Diesel fuel. B.S.F.C decreasing with decreasing the biodiesel content in the blend. The Brake Thermal efficiency reduces with increase in percentage of RME. The Brake Thermal efficiency of RME B20 at full load is 42.38% due to oxygen content in the blend which is slightly lower than the diesel duel. As load increases, the brake thermal efficiency increases and reduces the Brake Specific fuel consumption. The exhaust temperature for Diesel fuel and RME B20 are almost similar. The NOx emissions of Diesel fuel lower than the RME B20 due to higher oxygen content. The CO emissions increase with increase in percentage of Biodiesel. Carbon monoxide emissions are shown less differences between Diesel fuel and RME blends. Due high viscosity and oxygen content the Hydrocarbon emissions of RME B20 are less when compared with the diesel fuel.

References

[1] G Labeckas , S Slavinskas, The effect of rapeseed oil methyl ester on direct injection Diesel engine performance and emissions. Energy Conversion and Management. Vol. 47 (2006), p.1954-1967.

[2] O.M.I Nwafor and G.Rice, Performance of neat rapeseed oil blends in a diesel engine. Renewable Energy, Vol.6, No 3, pp 335-342, 1995.

[3] O. .M.I Nwafor. Emission characteristics of diesel engine operating on apeseed methyl ester. Renewable Energy, Vol.29, p 119-129, 2004.

[4] Sandeep Kumar Duran, Maninder Singh, Hardeep Singh. Karanja and Rapeseed Biodiesel: An Experimental Investigation of Performance and combustion Measurement of Diesel Engine, International Journal of Scientific & Engineering Research, Vol. 6, Issue 1, January 2015, p 295-299.

[5] Gvidonas Labeckas , Stasys Slavinskas, The effect of diesel fuel blending with Rapeseed Oil and RME on engine performance and emissions. Journal of KONES Internal Combustion Engines, 2005, Vol. 12, 1-2, p 187-194

[6] Nwafor OMI. Performance of Rapeseed Methyl Ester in diesel engine. J Appl Energy UK 1996;56(4):345-354.

[7] Police G, Prati M.V, Auriemma M and Alfuso, S. Regulated emissions of DI Diesel Engines fueled with methyl ester rapeseed oil. Proc. IMechE., 1993, pp139-144.

[8] Tsolakis A, Megaritis A. Exhaust gas assisted reforming of rapeseed methyl aster for reduced exhaust emissions of CI engines. Biomass Bioenergy 2004;27:493–505.

[9] Labeckas G., Slavinskas S., Ignatavicius T., The Research of Direct Injection Diesel Engine Performance Parameters when Operating on Pure Rapeseed Oil. Research papers of Lithuanian University of Agriculture VAGOS, Vol. 57(10) 2003, p. 117-123.

[10] McDonnell K.P., Ward S.M., McNulty P.B., Howard-Hildige R., Results of Engine and Vehicle Testing of Semirefined Rapeseed Oil. Transactions of the ASAE, Vol. 43(6) 2000, p. 1309-1316.

[11] Norbert Hemmerlein, Volker Korte, and Herwig Richter, Günter Schröder, Performance, Exhaust Emissions and durability of Modern Diesel Engines Running on Rapeseed Oil, Sae Technical Paper Series, 910848

[12] Hansen, K.F. and Jensen, M.G.: Chemical and biological characteristics of exhaust emissions from a DI Diesel engine fuelled with rapeseed oil methyl ester (RME), SAE Technical Paper No. 971689, 1997.

[13] Masjuku, B.H and Sapuan, M.S. Performance and wear analysis of small Diesel Engine fueled by Palm oil blends. Proc. Fourth International Conference on Small Engines and their fuels. 21-24 Sept, 1993. pp7-13.

[14] Obert, E.F.pollution. York. Internal Combustion Engine and air 1973, Intext Educational Publishers, New York

[15] Pischinger, G.H and Falcon, B.M Methyl esters of plant oils as Diesel fuels, either straight or in blends. ASAE, 1982, St. Joseph, Mich, 49085, pp198-208.

[16] Siemann RW, Blackman D, Pischinger CH, Carvalho LD. The influence of lubricant contamination by methyl esters of plant oils on oxidation stability and life. ASAE 1982, August 2–4, p. 209.

[17] Barsic NJ, Humke AL. Performance and emissions characteristics of a naturally aspirated diesel engine with vegetable oil fuels. SAE 1981, 810262.

[18] Pischinger GH, Siekmann RW, Falcon AM. Methyl esters of plant oils as diesel fuels, either straight or in blends. ASAE 1982, August 2–4, p. 198.

[19] Korus RA, Mousetis Tl, Lloyd L. Polymerization of vegetable oils. ASAE 1982, August 2–4, p. 218.

[20] Van der Walt AN, Hugo FJC. Attempts to prevent injector coking with sunflower oil by engine modifications and fuel additives. ASAE 1982, 49085, p. 230.

[21] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.