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Performance and Emission Evaluation of Blends of Diesel fuel with Waste Plastic Oil in a Diesel Engine

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Abstract*— The objective of this research was to study the effect of using waste plastic oil in a diesel engine without any engine modification. The engine used in this study is 6 cylinders naturally aspirated 4-stroke diesel engine (Compress Ignition) "Hino Wo6d". In present work , the engine fueled with blends of diesel fuel with plastic oil in the ratio of diesel to waste plastic oil 75:25(blend25%), 50:50(blend50%) and 25:75(blend75%) are experimentally measured and analyzed and compared with that of diesel fuel. The test results showed the specific fuel consumption of waste plastic oil blends were higher than diesel fuel. Amount of Carbon dioxide carbon monoxide hydrocarbon and nitrogen oxide from waste plastic oil were higher than diesel operation.

***Index Terms*— Waste plastic oil, Pyrolysis, Diesel engine.**

INTRODUCTION

Depleting fossil fuel reserves and increasing cost of the petroleum products are the big troubles of today's world. From past to present, tendency of oil price have increased consecutively. Especially, Thailand has deficient amount of fossil fuel. For this reason, Thailand has to import fossil fuel, e.g. petroleum for domestic demand. Furthermore, environmental problem in waste management is a big issue in present. Nowadays, plastics have become an indispensable part in daily life. There are 40,000 tons of waste plastic were generated every day in Thailand but only 8% of it can be recycled [1]. Disposal of the waste plastics e.g., land filling or firing poses a great hazard to the environment, and effective method has not yet been implemented. As mentioned above, lead to an intensive search for new alternative fuels. Therefore, the alternative fuel from waste plastic is considerably interesting.

Recently, alternative fuel is a significant factor to fulfill environmental and energy security. According to many researches, waste plastic can be distilled into liquid oil. Waste plastic oil can be used as alternative fuel, for example, diesel fuel, gasoline and fuel oil. In addition, it is proved that waste plastic oil can be used in diesel engine (compression ignition engine) and gasoline engine (spark ignition engine) [2]. From previous study, the performance of single cylinder diesel engine using waste plastic oil was examined by providing load from electric motor dynamometer. The results show a stable performance with brake thermal efficiency similar to that of diesel. It was found that the toxic gas carbon monoxide emission of engine fuelled by waste plastic oil was higher than engine fuelled by conventional diesel fuel [3]. The objective of this study is to investigate the engine performances in term of torque, power, exhaust emission (NOX, HC, CO, CO2) and fuel consumption using different ratio of waste plastic oil blended in diesel fuel. This study will focus on 6 cylinders naturally aspirated diesel engine at full load.

A. Scope of study

- The Diesel engine, "Hino engine 6-cylinders, 4-stroke model Wo6D and 5,730 c.c." is used to test on engine dynamometer test bench.
- The performance and emission are tested at 800, 1200, 1500, 1800 and 2000 rpm on 100% load.
- The fuel used is diesel blended with waste plastic oil with the ratio 100:0(diesel), 75:25(blend25%), 50:50(blend50%), 25:75(blend75%) by volume.

WASTE PLASTIC OIL

Waste plastic oil or pyrolysis oil is the chemical product from decomposition process of organic substance (waste plastic) by heating. The waste plastic is treated in cylindrical reactor at temperature 400-500 degree Celsius

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without oxygen. This pyrolysis process can also be used to produce liquid fuel similar to diesel. Presently, pyrolysis oil or oil from waste plastic widely use in dual fuel-generator set for generation electricity, marine diesel engine, and agriculture engine. Oil is the main product of pyrolysis process. Plastic scrap or waste plastic is used as raw material for pyrolysis process. The properties of waste plastic oil and diesel fuel are shown in Table 1.

Table 1: Comparisons of Properties of waste plastic oil, diesel.

Properties	Waste plastic oil	Diesel fuel
Density (g/cc)	0.8123	0.8377
Calorific value (kJ/kg)	45.05	45.49
Flash point (°C)	28	66
Carbon (%)	79.64	75.99
Hydrogen (%)	12.35	11.67
Oxygen (%)	7.85	12.34
Sulphur (%)	0.15	<0.01

EXPERIMENTAL SETUP

This experiment was tested engine dynamo meter test bench as shown in Fig 1. The three main parameters that characterize the performance of diesel engine are brake power, torque, and specific fuel consumption were bring to studied in this test. The brake power and torque were evaluated by dynamometer, and specific fuel consumption was evaluated by measuring the weight of fuel being supplied to the engine. A gas analyzer "Horiba mexa 584L"was used to measure the amount of NO, HC, CO, CO_2.

Table 2: Specification of the test engine.

Model	Hino W06d
Cooling system	Water
Fuel Type	Diesel
Fuel System	Direct injection
Charge System	Natural air aspired
Valve per cylinder	2
Cylinder alignment	L6
Displacement	5,759 cc
Power	108 kw at 3,200 rpm

Fig 1: Engine dynamometer test bench

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IV.RESULTS AND DISCUSSION

A. Engine performance

1) Torque

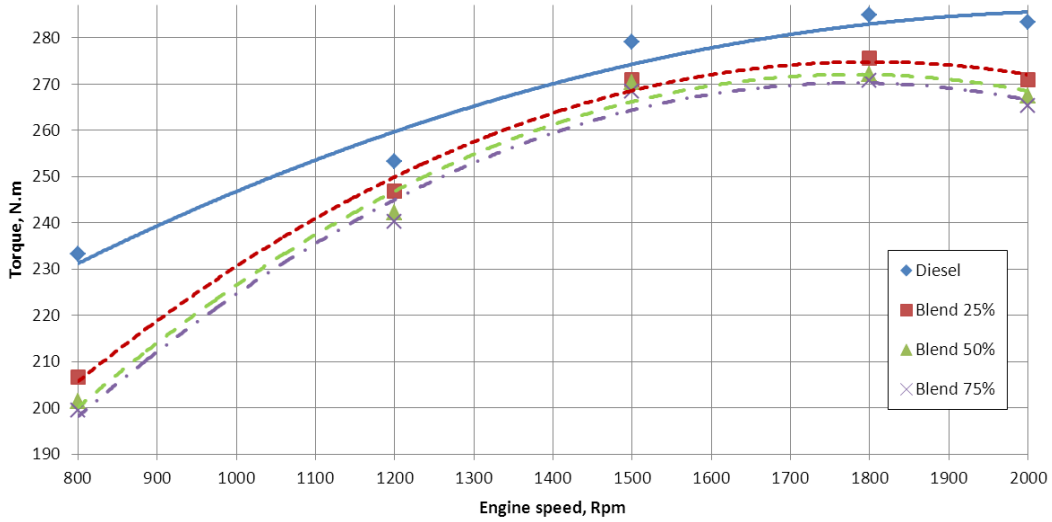

Fig 2: Variation of engine torque with engine speed for Waste plastic oil blends and diesel fuel

From Fig 2, it can be seen variation curves of all test fuels. Diesel and all fuel blends show increasing trends with respect to increase in engine speed from 800 rpm to 1800 rpm. After the 1800 rpm speed engine the torque of the engine gradually decreased until engine speed reach 2000 rpm due to augmentation in mechanical losses. The maximum torque values of diesel and diesel blended with waste plastic oil ratio 75:25, 50:50 and 25:75 in load 100% were obtained at the 1800 rpm was 284.85 N.m, 275.69 N.m, 272.12 N.m and 270.70 N.m respectively. The main reason of torque reduction was considered from the slightly lower heating values of waste plastic oil.

2) Power

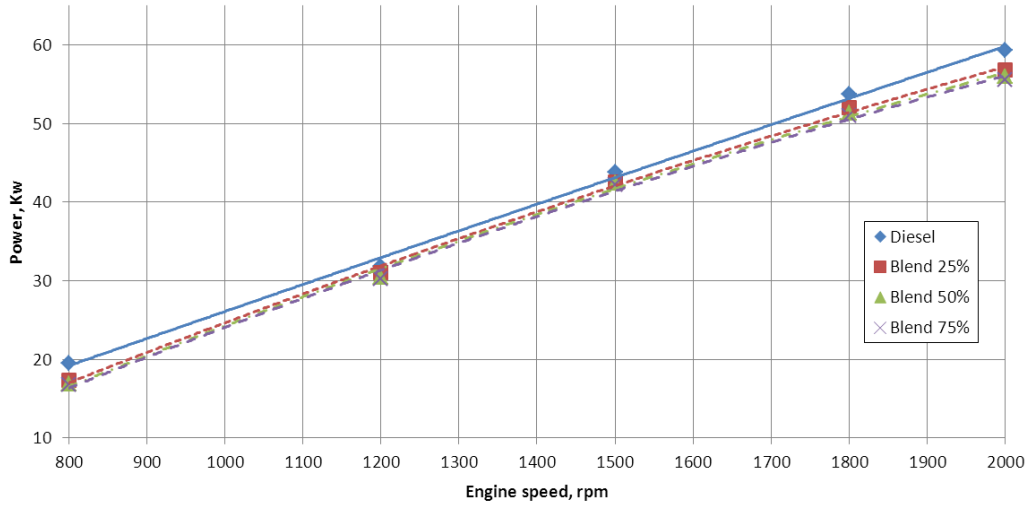

Fig 3: Variation of engine power with engine speed for waste plastic oil blends and diesel fuel.

From graph power-engine speed, as shown in Fig 3 at 100% load, power curves of all test fuels were presented. Power values of diesel, blend 25%, blend50% and blend75% in load 100% showed increasing trends with respect to increase in engine speed. The linear increasing trends were obviously as shown in Figure 3. Power values of diesel were highest among all the test fuels. The lowest power values were obtained for blend 75%, blend 50% and blend 25% respectively. Besides, the blended fuel also generated quiet similar values of power at all test speed engine. The reduction of power values of waste plastic oil blend fuel can be mainly ascribed to slightly lower heating value of waste plastic oil.

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3) *Brake specific fuel consumption*

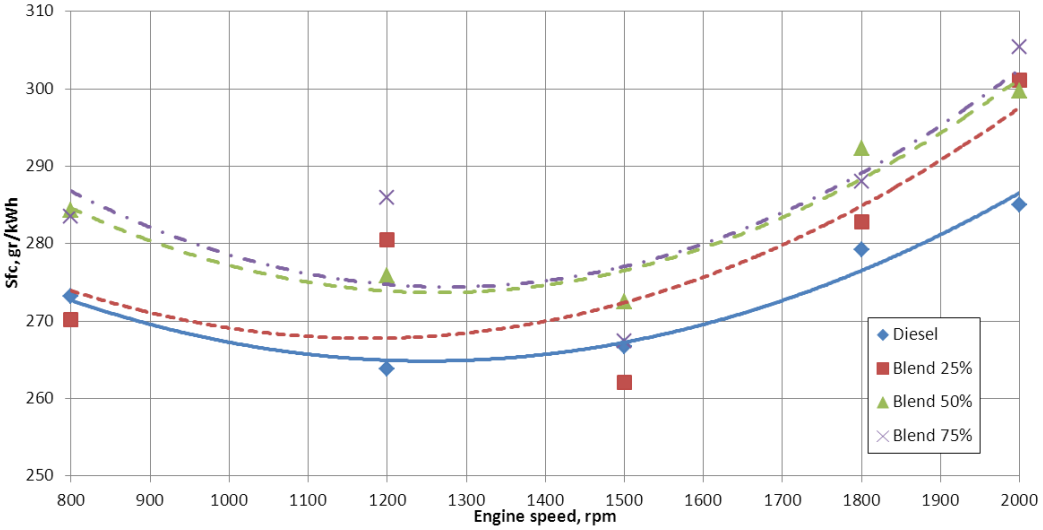

Fig 4: Variation of sfc with engine speed for waste plastic oil blends and diesel fuel.

The variation of sfc with engine speed for waste plastic oil blends and diesel fuel are presented in Fig 4. Diesel and all fuel blends show decreasing trends with respect to increase in engine speed from 800 rpm to 1500 rpm. After 1500 rpm engine speed sfc values for all test fuel increased due to mechanical losses and incomplete combustion.

B. Exhaust emission

1) Hydrocarbon emission

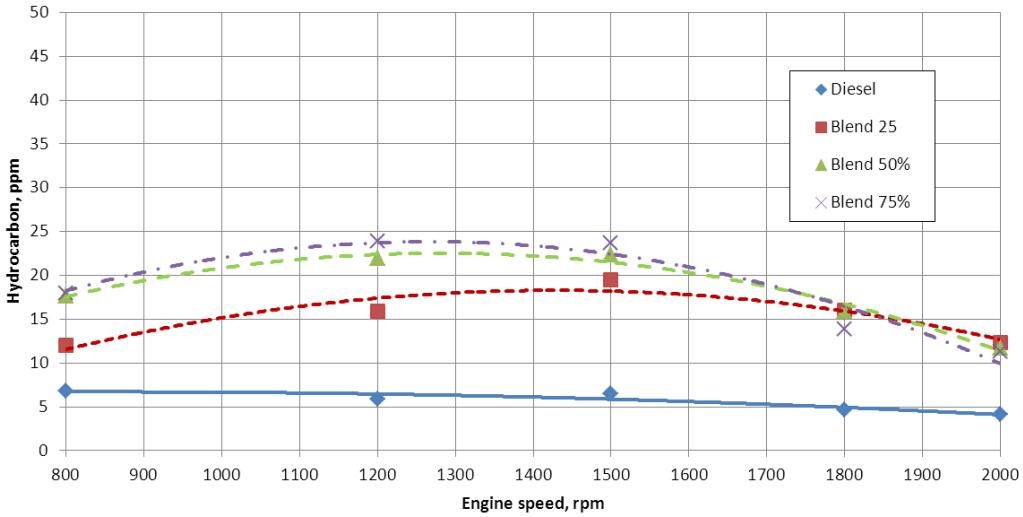

Fig 5: Variation of HC emission with engine speed for waste plastic oil blends and diesel fuel.

From Fig 5 shows the variation of hydrocarbon with speed engine. The results show that the hydrocarbon increased with increased of concentration of waste plastic oil in fuel. Hydrocarbon ranges from 7 ppm 800 rpm speed engine to 4 ppm at 2000 speed for diesel fuel. For blend 25% it varies from 21 ppm to 11 ppm between 800 rpm to 2000 rpm speed engine and for 50% blend, it varies from 10 ppm to 24 ppm between 800 rpm to 2000 rpm engine speed. The highest hydrocarbons are from blend 75%, it varies from 10 ppm to 25 ppm between 800 rpm to 2000 rpm engine speed. From the results, it can be seen that the amount of hydrocarbon from waste plastic oil is higher than diesel fuel.

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2) *Nitrogen oxide*

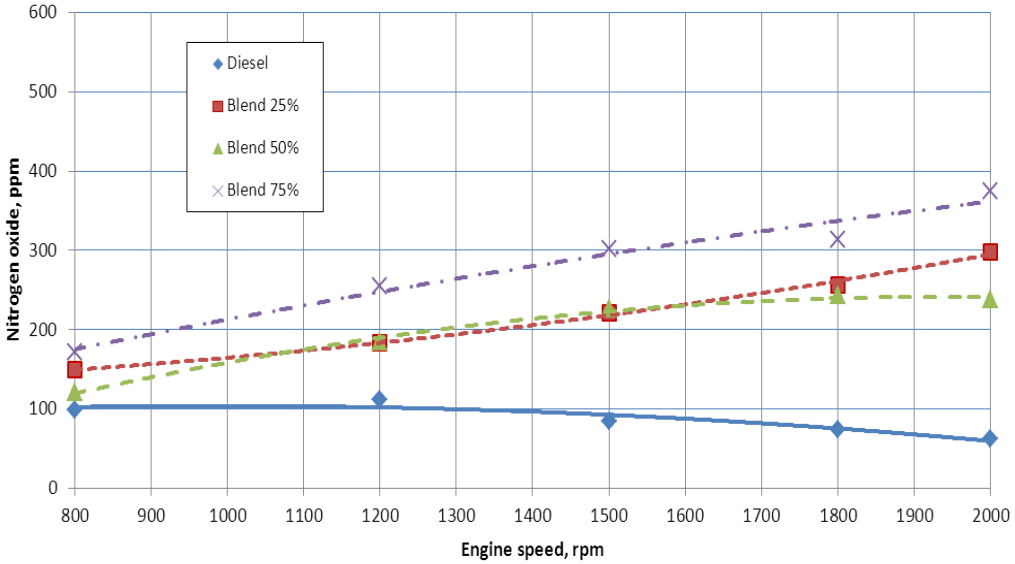

Fig 6: Variation of NO emission with engine speed for waste plastic oil blends and diesel fuel.

From Fi 6, NO emission are compared, it can be seen the variation of nitrogen oxide emission with engine speed. The NO emissions from waste plastic oil blended with diesel are higher than diesel fuel for all engine speed. This is due to the local distribution of fuel and temperature in combustion chamber that affects the emission characteristics.

3) *Carbon dioxide*

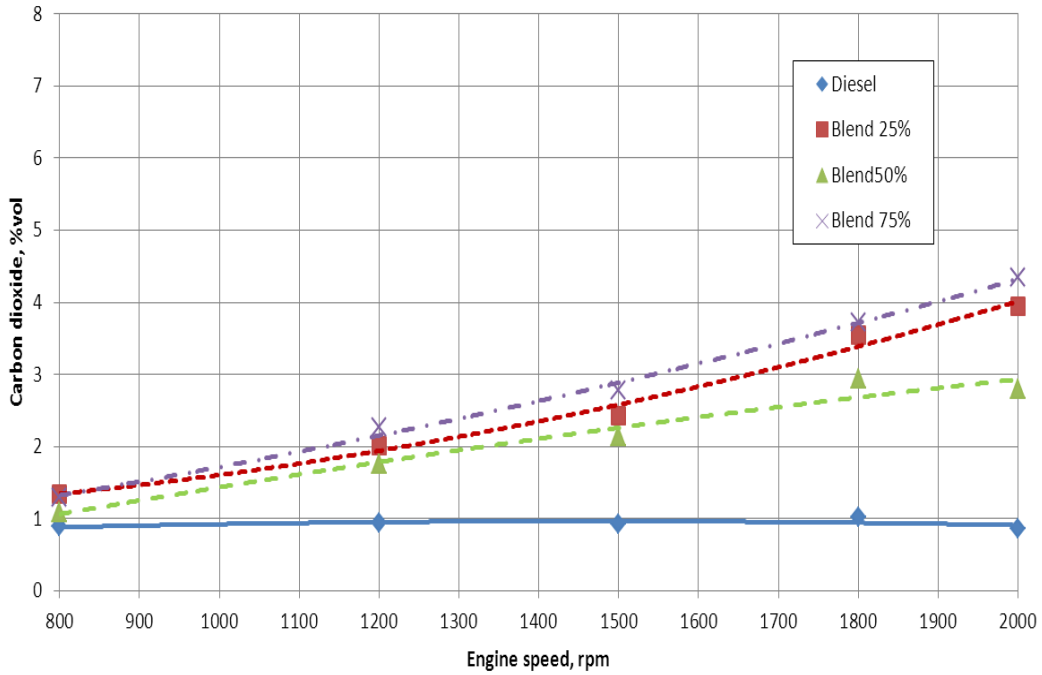

Fig 7: Variation of CO_2 with engine speed for Waste plastic oil blends and diesel fuel.

The variation of carbon dioxide emission with engine speed is illustrated in Fig 7., for all fuels test. It can be seen that the CO_2 gas emission produced while the engine running with waste plastic oil blended with diesel higher than diesel fuel at all engine speed conditions. This may due to late burning of fuel leading to incomplete oxidation of CO_2.

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4) Carbon monoxide

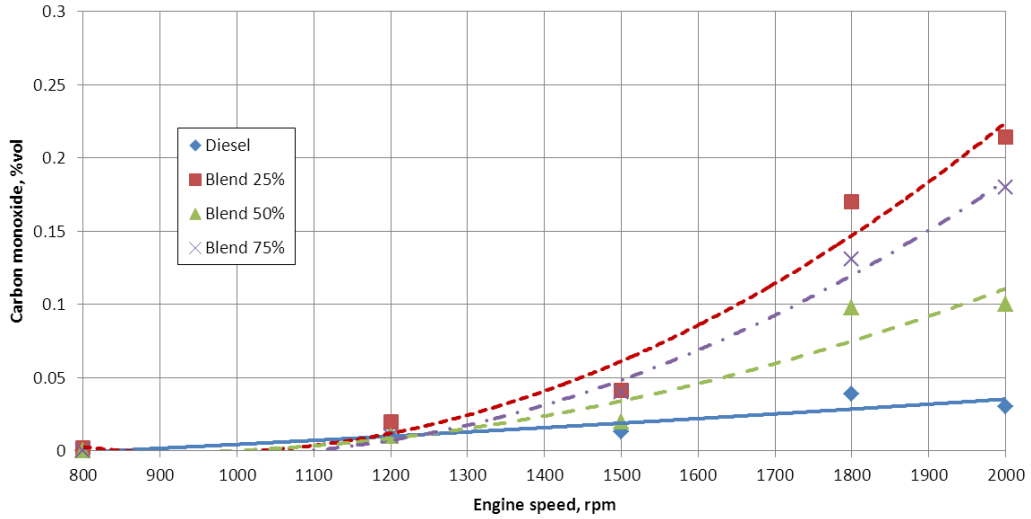

Fig 8: Variation of CO with engine speed for waste plastic oil blends and diesel fuel.

The carbon monoxide result from incomplete combustion, it mainly dependent on the air and fuel ratio relative to stoichiometric proportion as always run on lean mixture compared with S.I. engine, which operate near the stoichiometric mixture. The rapidly increase in CO at higher engine speed due to higher fuel consumption. The result of all blended fuel affect to higher value of CO than diesel. Moreover, CO from diesel engine generally depends upon fuel chemical and physical properties.

V. CONCLUSION

From the experimental investigation using waste plastic oil and diesel on a 6 cylinders diesel engine, the following are this study's conclusion:

- Specific fuel consumption for waste plastic oil is higher than diesel fuel operation.
- CO and CO_2 emission for waste plastic oil blends is higher than diesel operation.
- NO emission increased with an increase in the fuel blended ratio.
- Hydrocarbon emission for waste plastic oil is higher than diesel.
- All blended fuels test can be directly used in a 6 cylinders diesel engine without modification.

REFERENCES

[1] http://www.pcd.go.th/info_serv/waste_wastethai.htm "Waste plastic in Thailand" Pollution Control Department. Thailand.

[2] Ioannis S. Arvanitoyannis, Persefoni Tserkezou, Cereal waste management: treatment methods and potential uses of treated waste, Waste Management for the Food Industries (2008) 629–702.

[3] M. Mani, C. Subash and G. Nagarajan. "Performance, emission and combustion characteristics of a DI diesel engine using waste plastic oil." Department of Mechanical

[4] S. Murugan, M.C. Ramaswamy and G. Nagarajan. "Assessment of pyrolysis oil as an energy source for diesel engines." Rajalakshmi Engineering College, Chennai, India Anna University, Chennai, India. (2008).

[5] P. McCarthy, M.G. Rasul and S. Moazzem. "Analysis and comparison of performance and emissions of an internal combustion engine fuelled with petroleum diesel and different bio-diesels." School of Engineering and Built Environment, Faculty of Sciences, Engineering and Health, CQ University, Rock Hampton, Queensland 4702, Australia. (2011).

[6] C.D. Rakopoulos, et al., "Performance and emissions of bus engine using blends of diesel fuel with bio-diesel of sunflower or cottonseed oils derived from Greek feedstock." Internal Combustion Engines Laboratory, Department of Thermal Engineering, School of Mechanical Engineering, National Technical University of Athens (NTUA), 9 Heroon Polytechniou St., Zografou Campus, 15780 Athens, Greece. (2007).

[7] R.D. Misra, M.S. Murthy "Performance, emission and combustion evaluation of soapnut oil–diesel blends in a compression ignition engine." Mechanical Engineering Department, National Institute of Technology, Silchar, Assam, India. (2011).

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
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[8] http://aqnis.pcd.go.th/node/3162 "Alternative energy" Air Quality and Noise Management Bureau, Pollution Control Department. Thailand.

[9] Orhan Arpa "Experimental investigation of effect of diesel-like fuel obtained from waste lubrication oil on engine performance and exhaust emission." Mechanical Engineering Department, Dicle University, Diyarbakir, Turkey. (2010).

[10] S. Murugan "The use of tyre pyrolysis oil in diesel engine" Mechanical Engineering Department, Rajalakshmi Engineering Collage, Tamil Nadu, India. (2008).

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