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### STUDY THE EFFECT OF BLENDING KEROSENE WITH DIESEL FUEL ON THE PERFORMANCE AND EMISSIONS OF DIESEL ENGINE

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#### ABSTRACT

An Experimental study was conducted to evaluate the effect of blending kerosene (by different volume) with diesel fuel on the performance and emissions of a single cylinder 4-stroke air cooled DI diesel engine running at fixed speed with different loads (torques). Two levels of blend 10% and 20% of kerosene blending by volume with diesel fuel were named K10 and K20 respectively, while pure diesel was considered as a baseline and named D. The treatments include engine speed that was running at constant speed 1500 rpm, with three levels of load (torque) 2, 6 and 10 N.m and three types of fuels D, K10 and K20. Performance parameters that were studied involve brake specific fuel consumption, brake thermal efficiency and exhaust temperature. Furthermore, the exhaust emissions were analyzed to find the effect of selected blends on nitrogen oxides (NO<sub>x</sub>) and carbon dioxide (CO<sub>2</sub>) emissions. Results showed that the bsfc has been reduced by 14.1% and 20.1% when engine fueled with K10 and K20 respectively at low load compared with pure diesel. Exhaust gas temperature, BTE, CO<sub>2</sub> and NO<sub>x</sub> concentration have been increased when engine fueled with K10 and K20 instead of diesel fuel(D). These results indicated the possibility of using blending kerosene (by 10% and 20% by volume) with diesel fuel without any modification in the engine

**KEYWORDS:** brakes specific fuel consumption (bsfc); brake thermal efficiency (BTE); exhaust temperature; exhaust emissions.

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#### INTRODUCTION

The internal combustion engines (IC) is one of the most common forms of engine or prime movers. The main type of internal combustion engine are SI engines, when fuel ignited by a spark, and CI engines, where the rise in temperature and pressure during compression is sufficient to cause spontaneous ignition of the fuel. Both kinds of engines can work in different operating cycles. Ignition of the fuel.

Diesel engines are extensively used worldwide for transportation, decentralized power generation, agricultural applications and industrial sectors because of their high fuel conversion efficiency, ruggedness and relatively easy operation [1]. However, there exist two major challenges to keep diesel engine as one of the most popular power providers. One is related to fossil fuel sustainability: the crude oil resource on earth is limited, this fact is pushing the researchers for suitable alternative fuels. The other challenge is related with environmental concern. So far, compression ignition engines have adopted many technical breakthroughs to meet the requirements of more and more stringent emission regulation Ruijun, et al [2].

Kerosene is a fuel with lower cetane number than diesel fuel, thus it should give a longer ignition delay. This makes it viable for lower emissions since the longer

ignition delay means longer time for the fuel to mix with the in-cylinder gas prior to combustion onset [3].

In general, Number 2 diesel fuel will develop low temperature problems sooner than will Number 1 diesel fuel. Number 1 diesel fuel is sometimes referred to as kerosene. The gelling of diesel fuel in cold climates is a commonly known phenomenon and diesel engine designers, as well as customers and diesel engine designers, have learned over time to manage the cold flow problems associated with Number 2 diesel fuel in the winter time [4]. Several studies [5-8] have been done by using different vegetable oil blends with kerosene to improve the performance of a small type high speed diesel engine under high load condition. They worked with a single cylinder direct injection, 4-stroke air cooled diesel engine applying four blends (20%, 40%, 60%, 80% by volume) of soybean oil with kerosene as well as rapeseed oil with kerosene and compared the results with that of pure diesel fuel. They also studied the spray distribution of each blend in atmosphere used four whole nozzle injector. The result shows that a blend of 20% vegetable oil with 80% kerosene by volume fairly improves performance of the test engine under high load. In Nihon University, Japan, Narayan C.M., [9], have tested a single cylinder, water cooled diesel engine running with blends of a heavy fuel

and low grade oil kerosene for comparison of performance to diesel. The results showed that a mixture of 60% fuel oil and 40% kerosene (by volume) improved thermal efficiency fairly in case of heavy loading for high pressure injection. Osueke, et al [10] blended in his research kerosene with diesel fuel by 20;80,30:70,40:60,50:50,60:40,70:30 and 80:20 kerosene blends by volume and mentioned that as the load increases the bsfc increase and also mentioned that blending kerosene with diesel fuel contributes slightly increased in engine emissions. Ejilah, et al [11] achieved in his experimental research that the combustion quality of kerosene and its blends with diesel are to a large extent, affected by the calorific values of the fuels, ignition ability, and stoichiometric mixture, reactant concentrations and their specific heat capacities

The most important problem facing the consumers of fuel in Iraq (especially in summer season) is the great demand of using diesel fuel, in the same time there is a reduction in the consumption of kerosene fuel in summer. According to that it is necessary to make experiments in which specific ratio diesel fuel can be mixed with kerosene on condition that this mixture doesn't affect the performance and emissions of diesel engine, thus, kerosene can be used in summer and decrease the import of diesel fuel too.

## MATERIALS AND METHODS

### FUEL USED

Pure diesel fuel (named D) was purchased from local fuel station and used as base line fuel. Two blends of diesel – kerosene (with 10% and 20% kerosene blending by volume) were named K10 and K20 respectively, were used in this experiment, all these fuels were analyzed in the lab of AL- Daura Refinery. The properties of the tested fuels are shown in Table 1.

*Table 1. Properties of fuels used.*

Data	D	K10	K20
SP. Gravity @ 15.6°C	0.834	0.831	0.827
API. Gr. @ 15.6°C	38.1	38.7	39.5
Flash point °C	77.0	70.9	65.0
Colour (ASTM)	0.5	0.5	0.5
Pour Point °C	-15	-18	-18
Vis Cst @ 40 °C	3	2.8	2,56
Carbon Res. Wt %	0.1	0.8	0.05
Sulfur. Wt %	1.2	1.09	0.98
Density @ 15.6°C kg/m <sup>3</sup>	834	831	827
Cetane No.	56	57	58
Calorific Value KJ/Kg	45786	45828	45886

### TEST ENGINE

The experiment was conducted in a single cylinder four stroke DI diesel engine. The specifications of the tested engine have been shown in Table 2.

*Table 2. Specifications of testing engine.*

Item	Specification
Engine Manufacture	TQ TD 212 UK
Fuel Type	Diesel
No. of Cylinders	1
Max. Power	3.5 kW@3500 rpm
Engine Capacity	232 cm <sup>3</sup>
Bore	69 mm
Stroke	62 mm
Compression Ratio	22;1

The test engine rig and accessories are shown in Figure 1. The engine test accessories include:

**Engine Cycle Analyzer (ECA 100)** that can be used with the test engine that is specially modified with cylinder head pressure transducer and crank angle encoder.

**Versatile Data Acquisition System (VDAS)**

The VDAS apparatus is a two-part product (hardware and software) that allows the user to reduce errors, save experiment time, record the test results in a suitable compute and automatically calculate important values.

**Instrumentation Unit**

The instrumentation unit is designed to housing the instruments necessary for measuring the engine performance, which include fuel consumption, torque, exhaust gas temperature display.



*Fig. 1: Photo of engine test rig.*

The engine was linked horizontally with a hydraulic dynamometer. The fuel flows into the bottom of a pipette, graduated in volumes of 8, 16 and 32 ml. Fuel consumption is determined by measuring the time (t) taken for the engine to consume a given volume of fuel. Exhaust gas temperature is measured by a chrome/alumel thermocouple, while the air consumption is measured by orifice chamber method.

**TEST PROCEDURE**

Initially the system is drained and refilling with pure diesel fuel (D) before commencing test requires, removing any air bubbles that may be collected in the fuel system, the engine run without load for 20 minutes for warming up. The speed of the engine was increased by the control level of the fuel at the same load until the engine becomes stable, which is determined from the stability of the exhaust temperature. engine speed was fixed at 1500 rpm, and the torque was increased to 2 Nm gradually by increasing the flow of water which was controlled by a needle valve and tab and let the engine works for 2 minutes at that fixed speed and load, then the tap on the fuel line was closed to isolate the fuel tank from the engine to enable the fuel to be consumed from the pipette. The fuel consumption was determined by measuring the time taken by the engine to consume a given volume of fuel, during that procedure, results were recorded which include air consumption from manometer, exhaust temperature from meter of exhaust temperature in instrumentation unit. The exhaust emissions were measured by the exhaust gas analyzer device type AIRREX (HG 545) which measures CO<sub>2</sub> concentration in the range (0-20%) with resolution 0.01% and NO<sub>x</sub> emission in the range (0-5000 ppm) with resolution 1 ppm.

In the second step the torque changed to 6 Nm and the previous steps were repeated and so that for the rest torque 10N.m, eventually, the temperature and pressure of the laboratory were recorded. Then, other types of fuel were used by applying the same steps above. When changing the fuel to another type K10 and K20, draining and flushing the system must be done.

Every test was repeated three times to be more accurate and the average value was taken. Brake power, brake specific fuel consumption and brake thermal efficiency was calculating using the collected test data.

**RESULTS AND DISCUSSION**

The brake specific fuel consumption is the ratio of mass fuel consumption to the brake power and it reflects how good the engine performance is [12]. Fig. 2 expressed the variation of bsfc with loads for the diesel engine test fueled with D, K10 and K20. It is clear from the figure that as the load increases the bsfc decrease for all fuels selected, At the same time it can be showed that bsfc decreases with increase kerosene addition. The higher bsfc (501.53 g/kW.h) registered with pure diesel fuel at low load while K10 and K20 blend fuels registered 430.76 g/kW.h and 400.61 g/kW.h respectively at the same load and speed, the reason may be due to the higher density and lower heating value of pure diesel fuel cause a reduction in brake power and consequently increasing the bsfc. The figure also

showed that there were no significant difference in bsfc for all types of fuel tested at full load

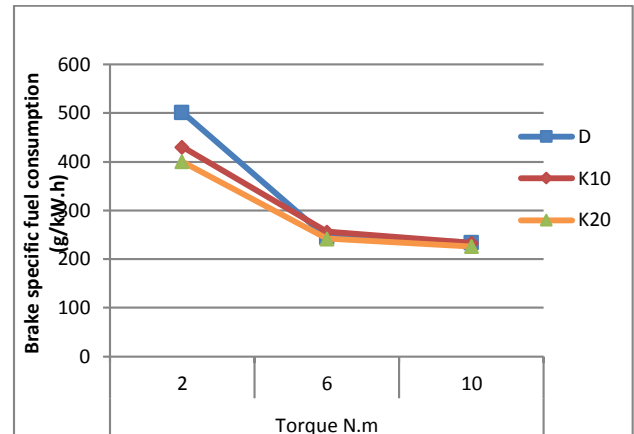


Fig. 2: Variation in bsfc with engine torque for diesel and two blends kerosene diesel fuel.

Thermal efficiency can be expressed as the ratio of the net work output to the energy required to produce that work output. If the work output is brake power, then the thermal efficiency is called brake thermal efficiency (BTE) [13]. Fig. 3 shows the effect of fuel type on BTE at different loads with engine run at 1500 rpm. It has been seen from the figure that the BTE increased as load increase for all types of fuel tested. Brake thermal efficiency is always found to be higher with increasing the kerosene blends as compared with baseline diesel fuel, this is because of the fuel properties such lower viscosity, density, and higher calorific value of blends K10 and K20. The higher BTE value was 33.38% registered by blend fuel K20 at full load while diesel fuel registered the lowest 32.74% at the same load and speed. The lowest BTE value was 15.14% registered by using diesel fuel at low load (torque 2 Nm) and engine speed 1500 rpm, while when using blends fuel K10 and K20 the BTE values were 17.61% and 18.80% respectively at the same load and speed.

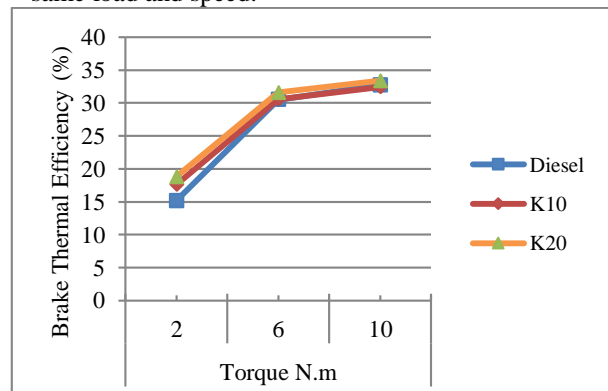


Fig. 3: Variation in BTE with engine torque for diesel and two blends kerosene diesel fuel.

The effect of fuel types on the exhaust temperature at different loads is presented in Fig. 4. As shown in the figure, exhaust gas temperature increases as the engine load increases for all fuel selected. On the other hand it is found that exhaust gas temperature increases with kerosene addition to diesel fuel due to the higher calorific value for kerosene – diesel blend over pure diesel fuel that caused a high pressure is equivalent to high escape velocity and longer spray length, providing opportunity for the fuel to fully atomize and granting excess air access to the combustion process, and consequently increase the exhaust gas temperature. The highest exhaust temperature was 314 °C recorded by blend fuel K20 at full load, while using diesel fuel recorded 260 °C at the same load. The lowest exhaust gas temperature 112 °C recorded by diesel fuel at low load.

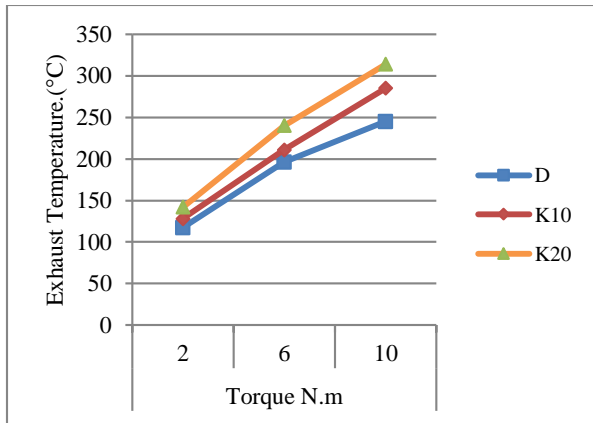


Fig. 4: Variation in exhaust temperature with engine torque for diesel and two blends kerosene diesel fuel.

Carbon dioxide CO<sub>2</sub> is produced by complete combustion of fuel in internal combustion engine. The effect of pure diesel fuel and blending kerosene with diesel fuel on CO<sub>2</sub> concentration at different engine loads and fixed engine speed 1500 rpm was presented in Fig.5. As shown in the figure the CO<sub>2</sub> emission concentration increases because as load increase need to inject excessive fuel to have the same power. The CO<sub>2</sub> concentration for pure diesel fuel and blend fuel K10 was almost equal at high load. The highest level of CO<sub>2</sub> is recorded by using blend fuel K20 due to the higher oxidation process between carbon and oxygen molecules.

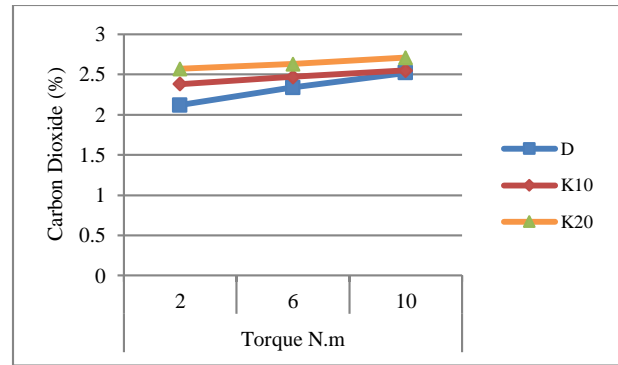


Fig. 5: Variation in CO<sub>2</sub> concentration with engine torque for diesel and two blends kerosene diesel fuel.

The basic exhaust emissions from engines contain combinations of NO and NO<sub>2</sub> that is indicated as NO<sub>x</sub> [14]. The effect of diesel and kerosene diesel blends on concentration of NO<sub>x</sub> formation at different engine load is shown in Fig. 6. It is clear that NO<sub>x</sub> concentration increases as the engine load (torque) increases for all fuels selected due to the increase in combustion temperature. Blend fuel K20 recorded the highest amount of NO<sub>x</sub> (252 ppm) than the other fuels at full load due to the higher heating value. The lowest amount of NO<sub>x</sub> (156 ppm) registered by diesel fuel at low load.

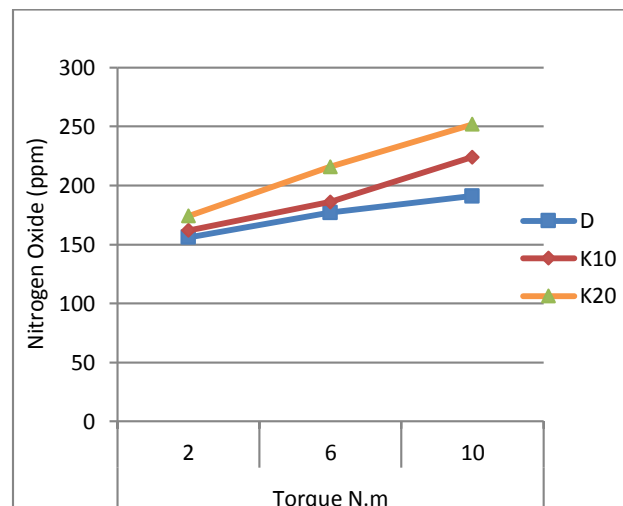


Fig. 6 : Variation in NO<sub>x</sub> concentration with engine torque for diesel and two blends kerosene diesel fuel.

**CONCLUSION**

- 1- Exhaust gas temperature, CO<sub>2</sub> and NO<sub>x</sub> concentration have been increased when engine fueled with K10 and K20 as compared with pure diesel fuel(D)
- 2- Brake thermal efficiency has been slightly increased with K10 and K20 blends as compared with pure diesel fuel (D).
- 3- The bsfc has been reduced by 14.1% and 20.1%

when engine fueled with K10 and K20 respectively at low load as compared with pure diesel.

## REFERENCES

- 1- Chauhan,B.S., Kumar, N. and Cho, H.M., Performance and Emission Studies on an Agriculture Engine on Neat Jatropa Oil. Journal of Mechanical Science and Technology 24 (2) (2010) 529-535.
- 2- Ruijin, Z., Xibin,W., Haiyan,M., Xiaofeng,Y. and Zuohua,H., Effect of dimethoxy-methane and exhaust gas recirculation on combustion and emission characteristics of a direct injection diesel engine. Journal of Fuel, Vol.90, Issue 5 , 2011; pp.1731-1737.
- 3- Bharj R.S., chemical analysis of blending of diesel and kerosene fuels used in small CI engine, 2nd International Conference on Role of Technology in Nation Building (ICRTNB), 2013.
- 4- Steven, R. W., and Maurice E. L., Survey of Diesel Fuels and Aviation Kerosene From U.S. Military Installations, Presented at the 6th International Conference on Stability and Handling of Liquid Fuels,1997,pp.13-17,Vancouver, B.C., Canada.
- 5- Ameer Uddin,S.M.,Azad,A.K.,Alam,M.M.and Ahmed,J.U., Performance of a diesel Engine Run with Mustard-Kerosene Blends, The 6th BSME International Conference on Thermal Engineering, Procedia Engineering 105 ( 2015 ) 698 – 704
- 6- Kumar Reddy, V.K., Experimental investigation on the use of vegetable oil fuels in a 4- stroke single cylinder diesel engine;2000,PhD Thesis, submitted at JNTU, Anantapur.
- 7- Hyzayyin,A.S.,Bawady,A.H.,Rady,M.A.and Dawood,A., Experimental evaluation of diesel engine performance and emission using blends of Jojoba oil and diesel fuels; 2004; Energy Compression and Management, Vol. 45 pp. 2093-2112.
- 8- Azad,A.K.,AmeerUddin,S.M. and Alam, M.M., Experimental study of DL diesel engine performance using bio diesel blends with Kerosene; International Journal of Energy and Environment; 2013; Vol.4;Issue 2; pp. 265-278, Bangladesh.
- 9- Narayan, C.M., Vegetable oil as engine fuel-prospect and retrospect; Proceeding of Recent Trends in Automotive Fuels,2002 Nagpur, India.
- 10- Osueke C.O., et al, Fuel adulteration in Nigeria and its consequences; International Journal of Mechanical & Mechatronics Engineering IJMME; 2011 Vol: 11 No.4 pp. 32-35. Nigeria
- 11- .Ejilah, I. R., Olorunnishola, A.A.G.and Enyejo, L.A. A Comparative Analysis of the Combustion Behavior of Adulterated Kerosene Fuel Samples in a Pressurized Cooking Stove. Global Journal of Researches in Engineering Mechanical and Mechanics Engineering V. 13 Issue 6 Version 1.0 Year 2013.
- 12- Mohanty, R.K., A text book of Internal Combustion Engines, 1st ed., Standard Book House. 2007,pp 652.
- 13- Pathak, G.K. and Chavan, D.K.,Thermal Engineering,1st ed, Rajsons Publications Pvt.Ltd.,2008,pp, 1076-1077.
- 14- Siddharth, S., ‘‘Green Energy-Anaerobic Digestion. Converting Waste to Electricity’’ WSEAS Transactions on Environment and Development, Issue 7, Volume 2, July 2006