Experimental Investigation of Performance Parameters of Direct Injection Diesel Engine Fuelled with Diesel and Ethanol Blends

Saadi Turied Kurdi, Hassan Abad al-wahab Anjal, Hussein Ahmed Abd Yaqoob

Abstract*—An experimental study of the measurement of performance parameters of a single cylinder four stroke diesel engine using diesel fuel produced in Iraq and blended with ethanol was carried out. The test fuels were used in this study included E0 Beji (100 % diesel Beji fuel), E0 Basra (100 % diesel Basra fuel), E0 Daura (100 % diesel Daura fuel), E8 blended (8% ethanol and 92% diesel Basra fuel in vol.), and E10 blended (10% ethanol and 90% diesel Basra fuel in vol.). The experimental measurements were performed at compression ratio of 22.5 at engine speed ranging from 1100 to 2600 rpm with an increment of 500 rpm, and engine torque ranging from 2 to 10 N.m with an increment of 2 N.m. Brake specific fuel consumption, brake thermal efficiency, brake power, mechanical efficiency, brake mean effective pressure and exhaust gas temperature were studied in this research. The experimental data from engine during test have been saved on the computerized program (ECA 100, VDAS) connected to the unit.The results show that the E8 blended fuel type registered the high value of brake specific fuel consumption .There were about 28.02 % for E8 blended fuel, 20.88 % E0 Beji fuel, 19.2 % for E0 Basra fuel, and 8.24% for E10 blended fuel higher of brake specific fuel consumption than that E0 Daura fuel. E0 Daura fuel type registered the high value of brake thermal efficiency followed by E0 Basra, E10 blended, and other types. E0 Daura fuel type recorded the high value of mechanical efficiency. E10 slightly recorded the higher value of brake mean effective pressure for all torques and speeds. E0 Basra diesel fuel gives higher exhaust gas temperature for all torques and speeds.

Keywords*— Diesel fuel; ethanol; Brake Specific Fuel Consumption; Indicated Power; Exhaust Gas Temperature .

I. INTRODUCTION

Diesel engine are widely used in different fields including engineering machinery, automobile, shipping power requirement, electricity production and agricultural activities due to high combustion efficiency, reliability, adaptability, excellent drivability and cost effectiveness. The performance of diesel engines depends on various factors like fuel quantity injected, fuel injection timing, fuel injection pressure, shape of the combustion chamber, position and size of the injection nozzle hole, fuel spray pattern, air swirl etc. Ethanol (ethyl alcohol, grain alcohol, CH3–CH2–OH) is a liquid biofuel alternative can be produced by the fermentation of virtually any source of sugar or starch, the most common sources being sugar cane, wheat and sugar beet [1].

Revised Version Manuscript Received on December 26, 2015.

Dr. Saadi Turied Kurdi, lecturer, Electromechanical Engineering Department, University of Technology, Baghdad, Iraq

Dr. Hassan Abad al-wahab Anjal Associate Professor, Electro- Mechanical Engineering Department, University of Technology, Baghdad, Iraq

Hussein Ahmed Abd Yaqoob, Master Student, Electromechanical Engineering Department, University of Technology, Baghdad, Iraq

Furthermore, the ethanol has a high octane rating, higher flame speeds, higher heats of vaporization than gasoline, and oxygen content.it in two-column format, including figures and tables. These properties allow for a higher compression ratio, and shorter ignition delay, therefore has a positive influence on engine efficiency and performance [2]. Diesel-ethanol blends are a more viable alternative and require little or no change in diesel engines In the past decades, many investigations were carried out to apply ethanol to diesel engines. Prosad et al.[3] studied the effect of diesel-ethanol blends on brake fuel consumption, brake thermal efficiency ,exhaust gas temperature, and mechanical efficiency of four stroke ,direct injection diesel engine .The reported bsfc for blends is higher than the diesel. The results show that there are some differences for the brake thermal efficiency for the ethanol compared with those of pure diesel .the exhaust gas temperature for all the type of fuels tested increases with increase in the load exhaust gas temperature of ethanol blends are lower than the pure diesel. Mechanical efficiency of ethanol blends is higher than pure diesel. Nivesh [4] investigated the performance of a DI compression ignition engine operated on diesel-biodiesel-ethanol using a single cylinder, water cooled, direct injection. The results indicated that the brake thermal efficiency of fuel blends is higher than diesel .He found that the specific fuel consumption for all blends has increased with compared to pure diesel and it is observed that mechanical efficiency has decreased for all fuel blends. Senthil and Silambarasan [5] studied the effect of ethanol blends addition on performance of a single cylinder, water cooled, four stroke direct injection compression ignition engine operated with jatropha, and pongamia methyl esters. They observed that brake thermal efficiency of pongamia –ethanol (50-50) is higher than other fuel blends. Nagdeote and Deshmukh [6] conducted experiments on the utilization of diethyl ether and ethanol additives with biodiesel-diesel blended in a single cylinder, four stroke ,direct injection diesel engine .The experimental results show that the brake specific fuel is lower when used (15% biodiesel,80%diesel , and 5% diethyl ether in vol.) compared with (20% biodiesel ,and 80%diesel in vol.). Padala et al. [7] investigated the performance of a single cylinder diesel engine operated on ethanol and diesel dual fuelling .They reported that ignition delay period increases with increasing ethanol fraction. They also showed that brake thermal efficiency increases with increase in ethanol fraction. Velliangiri

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

and Krishnan [8] experimentally investigated the performance of ethanol fuelled a four stroke single cylinder diesel engine .They used two different ignition mode (i) high compression (ii)ultrahigh compression .The results show that brake thermal efficiency was higher for ethanol fuel. Li et al. [9] conducted experiments on a single cylinder DI diesel engine using neat diesel and ethanol –diesel blend fuels,the content of ethanol is 5 % vol, 10 % vol, 20 % vol .The experimental results brake specific fuel consumption, and the brake thermal efficiency increased with an increase of ethanol content in the blended fuel. Ajv et al. [10] experimentally studied the performance of a diesel engine using ethanol-diesel blends, the content of ethanol is 5%,10%,15%,and 20% in vol. They reported that the exhaust gas temperature was lower with operations on ethanol –diesel blends. Huang et al. [11] studied the performance of a diesel engine using ethanol-diesel blends. The results indicated that slightly increases in the fuel specific consumption, and the thermal efficiency increases with the blends comparing with pure diesel fuel. The use of ethanol as a blend with diesel fuel is increasing. It can be used as a fuel in a number of different ways as a blend with diesel (8% and 10%) and as a fuel in experiments blended with Basra diesel fuel.

II. THEORETICAL PART

Engine performance is an indication of the degree of success with which it is doing the conversion of the chemical energy contained in the fuel into useful mechanical work

A. Brake Power (bp):

Brake power is the output power of an engine measured by developing the power into a brake dynamometer on the output shaft. Dynamometer measures the speed and torque of the shaft. The Brake power is calculate with the formula.

$$bp = \frac{2*\pi*N*T_r}{60*1000} \quad (kW) \qquad (1)$$

N = Engine Speed (rpm)

T_r = Torque Produced (Nm).

B. Indicated Power (ip)

Indicated power is the power developed inside the cylinder and is proportional to the rate at which work is done on the piston.

$$iP = \frac{imep*A*L*n*k}{60} \quad (kW) \qquad (2)$$

imep : indicated mean effective pressure in kN/m^2

A: piston surface area (m^2)

L: stroke length (m)

n: No of working stroke per minute

N: speed (rpm)

k: No of cylinder

C. Friction Power (fp)

The different between the indicated power and the brake power of an engine is (due to mechanical friction and other losses) termed the friction power.

$$fp = ip - bp \qquad (3)$$

D. Mechanical Efficiency (η_m)

Mechanical efficiency is defined as the ratio of the brake power (bp) of the engine to its indicated power (ip).

$$\eta_m = \frac{bp}{ip} \qquad (4)$$

E. Mean Effective Pressure (mep)

The mean pressure is defined as a hypothetical pressure which is assumed to act on the piston throughout the power stroke [12].

These are three types of the Mean effective pressure:

a) Indicated mean effective pressure

b) Brake mean effective pressure

c) Frictional mean effective pressure

a) Indicated Mean Effective Pressure (imep)

The mean effective pressure is based on indicated power.

$$imep = \frac{iP*60}{A*L*N*k} \qquad (5)$$

b) Brake Mean Effective Pressure (bmep)

The mean effective pressure is based on brake power.

$$bmep = \frac{bP*60}{A*L*N*k} \qquad (6)$$

c) Frictional Mean Effective Pressure(fmep)

The Frictional mean effective pressure is based on frictional power.

$$fmep = imep - bmep \qquad (7)$$

F. Fuel Consumption ($\dot{m}_f$) kg/hr

The fuel consumption is determined by measuring the time (t) taken for the engine to consume a given volume of fuel.

$$\dot{m}_f = \frac{\rho_f \times v_f \times 0.001}{t} \times 3600 \qquad (8)$$

ρ_f = specific mass of the fuel (kg/m^3)

t = time to empty burette (s)

v_f = volume of fuel =8$\times 10^{-6}$ (m^3)

G. Brake Specific Fuel Consumption (bsfc)

The brake specific fuel consumption (bsfc) represents the fuel flow rate per unit brake power output [13].

$$bsfc = \frac{\dot{m}f}{bp} \quad (kg/kW.hr) \qquad (9)$$

H. Brake Thermal Efficiency (η_{bth})

Brake thermal efficiency can be defined as the ratio of the brake power to the engine fuel energy as in equation (10) [13,14].

$$\eta_{bth} = \frac{bP*3600}{\dot{m}f*LCV} \qquad (10)$$

LCV: lower calorific value of the fuel

III. THE EXPERIMENTAL TEST RIG

The experiments were carried out in a single cylinder four stroke variable

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

speed air cooled direct injection diesel engine type (TD 212) made in UK. The basic data of the engine used are given in table (1). The engine was coupled with dynamometer. Thermocouples were used to measure the temperature of exhaust gases. Experimental Setup, test diesel engine and the schematic diagram of the engine test are shown in figure (1), figure (2)and figure (3) respectively.

TABLE (1): TECHNICAL SPECIFICATIONS THE ENGINE [15]

Item	Specification
Engine manufacture	TQ TD 212,UK
Fuel type	Diesel
Oil Type	Multi grade SAE 5W-40
Cylinder bore	69 mm
Connecting rod length	104 mm
Engine capacity	232 cm^3
Compression ratio	22:1
No of strokes	4
No of cylinder	1
Maximum power	3.5 kW at 3600 rev/min
Maximum torque	16 N.m. at 3600 rev/min

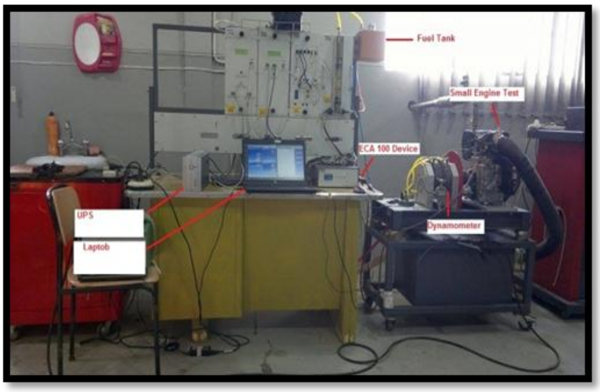

Fig. (1) Experimental Setup

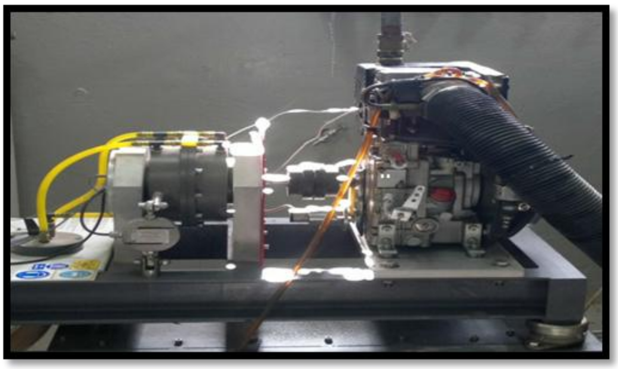

Fig. (2) Test diesel engine

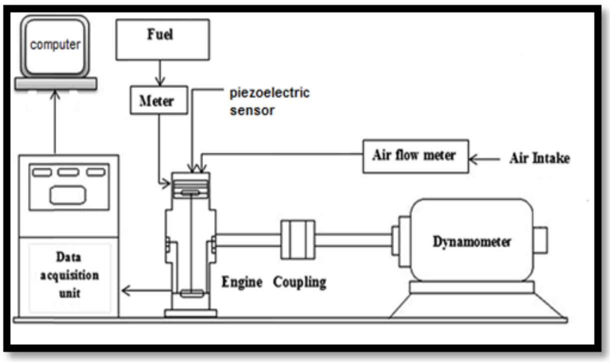

Fig. (3) Schematic diagram of the test diesel engine

IV. TYPE OF TESTED FUEL

The test fuels are denoted as E0 Beji (100 % diesel), E0 Basra (100% diesel), E0 Daura (100% diesel),E8 blended (8% ethanol and 92 % diesel), and E10 (10% ethanol and 90 % diesel), these samples were chemically analyzed before used in testing at midland refineries company AL- Daura - Quality Control and Researches Department in Baghdad . Results analyze of above five types of fuel which were shown in table2 .

Table .(2) Fuel Properties [16]

Lab . Insp. Data	E0 Beji	E0 Basra	E0 Daur	E8 Blende	E10 Blended
Density @15°C	0.8413	0.8300	0.8388	0.8285	0.8290
Flash point °C			72.8		
SP. Gravity @15.6°C	0.8418	0.8304	0.8393	0.8289	0.8294
API Gravity @15.6°C	36.6	38.9	37.1	39.2	39.1
Calorific Value Kal/kg	10912	10952	10921	10957	10955
Cetane Number	55.5	58.0	56.0	58.5	58.5

V. TEST PROCEDURE

The experiments were carried out by five test fuels at four levels of speed 1100, 1600, 2100, and 2600 rpm with five levels of torques 2, 4, 6, 8, and 10 N.m. Before starting the engine to a new fuel the lubricating oil level in the engine is checked and it was allowed to run for enough time to consume the remaining fuel from the previous experiment. The experimental work was started a preliminary study of the engine running on (E0 Beji) diesel fuel at slight for 15 minutes to reach stability of engine then increased the speed to 1100 rpm and torque 2 N.m.

Fuel consumption is measured with a pipette (8 ml) volume and stop watch, after running the program (ECA 100) and the program (VDAS). A thermocouple was placed in the exhaust manifold near the exhaust valve to measure exhaust gas temperature. The experimental data are saved in the computer to determine exhaust gas temperature, fuel consumption, speed, torque, indicated power and brake power. In the next step the engine speed was fixed at 1100 rpm and load was changed to 4Nm. The same procedure as in above step was repeated for recording of the results. This procedure is repeated by changing torques from 6, 8, and 10Nm. The test procedure is repeated for each type of fuel for each engine speeds and for each torques .for each experiment, three runs were performed to obtain an average value of the experimental data.

VI. RESULTS AND DISCUSSION

A. Brake Specific Fuel Consumption.

Figure (4) shows the effect of the engine torque on brake specific fuel consumption for diesel and ethanol-diesel blended at speed of 2600 rpm.E8 Blended fuel type registered the high value of brake specific fuel consumption followed by Beji , E10 blended,E0 Basra ,and E0 Daura .It is due to more oxygen and higher cetane number in the E8 blended leads to leaner combustion resulting in higher brake specific fuel consumption [17].

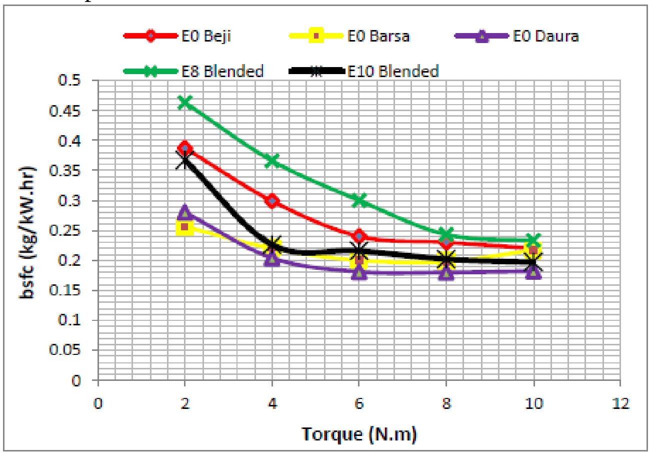

Fig. (4) Effect of engine torque on bsfc (kg/kW.hr) for diesel and ethanol-diesel blended at engine speed= 2600 rpm.

Figure (5) shows the effect of the engine speed on brake specific fuel consumption for diesel and ethanol-diesel blended at torque 10N.m .E8 Blended fuel type registered the high value of brake specific fuel consumption .There were about 28.02% for E8 blended fuel,20.88% E0 Beji fuel, 19.2 % for E0 Basra fuel, 8.24% for E10 blended fuel higher of brake specific fuel consumption than that E0 Daura fuel.

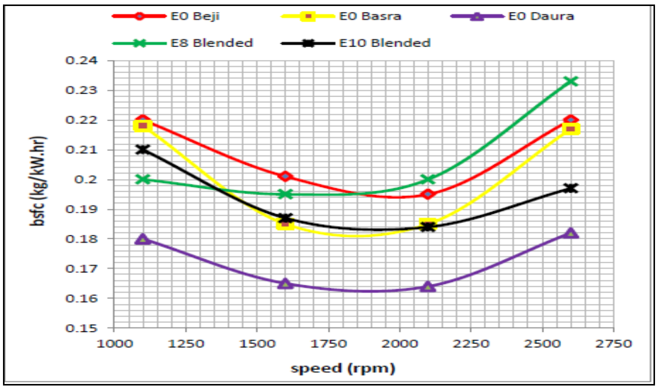

Fig. (5) Effect of engine speed on the bsfc (kg/kW.hr) for diesel and ethanol-diesel blended at torque =10 N.m.

B. Brake Thermal Efficiency (η_{bth})*:*

Figure (6) shows the effect of the engine torque on brake thermal efficiency for diesel and ethanol-diesel blended at speed of 2600 rpm.E0 Daura Blended fuel type registered the high value of brake thermal efficiency followed by E0 Basra, E10 blended, and others. .

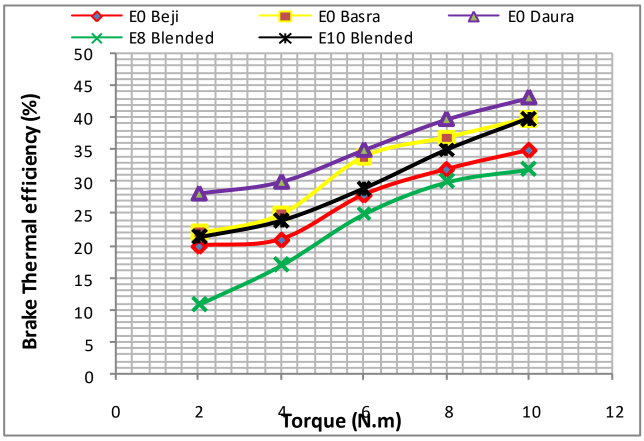

Fig. (6) Effect of engine torque on Brake Thermal Efficiency (%) for diesel and ethanol-diesel blended at engine speed= 2600 rpm.

Figure (7) shows the effect of the engine speed on brake thermal efficiency for diesel and ethanol-diesel blended at torque 10N.m .E0 Daura Blended fuel type registered the high value of brake thermal efficiency followed by E0 Basra, E10 blended, and others. The maximum brake thermal efficiency 0.48 of E0 Daura decreased to 0.45 (6.25%), 0.42 (12.5%), 0.41 (14.58%), and 0.4 (20%) when using E0 Basra, E10 blended, E0 Beji, and E8 blended at speed 2100 rpm. This is because of the reduction in brake specific fuel consumption of the E0 Daura and E0 Basra

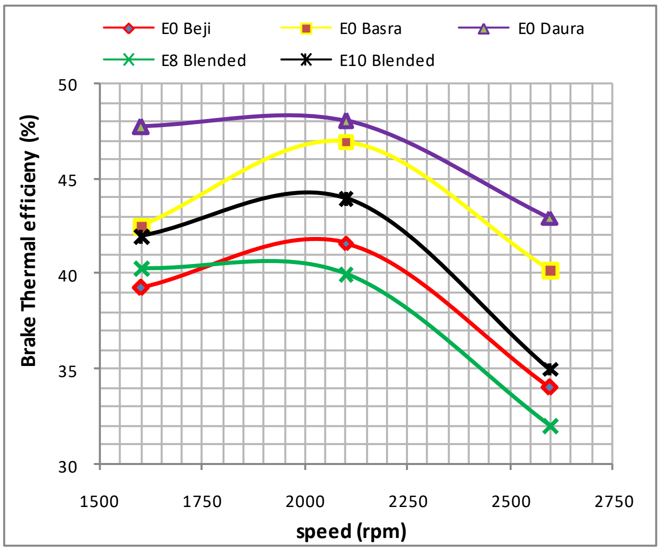

Fig. (7) Effect of engine speed on Brake Thermal Efficiency (%) for diesel and ethanol-diesel blended at engine torque= 10 N.m.

C. Brake Power:

Figure (8) shows the

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

effect of engine torque on brake power at speeds 2600 rpm. The result shows that relationship between brake power and torque is proportional .That mean when the torque increase, the brake power increases too and diesel and ethanol-diesel blended are in the same values.

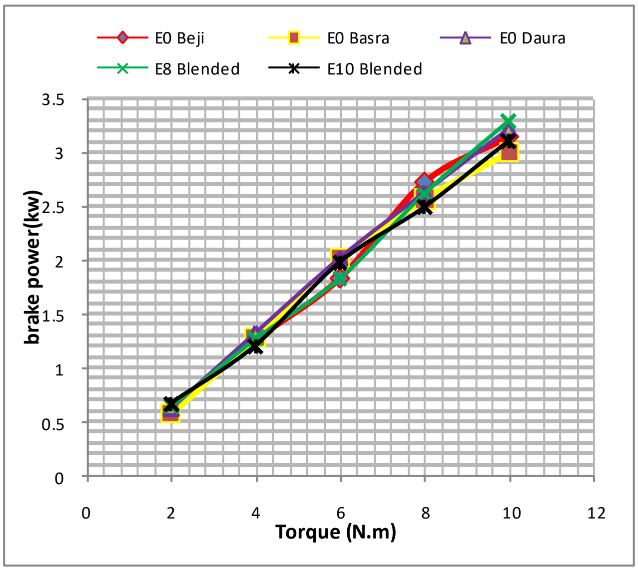

Fig. (8) Effect of engine torque on brake power (kW) for diesel and ethanol-diesel blended at engine speed= 2600 rpm.

Figure (9) shows the effect of engine speed on brake power at torque 10 N.m .The result shows that relationship between brake power and speed is proportional .That means when speed increases ,the brake power increases too and diesel and ethanol-diesel blended are in the same values.

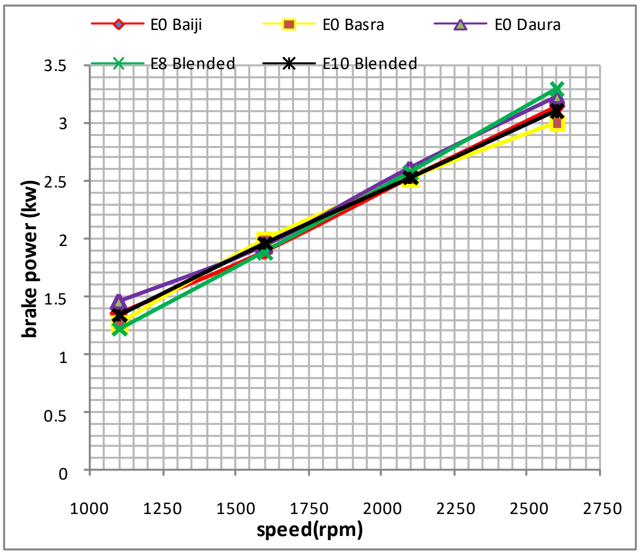

Fig. (9): Effect of engine speed on brake power (kW) for diesel and ethanol-diesel blended at engine torque= 10Nm.

D. Mechanical efficiency (η_m):

Figure (10) shows the effect of engine torque on mechanical efficiency at speed 2600 rpm .The results show that mechanical efficiency increases when the torque was increased for all fuels .This was due to increase in power with increase in torque and frictional power remains constant. It was also observed that mechanical efficiency was better with E0 Daura for any given torque. The reason for the improved mechanical efficiency for higher concentration blends was that as the proportion of E0 Daura was raised, the viscosity of blend increases [18].

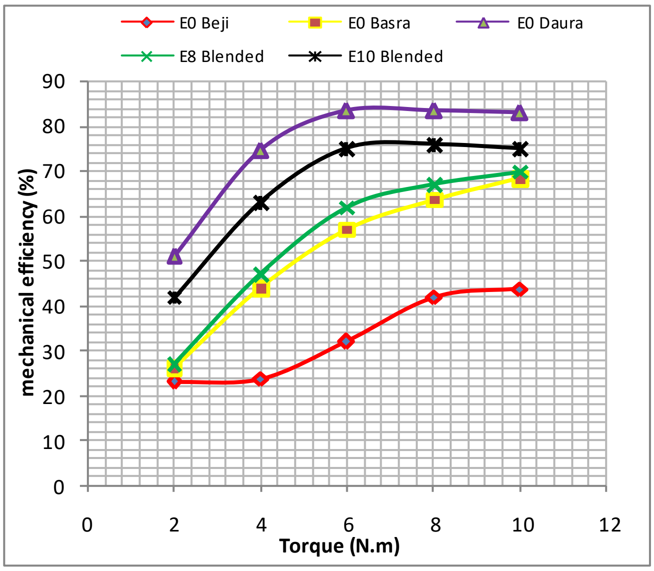

Fig. (10): Effect of engine torque on Mechanical efficiency (%) for diesel and ethanol-diesel blended at engine speed= 2600 rpm.

Figure (11) shows the effect of the engine speed on mechanical efficiency for diesel and ethanol-diesel blended at torque 10N.m .E0 Daura blended fuel type registered the high value of mechanical efficiency. The maximum mechanical efficiency 0.83 of E0 Daura decreased to 0.7 (15.66%), 0.68 (18.07%), 0.6 (27.7%), and 0.4 (51.8%) when using E8 blended ,E0 Basra, E10 blended, and E0 Beji at speed 2600 rpm.

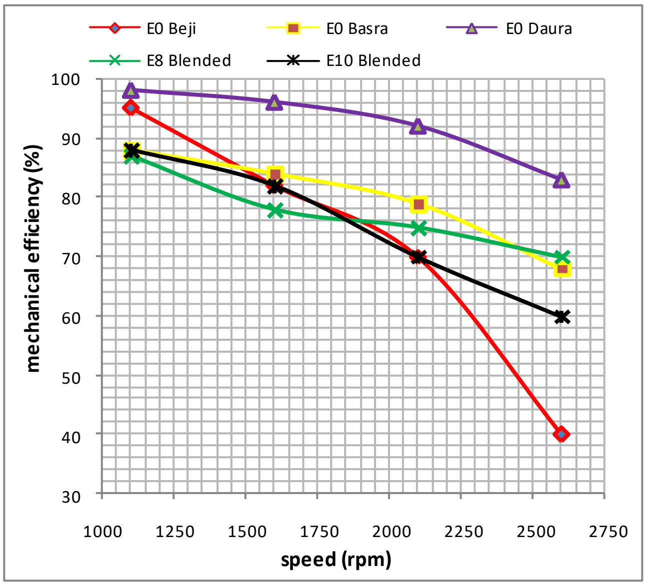

Fig. (11): Effect of engine speed on Mechanical efficiency (%) for diesel and ethanol-diesel blended at engine torque= 10Nm.

E. Brake mean effective pressure

Figure (12) shows the effect of engine torque on brake mean effective pressure at speeds 2600 rpm. The result shows that relationship between brake power and mean effective pressure is proportional .That mean when the torque increase, the brake mean effective pressure increases and E10 slightly recorded the higher value of brake mean effective pressure for all torques.

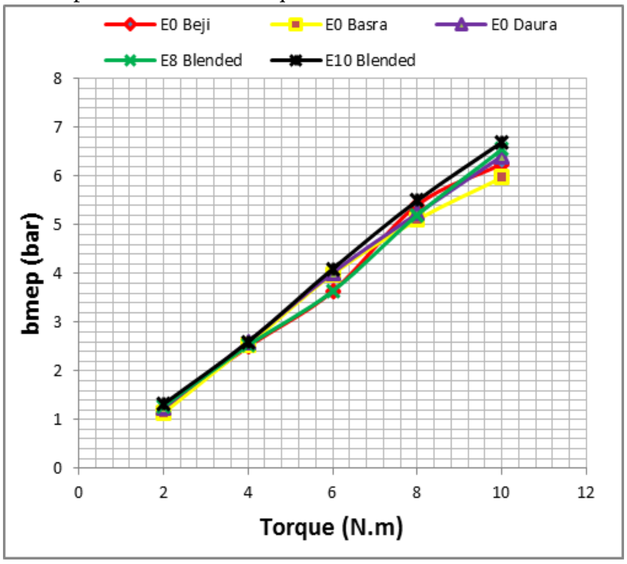

Fig. (12) Effect of engine torque on the brake mean effective pressure for diesel and ethanol-diesel blended at speed= 2600 rpm.

Figure (13) shows the effect of the engine speed on brake mean effective pressure for diesel and ethanol-diesel blended at torque 10N.m .E10 blended fuel type registered the high value of brake mean effective pressure for all speeds.

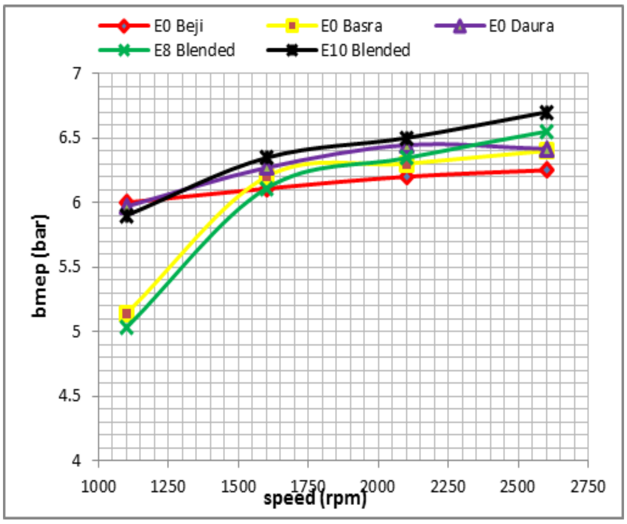

Fig. (13) Effect of engine speed on the brake mean effective pressure for diesel and ethanol-diesel blended at torque =10N.m.

F. Exhaust gas temperature

Figure (14) shows E0 Basra gave higher exhaust gas temperature. At higher speeds the exhaust temperature of all fuels was decreased than E0 Basra fuel .This may be related to the effect of higher heating value is the dominant, where the oxygen content loss its positive effect at high speed

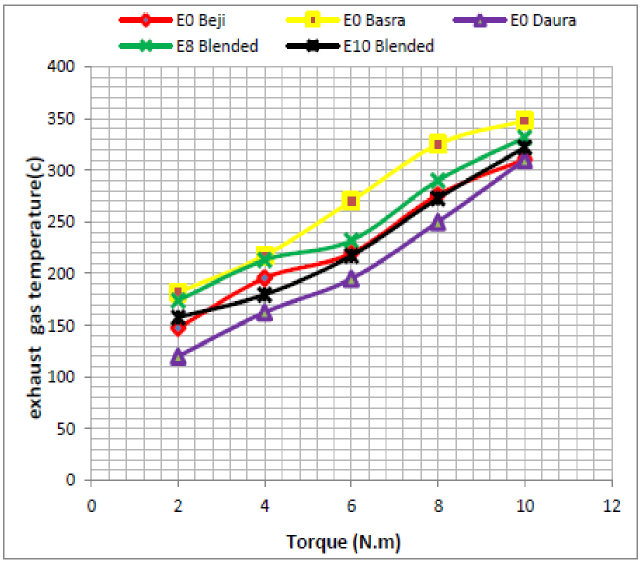

Fig. (14) Effect of engine torque on the exhaust gas temperature for diesel and ethanol-diesel blended at speed= 2600 rpm.

Figure (15) at torque =10 N.m, diesel and ethanol-diesel blended shows very slight change in exhaust gas temperature at low speed. E0 Basra gave higher exhaust gas temperature at higher speeds .There were about 10.98% for E0 Basra fuel ,7% for E8 blended fuel,3.87% for E10 blended fuel ,1.612% for E0 Beji higher of exhaust gas temperature than that E0 Daura fuel. This may be related to the effect of higher heating value is the dominant .The evident increase of exhaust gas temperature for E8 blended and E10 blended may be due to its highest oxygen content of ethanol.

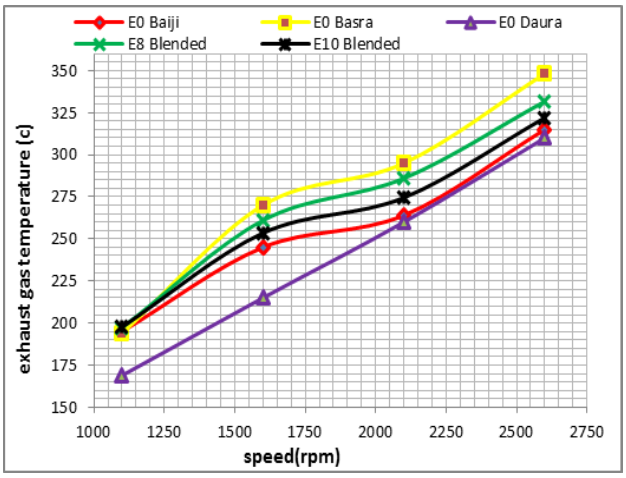

Fig. (15) Effect of engine speed on the exhaust gas temperature for diesel and ethanol-diesel blended at torque =10N.m.

VII. CONCLUSIONS

The conclusions that are extracted from the present study are as following.

1. E8 blended fuel type registered the high value of brake specific fuel

consumption followed by Beji , E10 blended,E0 Basra ,and E0 Daura

2. E0 Daura blended fuel type registered the high value of brake thermal efficiency followed by E0 Basra, E10 blended, and others.

3. E0 Daura blended fuel type registered the high value of mechanical efficiency. The maximum mechanical efficiency 0.83 of E0 Daura decreased to 0.7 (15.66%), 0.68 (18.07%), 0.6 (27.7%), and 0.4 (51.8%) when using E8 blended ,E0 Basra, E10 blended, and E0 Beji at speed 2600 rpm.
4. E10 slightly recorded the higher value of brake mean effective pressure for all torques and speeds.
5. For E0 Basra fuel has high value of exhaust gas temperature with high speed. There were about 10.98 % for E0 Basra fuel, 7 % for E8 blended fuel, 3.87 % for E10 blended, 1.612 % for E0 Beji fuel, higher of exhaust gas temperature than that E0 Daura fuel

ACKNOWLEDGMENT

We wish to express our thanks to the staff of the Electromechanical Engineering Department, University of Technology.We would like to thank Baghdad Technology Institute and its staff to provide the facilities in our project in Internal Combustion Engine Laboratory, Department of Machines and equipment, especially Mr. Nahedh Abdulameer Muhamed Hassan and Mr. Mohaned Hatam Fizaa who supported our throughout the work. Thanks are also due to the engineers of Internal Combustion Laboratory; who helped our in all experimental tests all along

REFERENCES

1. Creating Markets for Renewable Energy Technologies EU RES Technology Marketing Campaign," Bioethanol Production and Use", EUROPEAN BIOMASS INDUSTRY ASSOCIATION, pp.63-65, Rue d'Arlon, B-1040 Brussels,2006
2. Mustafa Balata, Havva Balat, Cahide Oz," Progress in bioethanol processing", Progress in Energy and Combustion Science 34, pp. 551–573, 2008.
3. S. Durga Prasad, G. Venkateswara Rao, K. Sri Rama Murthy," Effect of diesel-ethanol blends on performance of a diesel engine at different injection pressures", International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013.
4. Nivesh Vijayan, " Performance and Emission Characteristics of Diesel Engine Fuelled With Diesel-Biodiesel-Ethanol Blends", International Journal of Science and Research (IJSR), Volume 3 Issue 10, October 2014..
5. R Senthil and R Silambarasam,"Effect of ethanol blend addition on performance and emission of diesel engine operated with jatropha & pongamia methyl esters". Journal of Scientific & Industrial Research, Vol. 73, pp. 453-455 July 2014
6. D. D .Nagdeote, M. M. Deshmukh," Experimental Study of Diethyl Ether and Ethanol Additives with Biodiesel-Diesel Blended Fuel Engine", International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 3, March 2012
7. S. Padala, C. Woo, S. Kook, E.R. Hawkes," Performance Improvement of a Compression Ignition Engine by Ethanol and Diesel Dual-Fuelling", 18 th Australasian Fluid Mechanics Conference Launceston, Australia 3-7 December 2012.
8. M. Velliangiri and A. S. Krishnan, " An Experimental Investigation of Performance and Emission in Ethanol Fuelled Direct Injection Internal Combustion Engines with Zirconia Coating", Journal of Energy Technologies and Policy, Vol.2, No.2, 2012..
9. De-gang Li, Huang Zhen, Lu Xingcai, Zhang Wu-gao, Yang jian – guang,"Physico-chemical properties of ethanol-diesel blend fuel and its effect on performance and emissions of diesel engines", Journal of Renewable energy. 30, pp. 967-976. 2005.
10. E. A. Ajv, Bachchan Singh, T. K.,Bhatta Charya, "Experimental study of some performance parameter of a constant speed diesel engine using ethanol-diesel blend as fuel", Journal of Biomass and Bioenergy. 17: 357-365, 1999.
11. Jincheng Huang, Yaodong Wang, Shuangding LI, Anthony P, Roskilly, Hony dong Yu and Huiten Li," Experimental investigation on the performance and emission of a diesel engine fuelled with ethanol diesel blends", Journal of Applied Thermal Engineering. 29(11-12): 2484-2490, 2009.
12. R. Bhaskar Reddy, B. Siddeswararao," Performance Characteristics and Analysis of 4-Stroke Single Cylinder Diesel Engine Blend With 50% of Honne Oil at Various Fuel Injection Pressures", Journal of Engineering Research and Applications, Vol.4, Issue 8(Version1), pp.10-20, August 2014.
13. Pulkrabek W. W, "Engineering fundamentals of the internal combustion engines", 2nd Ed. New York, Prentice Hall. 2005.
14. Rahman M.M, Mohammed M.K, Bakar R.A." Effects of Air Fuel Ratio and Engine Speed on Engine Performance of Hydrogen Fueled Port Injection Engine", American Journal of Scientific Research PP: 23-33,2009.
15. TD200 User Guide, TecQuipment Ltd, Bonsall Street, Long Eaton, Nottingham NG10 2AN, UK:
16. Quality Control and Research Department ,Al-Daura Midland Refineries Company, Iraq, 2014.
17. G. Venkata Subbaiah, K. Raja Gopal and Syed Altaf Hussain," The Effect of Biodiesel and Bioethanol Blended Diesel Fuel on the Performance and Emission Characteristics of a Direct Injection Diesel Engine", Iranica Journal of Energy & Environment 1 (3):pp. 211-221, 2010.
18. Mayank Chhabra," Performance characteristics of automotive diesel engine fueled with diesel and blends of biodiesel produced from waste soybean cooking oil", Scholars Research Library Archives of Applied Science Research, , 6 (5):pp.163-171,2014;

AUTHOR PROFILE

Dr. Saadi Turied Kurdi, received his B.Sc from Electrical Engineering in University of Sarajevo, Department of Aeronautical Engineering Republic of Bosnia and Herzegovina, formerly Yugoslavian in1981, his H.D.(Higher diploma) in Aeronautical Engineering Department (Flight data Recording Equipment- black Box) ,1988, his M.Sc from Electrical Engineering in University of Belgrade,, Department of Aeronautical Engineering Republic of Serbia. Formerly Yugoslavian in1983,and his PhD. from Electrical Engineering – Aircraft Power System University of Technology. Deparment of Electrical and Electronic in 2006 .He is currently working as lecturer in University of Technology .His current research interest include Aircraft Power System, Aircraft Machines and Power System-Stability and Control.

Dr. Hassan Abad al-wahab Anjal. received his B.Sc from University of Technology, Iraq in 1976. , his M.Sc AntoninUniversity,CSSR.Brno in1982. and his PhD from Antonin University ,CSSR in1986.He is currently working as Associate professor in University of Technology .His current research interest include combustion engine(theory &Desgin).

Hussein Ahmed Abd Yaqoob, received his B.Sc from University of Technology, Iraq in 2013.He is currently working as master student, Electro-mechanical Engineering department, University of Technology, Baghdad, Iraq His current research interest include Energy and Renewable energy.