Proceedings of the World Congress on Engineering 2011 Vol III
WCE 2011, July 6 - 8, 2011, London, U.K.

Performance of Single Cylinder DI Diesel Engine – Varied Compression Ratio Fueled With Blends of Ethanol

Eknath R. Deore, Ramchandra S. Jahagirdar, Milind Suryaji Patil, Purushottam S. Desale

Abstract - In present experimental investigation 3.75 kW diesel engine AV1 Single Cylinder water cooled, Kirloskar Make tested for blends of diesel with ethanol. Tests were conducted for three different compression ratios. Engine test setup was developed with moving cylinder head for variation of compression ratio to perform investigations using these blends. The engine performance studies were conducted with rope break dynamometer setup. Parameters like speed of engine, fuel consumption and torque were measured at different loads for pure diesel and for blends of diesel with ethanol at different compression ratio. Break Power, BSFC, BTE and heat balance were evaluated. Paper represents the test results for blends 5% to 20% and three different compression ratios.

Keywords: IC Engine, Diesel, Blends, Compression ratio, fuel properties, heat balance, engine performance

I. INTRODUCTION

Increase in petroleum prices, threat of global warming has generated an interest in developing alternative fuels for engine. Technologies now focusing on development of plant based fuels, plant oils, plant fats as an alternative fuel. Biodiesel is described as fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Biodiesel and ethanol can be produced from feedstock's that are generally considered to be renewable. Since the carbon in the biodiesel originated mostly from CO2 in the air, the full cycle CO2 emissions for biodiesel contribute much less to global warming than fossil fuels. Although biodiesel cannot entirely replace petroleum- based fuels, bio-fuels and diesel fuel blends can be used on existing engines to achieve both environmental and energy benefits. Ethanol is a low cost oxygenate with high oxygen content (35%) that has been used in ethanol–diesel fuel blends.

Manuscript Received March, 28, 2011Revised April, 22, 2011,

Eknath R Deore is Asst. Professor & Head Mechanical Engineering Department, S.S.V.P.S B.S.D College of Engineering, Dhule: 424005, INDIA, (Corresponding Author Phone +91-2562-272713 extn 350, erdmech@yahoo.com)
Ramchandra S Jahagirdar is Sr. Professors & Principal Mechanical Engineering Department, S.S.V.P.S B.S.D College of Engineering, Dhule: 424005, INDIA, (Phone +91-2562-272713 extn 350, j_ramchandra@yahoo.com)
Milind Suryaji Patil is Sr. Lecturer S.S.V.P.S B.S.D College of Engineering, Dhule: 424005, INDIA, (Phone +91-2562-272713 extn 350, mspiso2000@yahoo.com)
Purushottam S. Desale is Sr. Lecturer Mechanical Engineering Department S.S.V.P.S B.S.D College of Engineering, Dhule: 424005, INDIA, (Phone +91-2562-272713 extn 350, purudesale@yahoo.com)

The use of ethanol in diesel fuel can yield significant reduction of particulate matter (PM) emissions for motor vehicles (Ahmed, 2001; Lu¨ et al., 2004; He et al., 2003; Zhang et al., 2004) However, there are many technical barriers to the direct use of ethanol in diesel fuel due to the properties of ethanol, including low cetane number of ethanol and poor solubility of ethanol in diesel fuel in cold weather. In fact, diesel engines cannot operate normally on ethanol–diesel blend without special additives (McCormick and Parish, 2001; Gerdes and Suppes, 2001). In the present investigation diesel and its blend with ethanol from 5% to 20% are studied for three different compression ratios. Performance of engine was evaluated based on different % loading of the engine with various CR.

II. MATERIALS & EXPERIMENTAL SETUP

Commercial diesel fuel used in India which was obtained locally is used as a base line fuel for this study. Ethanol used in this study is anhydrous ethanol (99.7%) purity. The important chemical and physical properties of blends were determined by standard methods and compared with diesel. The analytical results are shown in Table II. Fuel and its blends density and heating value were measured in a laboratory with hydrometer and bomb-calorimeter. Properties of test fuels were reported in Table-II.

All experiments were performed with Kirloskar make single cylinder diesel engine. Table I shows the engine specifications. All experiments were performed after ensuring the full warm-up.

The volume of the combustion chamber is varied by moving a small secondary valve, which communicates with the chamber. Three different compression ratios were achieved with this arrangement for experimental analysis.

Plan was designed for the experimental investigation. Different blends of fuels by volume were tested. The fuel blends was 5%, 10%, 15%, & 20% i.e. blends of 5% ethanol with 95% diesel fuel, etc. and 100% of diesel fuel, as shown in Table III. The tests were conducted for different compression ratio and were repeated for four times for every kind of fuel, in order to increase the reliability of the test results. For each of the fuels and Compression ratio, the engine was run on five different loads, i.e. idle (0kg), 2kg, 4kg, 6kg and 8kg of break load on dynamometer. The engine load was controlled by dynamometer.

The engine performance tests were conducted with a rope brake-diesel engine set up. The parameters like speed of engine, fuel consumption and torque were measured at different loads for diesel and with various combinations of dual fuel. Brake power, brake specific fuel consumption and brake thermal efficiency was calculated using the collected test data. The engine was sufficiently warmed up at every stage and the cold water temperature was maintained at 52 °C. The fuel injection pressure was maintained at 200 bar throughout the experiment. A Honey Well Chromel-Alumel thermocouple with a digital display meter was used to measure the exhaust gas temperature.

III. RESULTS AND DISCUSSION

A. *Fuel Consumption*

Fig. 1 to 3 compares the specific fuel consumption of diesel and various blends of ethanol at varying brake loads and compression ratio. It was observed that the fuel consumption (kg/hr) at maximum load of 8 kg for blends of 5%, 10%, 15% & 20% were 0.638, 0.696, 0.670, 0.658 respectively for compression ratio of 25.10. However for the compression ratio of 24.78 it is observed as 0.672, 0.737, 0.708, 0.750 respectively for the blends and for Compression ratio 24.48 it was 0.784, 0.767, 0.736, and 0.798. For pure diesel it was observed as 0.617, 0.627 and 0.617 for a compression ratio of 25.10, 24.78 and 24.48 respectively. For the same maximum load on the engine fuel consumption was minimum for pure diesel compared with blends of ethanol.

B. *Break Thermal Efficiency*

Fig. 4 to 6 compares the break thermal efficiency of diesel and various blends of ethanol at varying brake loads and compression ratio. It was observed that the % break thermal efficiency at maximum load of 8 kg for blends of 5%, 10%, 15% & 20% were 28, 27, 27.5 & 28 for compression ratio of 25.10. However for compression ratio of 24.78 it was 27, 25, 26 &25 respectively for blends and for a compression ratio of 24.48 it was observed as 22, 24, 25 & 23. For pure diesel it was observed as 28, 27.5 & 27.6. Efficiency was observed to be good for a blend of mixture of 5 % ethanol with a compression ratio of 25.10.

C. *Volumetric Efficiency*

Fig. 07 to 09 compares the volumetric efficiency (%) of diesel and various blends of ethanol at varying brake loads and compression ratio. It was observed that break power at maximum load of 8 kg for blends of 5%, 10%, 15% & 20% were 68.25, 68.71, 67.05 and 68.44 for a compression ratio of 25.10. For a compression ratio of 24.78 it was 68.25, 71.91, 72.89 and 69.65 also for a compression ratio of 24.48 it was 68.44, 73.95, 75.49 and 72.79. For pure diesel it was observed as 67.34, 67.51 and 67.64. It was observed that volumetric efficiency was improved with the blending of ethanol. Maximum volumetric efficiency were observed with compression ratio of 24.48 with 15% of ethanol blend. Where as it is observed to be good for 5% blending at CR 25.10

D. *Exhaust Gas Temperature*

Fig. 10 to 12 compares the exhaust gas temperature (^{0}C) of diesel and various blends of ethanol at varying brake loads and compression ratio. It was observed that break power at maximum load of 8 kg for blends of 5%, 10%, 15% & 20% were 197, 205, 200 and 215 for compression ratio of 25.10. For a compression ratio of 24.78 exhaust gas temperature was 184, 195, 205 & 215 where as for a compression ratio of 24.48 it was 171, 187, 209 and 215. For pure diesel it was observed as 201, 200 & 205. Max exhaust gas temperature was 215^{0}C for a blend of 20% with a compression ratio of 25.10. Exhaust gas temperature is observed to be minimum for 5% of ethanol blend.

E. *Break Power*

Fig. 13 to 15 compares the break power of diesel and various blends of ethanol at varying brake loads and compression ratio. It was observed that break power at maximum load of 8 kg for blends of 5%, 10%, 15% & 20% were 2.110, 2.096, 2.096 & 2.053 for a compression ratio of 25.10. For a compression ratio of 24.78 it was observed as 2.110, 2.096, 2.068 & 2.068 and for a compression ratio of 24.48 it was 2.053, 2.082, 2.039 & 2.025 kW respectively for blends. For pure diesel it was 2.138, 2.02 & 2.025 kW. With increase in blending % break power was reduced for the given compression ratio. Maximum BP were observed as 2.110 for 5% blending at a compression ratio of 25.10.

IV. CONCLUSION

For all fuel sample tested it is observed that with the loading of the engine at 2.138 kW (@57 %) BTE of pure diesel and blend of diesel and ethanol was almost same. That of kerosene BTE was low compare with diesel and ethanol blend. For 20 % mixture of ethanol blend with diesel has a very good efficiency compared with pure diesel and blend of kerosene. Also it is observed that the 20 % ethanol blend is having higher volumetric efficiency compare with diesel and kerosene blend. Exhaust gas temperature for ethanol blend has not shown any substantial increase compare with pure diesel. Hence blending of ethanol at about 20 % can lead to a better performance of engine compare with pure diesel.

TABLE I
ENGINE SPECIFICATIONS

Engine Specifications	
Make	Kirloskar AV1
Number of Cylinder	1
Number of Stroke	4
Bore	85 mm
Stroke	110 mm
Power	3.75
Compression Ratio	25:1

Table – II
PROPERTIES OF TEST FUELS

Sr. No	Fuel	Density	CV	% change in CV
1	Diesel	822	42188	-
2	5%E+ Diesel	822	41398.6	-1.87
3	10%E+ Diesel	821	40609.2	-3.74
4	15%E+ Diesel	820	39819.8	-5.61
5	20%E+ Diesel	819	39030.4	-7.49

ISBN: 978-988-19251-5-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

TABLE – III
TEST PLAN

Run	Compression Ratio	Fuel	Frequency Tested
R01	CR1	A	4
		B	4
		C	4
		D	4
		E	4
R02	CR2	A	4
		B	4
		C	4
		D	4
		E	4
R03	CR3	A	4
		B	4
		C	4
		D	4
		E	4

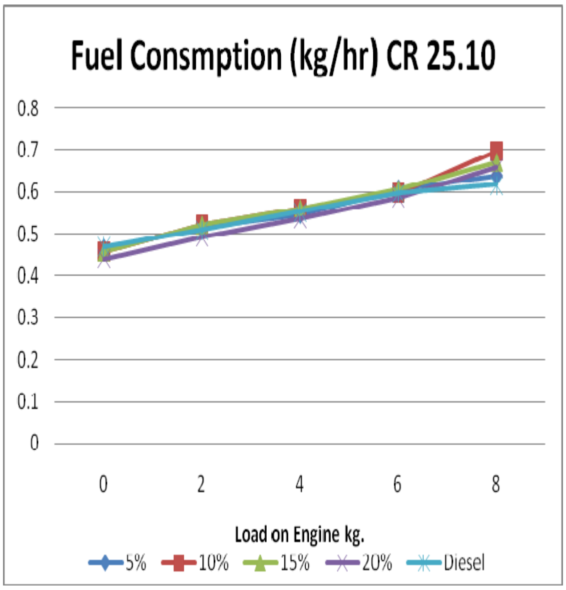

Fig 1 Fuel Consumption for Various Blends of Ethanol with CR 25.10

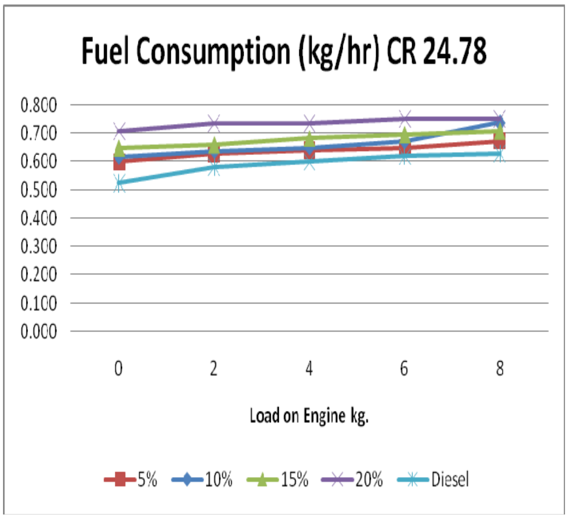

Fig 2 Fuel Consumption for Various Blends of Ethanol With CR 24.78

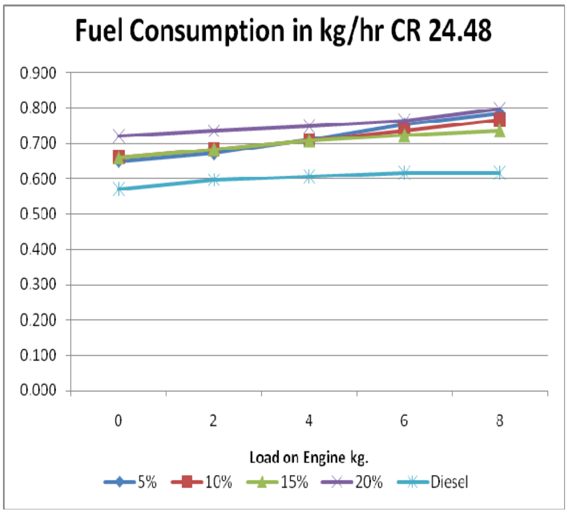

Fig 3 Fuel Consumption for Various Blends of Ethanol with CR 24.48

ISBN: 978-988-19251-5-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

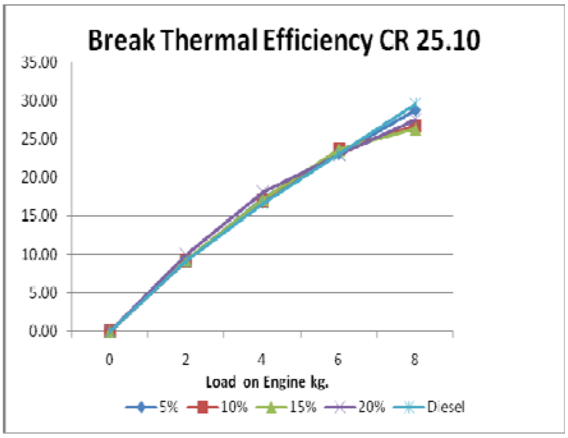

Fig 4 Break Thermal Efficiency for Various Blends of Ethanol with CR 25.10

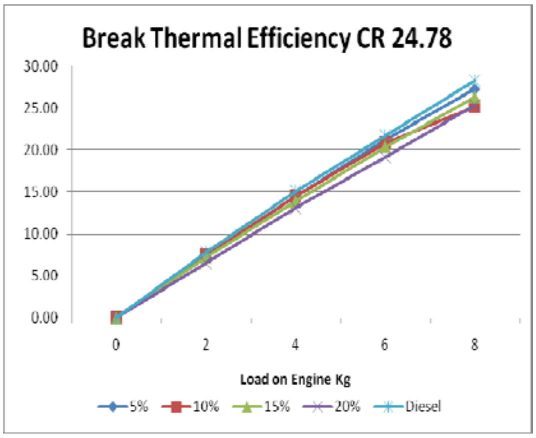

Fig 5 Break Thermal Efficiency for Various Blends of Ethanol with CR 24.78

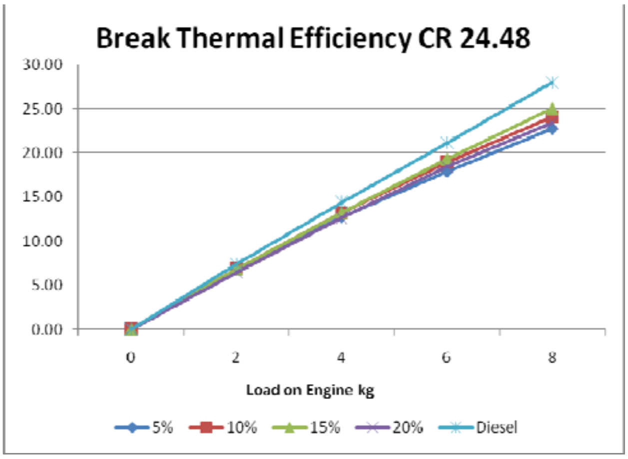

Fig 6 Break Thermal Efficiency for Various Blends of Ethanol with CR 24.48

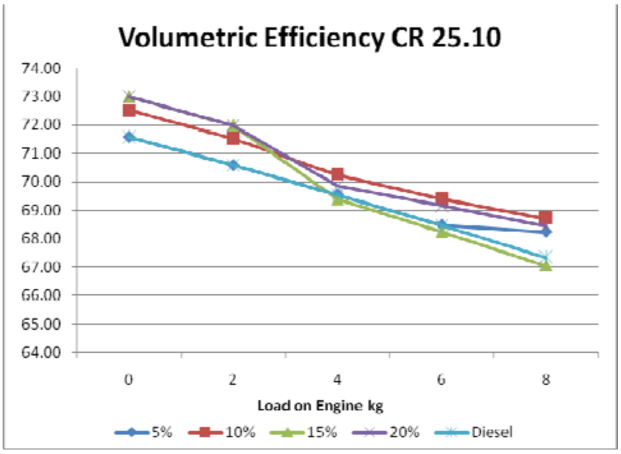

Fig 7 Volumetric Efficiency for Various Blends of Ethanol with CR 25.10

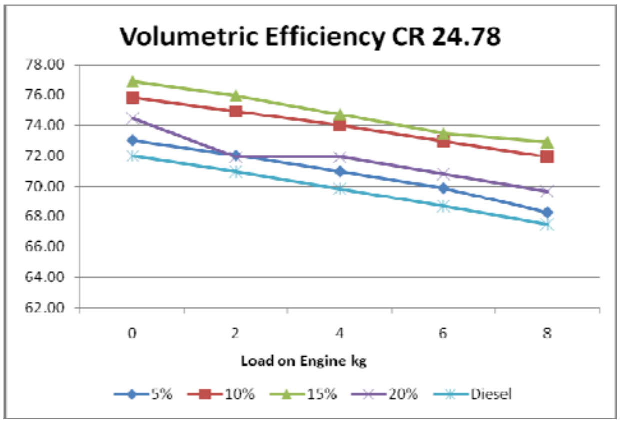

Fig 8 Volumetric Efficiency for Various Blends of Ethanol with CR 24.78

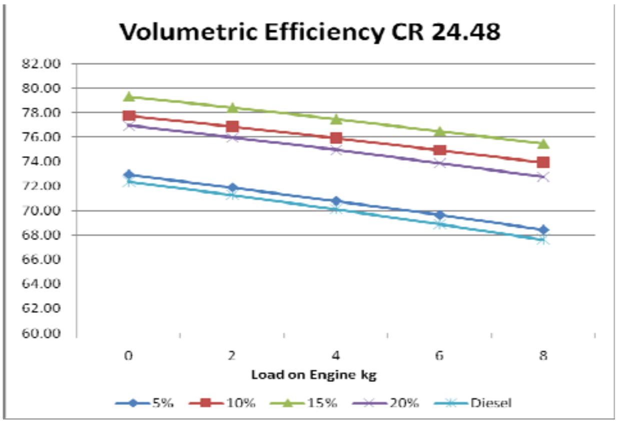

Fig 9 Volumetric Efficiency for Various Blends of Ethanol with CR 24.48

ISBN: 978-988-19251-5-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

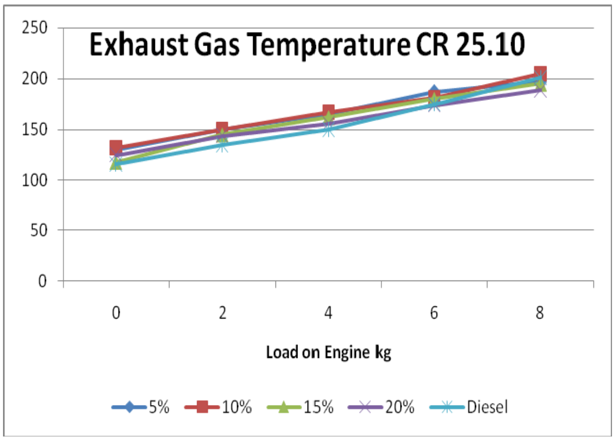

Fig 10 Exhaust Gas Temperature for Various Blends of Ethanol with CR 25.10

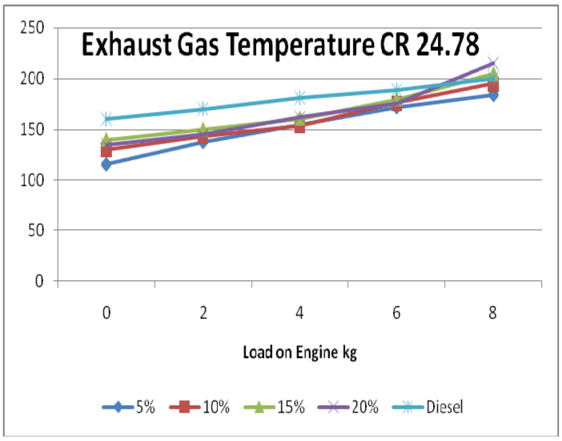

Fig 11 Exhaust Gas Temperature for Various Blends of Ethanol with CR 24.78

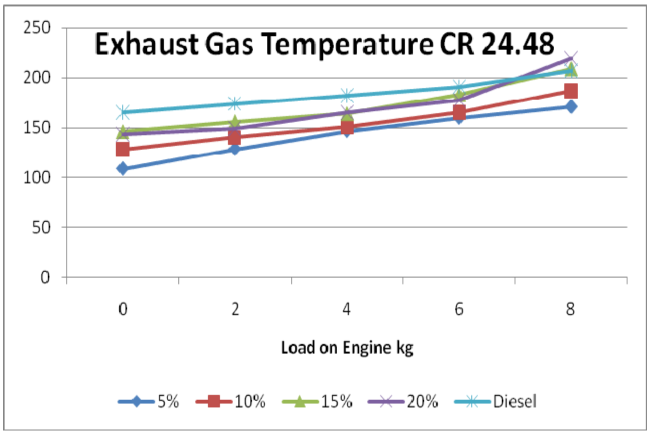

Fig 12 Exhaust Gas Temperature for Various Blends of Ethanol with CR 24.48

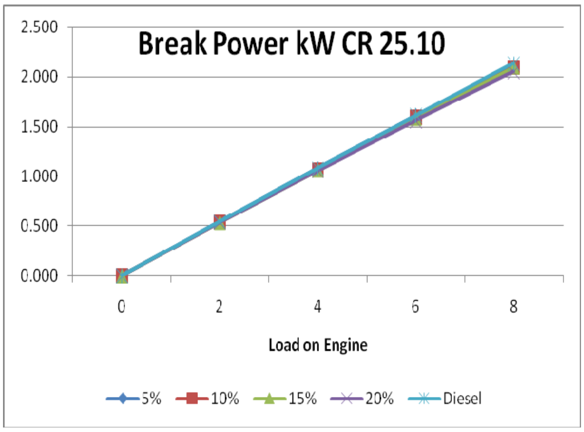

Fig 13 Break Power for Various Blends of Ethanol with CR 25.10

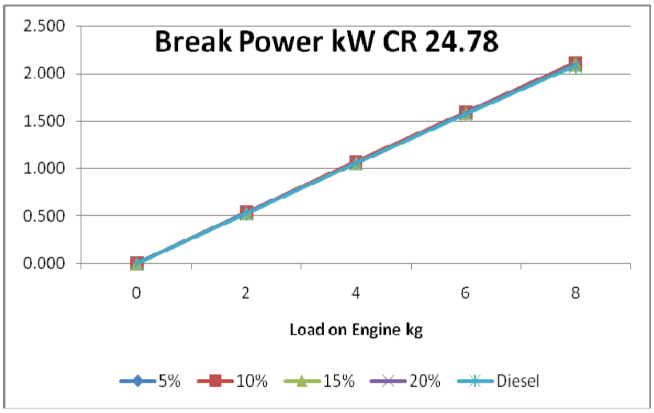

Fig 14 Break Power for Various Blends of Ethanol with CR 24.78

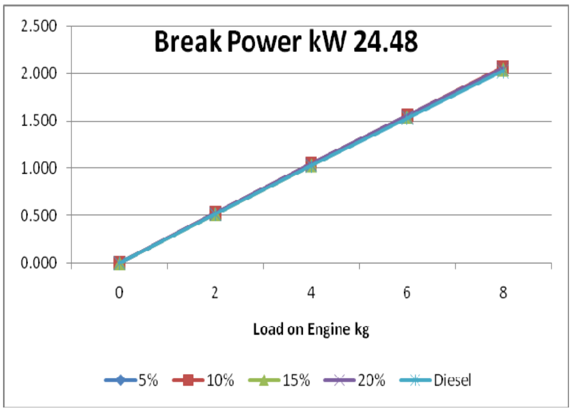

Fig 15 Break Power for Various Blends of Ethanol with CR 24.48

ISBN: 978-988-19251-5-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

REFERENCES

[1]. J. Yan, "Biofuels in Asia", 86 (2009), S1-S10

[2]. Ejaz M. Shahid, Younis Jamal, "A review of biodiesel as vehicular fuel", Renewable and Sustainable Energy Reviews 12 (9) (2008) 2484–2494.

[3]. F. Karaosmanoglu, Vegetable oil fuels: a review, Energy Sources 21 (3) (1999).

[4]. A.S. Ramadhas, Use of vegetable oils as I.C. engine fuels – a review, Renewable Energy 29 (5) (2004) 727–742.

[5]. L.C. Meher, D. Vidya Sagar, S.N. Naik, "Technical aspects of biodiesel production by transesterification—a review", Renewable and Sustainable Energy Reviews, 10 (2006), 248 – 268.

[6]. Hüseyin Aydin, Cumali Ilkılı, "Effect of ethanol blending with biodiesel on engine performance and exhaust emissions in a CI engine" Applied Thermal Engineering, 30 (2010), 1199 – 1204.

[7]. Christian Rodriguez Coronado, João Andrade de Carvalho Jr., Juliana Tiyoko Yoshioka, José Luz Silveira, "Determination of ecological efficiency in internal combustion engines: The use of biodiesel" Applied Thermal Engineering, 29 (2009), 1887 – 1892.

[8]. Jincheng Huang, Yaodong Wang, Shuangding Li, Anthony P. Roskilly, Hongdong Yu, Huifen Li, "Experimental investigation on the performance and emissions of a diesel engine fuelled with ethanol–diesel blends", Applied Thermal Engineering, 29 (2009), 2484 -2490.

[9]. Mustafa Canakci, Ahmet Erdil, Erol Arcaklioglu, "Performance and exhaust emissions of a biodiesel engine", Applied Energy 83 (2006), 594 – 605.

[10]. S. Kalligeros, F. Zannikos, S. Stournas, E. Lois, G. Anastopoulos,Ch. Teas, F. Sakellaropoulos, "An investigation of using biodiesel/marine diesel blends on the performance of a stationary diesel engine", Biomass and Bioenergy, 24 (2003), 141 – 149.

[11]. W. G. Wang, D.W. Lyons, N. N. Clak, and M. Gautam "Emission from Nine Heavy Trucks Fueled by diesel and biodiesel blend without any engine modifications" Environmental Science and Technology, 34 (2000), 933 – 939.

[12]. *D Ramesh and Sampathrajan,* "Investigation on Performance and Emission Characteristics of Diesel Engine with Jatropha Biodiesel and Its Blends", *Agricultural Engineering International: the CIGR journal. Manuscript EE 07 013 Vol X March 2008.*

[13]. A study of some fuel Properties of Local Ethanol Blended with Diesel fuel, *Ajav, E. A. and O. A. Akingbehin Agricultural Engineering International: the CIGR journal. Manuscript EE 01 003 Vol IV March 2002.*

[14]. Experimental Study of DI Diesel Engine Performance Using Three Different Biodiesel Fuels, *J. Patterson, M. G. Hassan, A. Clarke, K Hellgardt and R Chen, 2006-01-0234, Department of Aeronautical and Automotive Engineering Loughborough University UK*

[15]. Exhaust analysis and Performance of a Single Cylinder Diesel Engine Run on Dual Fuels, *V. P. Sethi, K. S. Salariya, IE (I) Journal – MC, Vol 85 April 2004*

ISBN: 978-988-19251-5-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)