Exhaust Gas Analysis on Twin Cylinder Diesel Engine with Different Pure and Blended Fuels

Kallu.Raja Sekhar
Department of Mechanical Engineering
Kuppam Engineering College,Kuppam,Andhra Pradesh,India

G.V.N.B.Prabhakar
Department of Mechanical Engineering
VKR,VNB@AGK College of Engineering,Gudivada,Krishna,Andhra Pradesh,India

Abstract-Diesel engines are being extensively used for rail, road transportation, farming and power generation. Apart from it, the increasing industrialization of the world has led to a steep rise for the demand of petroleum based fuels. The countries which are not having the petroleum resources are facing energy and foreign exchange crises mainly due to the import of crude petroleum. Hence, it is necessary to look for alternate fuels. This paper addresses the efficiency of twin cylinder diesel engine experimentally, when tested with different fuels.

The objective of the present study is to study the behaviour of the existing diesel engine, when tested with different fuels without any engine modification. The engine has been tested with pure diesel, pure bio-diesel (jatropa curcas and pongamia pinnata) and diesel blended with ethanol at different proportions (percentage by volume, E10, E15, E20, E25). E10 means ethanol 10% by volume added to the mineral diesel. Similarly, Bio-diesel and Kerosene also added to the diesel and conducted the experiment. Also, the diesel is blended with bio-diesel at different proportions (B10, B20, and B30) and compared the results with pure bio-diesel. To compare the efficiency variation, the engine has also been tested with diesel and kerosene mixture (K10, K20, K30) at different loads and the results are compared with pure diesel. To check the pollution level, the CO and CO2 emissions at full loads for all the fuels have been measured and compared.

Keywords – Bio-diesel, emission

I.INTRODUCTION

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources. For the diesel engines, seed oil bio fuels have been widely examined across the world [1-5] as a suitable alternative in field trails and laboratory tests. These have been found to give similar performance and emissions when compared with conventional diesel fuel, particularly when blended with diesel.

A diesel engine can perform satisfactorily on bio-diesel blends without any engine hardware modifications. Long term endurance test using bio-diesel proved that the bio-diesel can be used or substituting mineral diesel in long run. The 20% bio-diesel blend was found to be the optimum concentration for bio-diesel blend which improved the peak thermal efficiency [6]. Researchers in various countries carried out experimental research using vegetable oils and bio-diesel as petroleum fuel substitutes [1-5].

Using ethanol as a fuel additive to unleaded gasoline causes an improvement in engine performance and exhaust emissions [7]. Ethanol-diesel blends up to 20% can very well be used in present day constant speed CI engines without any hardware modifications [6-7]. Exhaust gas temperature and lubricating oil temperature were lower for ethanol-diesel blends than mineral diesel. Also significant reduction in CO, NO_x emission was observed while using ethanol-diesel blends. Huseyin et al [8-10] studied the effect of ethanol gasoline blends on spark ignition engine performance and exhaust gas emissions at different compression ratios. Spark ignition engine [11] performance with power gas fuel which is a mixture of CO/H2 and compared the results with gasoline and natural gas at similar conditions.

Ravikumar et al [12] conducted experimental studies on energy appropriation in a single cylinder diesel engine and analysed the heat transfer characteristics of the engine. Tzeng, G.H [13] evaluated the best alternative fuel for buses suitable for the urban area to explore the potential direction development in the future.

II.EXPERIMENTAL PROCEDURE AND EQUIPMENT

The internal combustion engine performance is indicated by the term efficiency (η). The break thermal efficiency (η_{bth}) and the break specific fuel consumption (bsfc) indicate the fuel economy per net power (kW) output produced. These two important parameters apart from exhaust gas analysis have been aimed at in this study. The results described in the present work are obtained from twin cylinder research engine which is designed to run on mineral diesel as a fuel. The objective is to asses whether satisfactory performance and low emissions can be achieved relatively or not. The engine to be tested was started and allowed to run at no load for about 30 minutes to reach the steady state for each fuel to be tested. Fuel consumption, temperature at corresponding positions, rpm, and exhaust gas temperature were noted for no load condition. After this the engine was loaded in steps and corresponding data for each load was noted. Typical view of test engine has shown in Figure 1. The specifications of test engine are shown in Table 1.

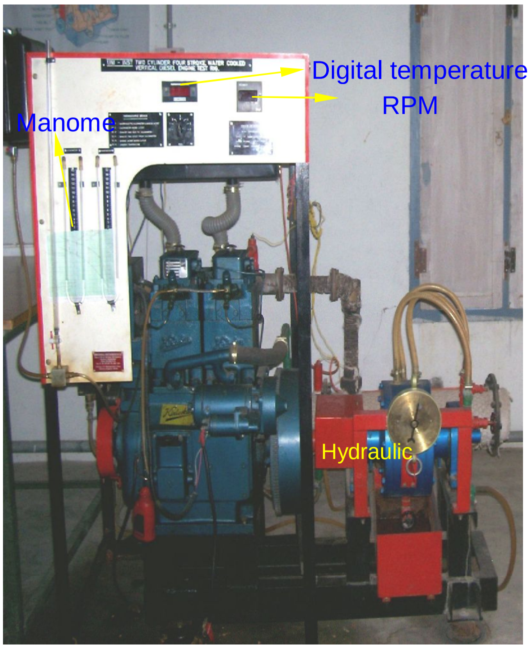

Figure 1. Typical view of 4-stroke twin cylinder diesel engine

The fuels that have been used in this project are commercially available mineral diesel, ethanol (99.99% pure), Bio-diesel (Jatropha curcas seed oil) and Kerosene. The diesel engine, is tested with pure bio diesel, and mineral diesel blended with bio-diesel, ethanol and kerosene at different proportions by volume separately. Some of the important properties of fuels used have shown in Table 2.

Table-1. Principal specifications of test engine

S.No	Specification	Value
1	BHP (Kirloskar Make; Model: TV2)	10
2	Rated speed	1500 RPM
3	Number of cylinders	2
4	Compression Ratio	17.5:1
5	Cylinder diameter	87.5 mm
6	Stroke length	110 mm
7	Type of ignition	Compression ignition
8	Method of loading	Hydraulic dynamometer
9	Method of starting	Crank start
10	Method of cooling	Water cooling

Table -2 Important physical properties of pure and blended fuels used for testing

S.NO	Fuel	Density (kg/m^3)	Calorific Value (kj/kg)	S.NO	Fuel	Density (kg/m^3)	Calorific Value (kj/kg)
1	Diesel	838	46057	9	Diesel+E10	832	44421.3
2	Bio-diesel	880	41000	10	Diesel+E15	830	43603.45
3	Ethanol	785	29700	11	Diesel+E20	827	42785.6
4	Kerosene	720	45400	12	Diesel+E25	824	41967.75
5	Diesel+B5	837	45804	13	Diesel+K10	826	45991.3
6	Diesel+B10	842	45551.3	14	Diesel+K20	814	45925.6
7	Diesel+B20	846	45045.6	15	Diesel+K30	802	45859.9
8	Diesel+B30	850	44539.9				

III. RESULTS AND DISCUSSIONS

The results described in the present work are obtained from twin cylinder diesel engine. To asses the trends, some tests have been made on diesel engine with mineral diesel, bio-diesel, and mineral diesel mixed with bio-diesel, ethanol, and kerosene by volume at different proportions. Variation of break thermal efficiency with load for different fuels has shown in Figure 2, Figure 3 and Figure 4. In all the three cases, break thermal efficiency of the engine with bio diesel as a fuel is relatively more than the other fuels at all loads. The tendency of variation is similar for all the fuels and the variation of efficiency is ±7% and within the limits of experimental error. Similar situation has been observed when the engine is tested with mixture of mineral diesel and bio diesel and diesel+Kerosene. It has been observed that the variation in efficiency relatively more at lower and high loads and less at medium loads as shown in Figure 3 and Figure 4.

Specific fuel consumption with load is shown in Figure 5, 6 and figure 7. Break specific fuel consumption per net kW-hr produced is compared and presented the results. It has been observed from the Figure 5 that the specific fuel consumption is lowest for diesel and highest for Diesel+E25 at low loads and all are clustered at higher loads. Figure 6 gives the variation of specific fuel consumption with load when diesel is mixed with bio-diesel. It is clear that the variation in fuel consumption is small at all loads. This may be attributed due to the fact that the calorific value and fuel properties are similar. The fuel consumption when the diesel is mixed with kerosene is shown in Figure 7. The tendency is similar to that of Figure 6, except that the variation is significant at low loads.

Carbon monoxide and carbon dioxide content in the exhaust gas when different fuels used has been presented in the form of bar graph for comparison. Figure 8 shows the carbon monoxide emission at constant speed and full load. The figure indicates that the carbon monoxide emission is more in case of Bio diesel and lowest when the diesel is mixed with 5% ethanol (by volume). Similarly, the carbon dioxide emission is presented in Figure 9. It has been observed that the carbon dioxide emission is lowest for bio diesel and diesel mixed with bio diesel. This may be due to the complete combustion of bio diesel.

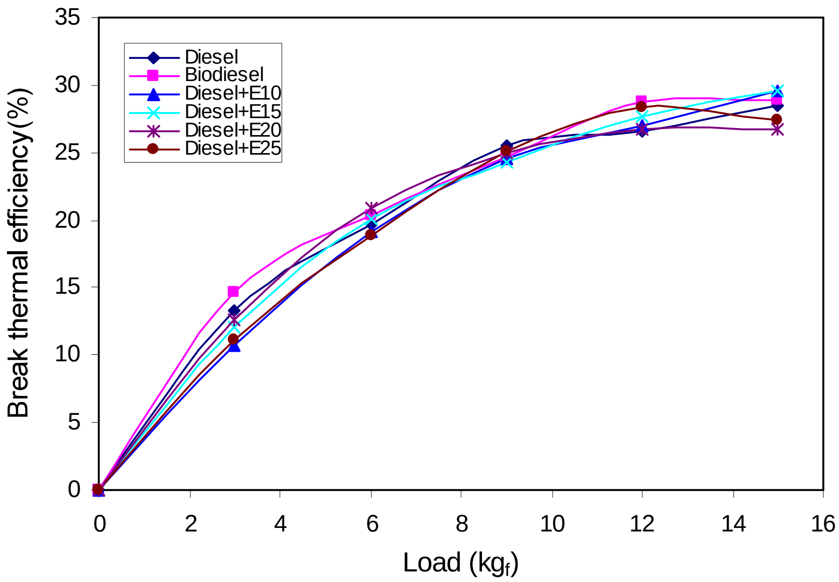

Figure 2. Variation of break thermal efficiency at different loads at constant speed when the mineral diesel blended with ethanol at different volumes

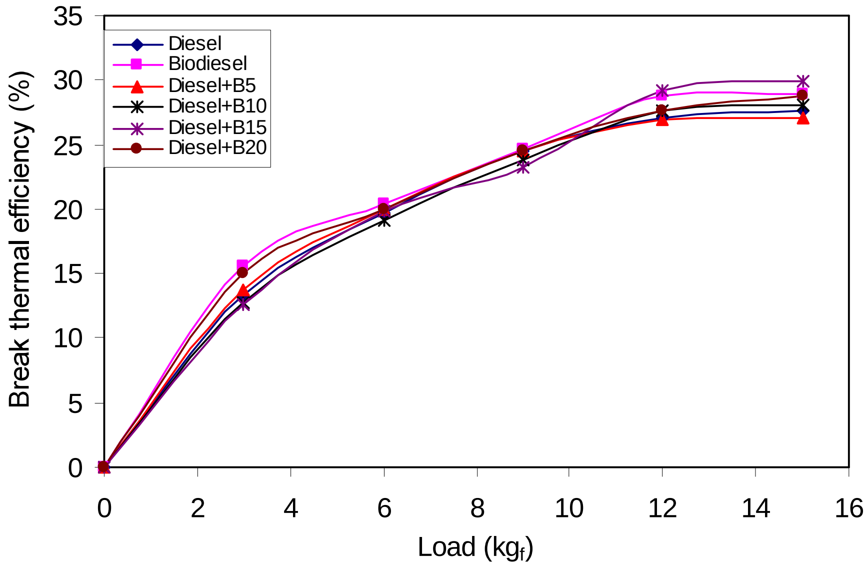

Figure 3. Variation of break thermal efficiency with load at constant speed when the mineral diesel blended with bio diesel at different volumes

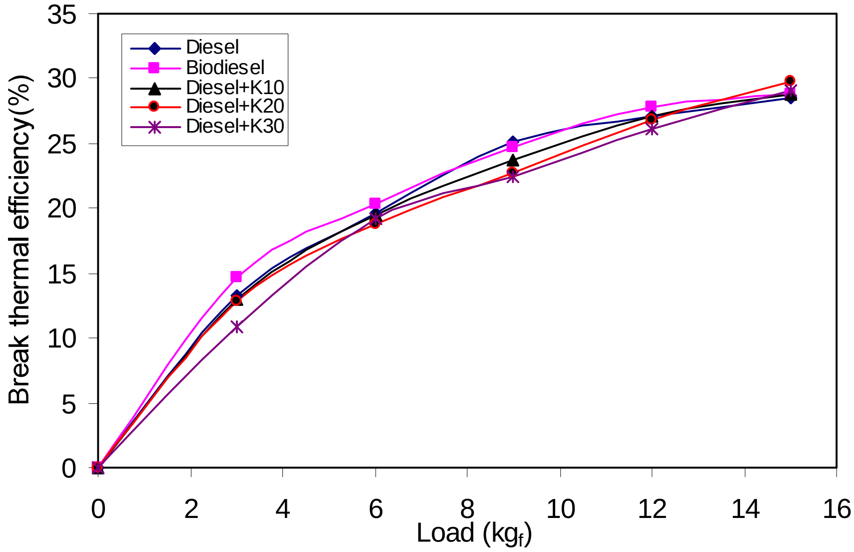

Figure 4. Variation of break thermal efficiency with load at constant speed when the mineral diesel blended with kerosene at different volumes

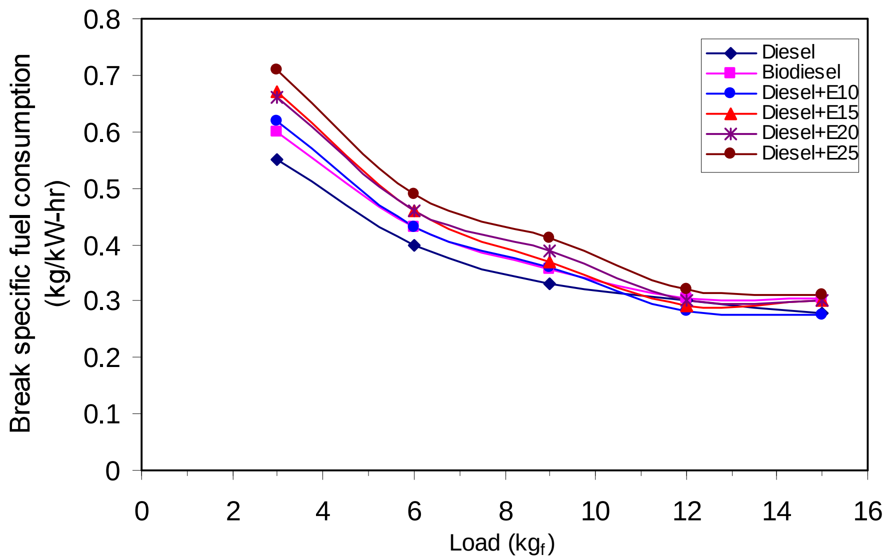

Figure 5. Comparison of break specific fuel consumption with load at constant speed when the mineral diesel blended with kerosene at different volumes

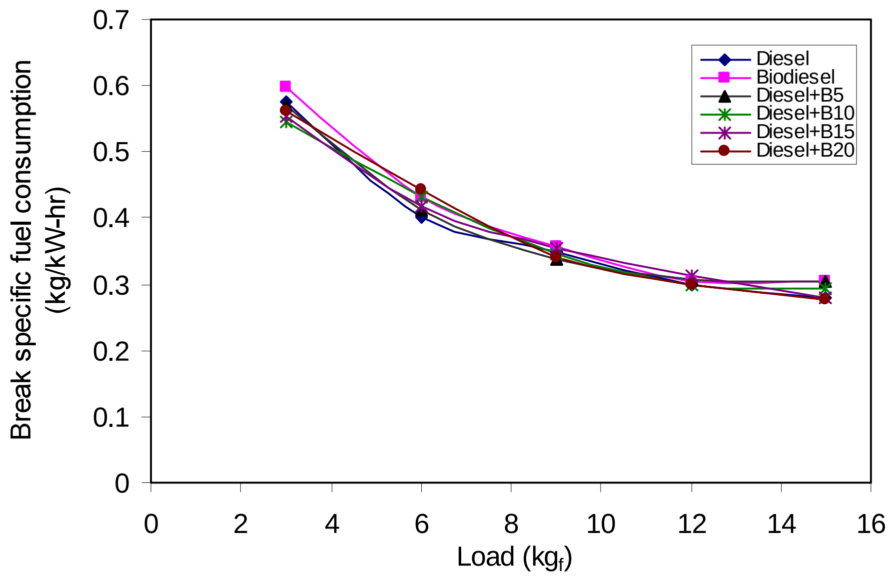

Figure 6. Variation of break specific fuel consumption with load at constant speed when the mineral diesel blended with bio-diesel at different volumes

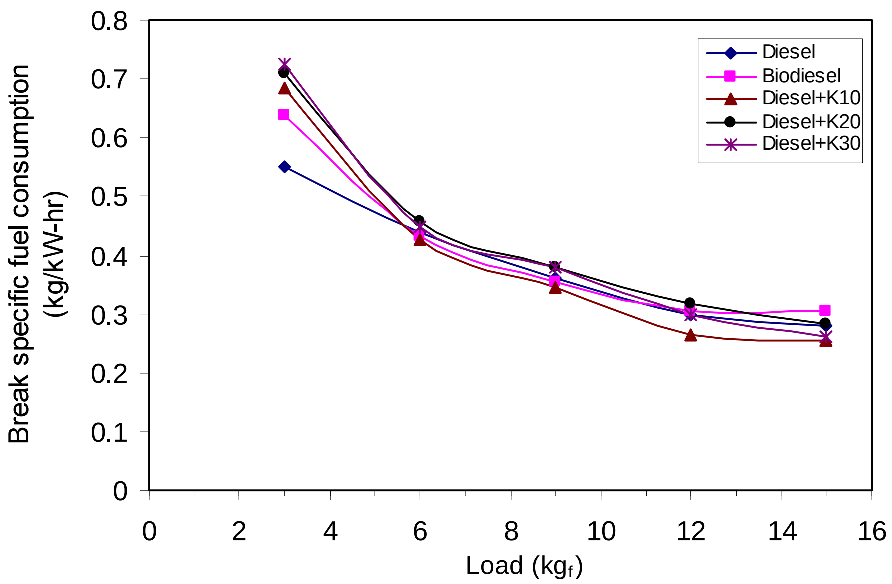

Figure 7. Variation of break specific fuel consumption with load at constant speed when the diesel is blended with kerosene at different proportions

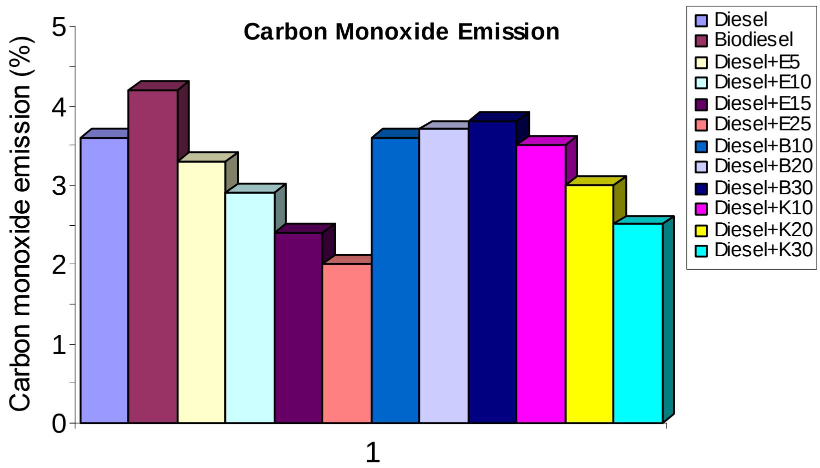

Figure 8. Carbon monoxide emission at constant speed and at full load when the diesel engine is tested with different pure and blended fuels

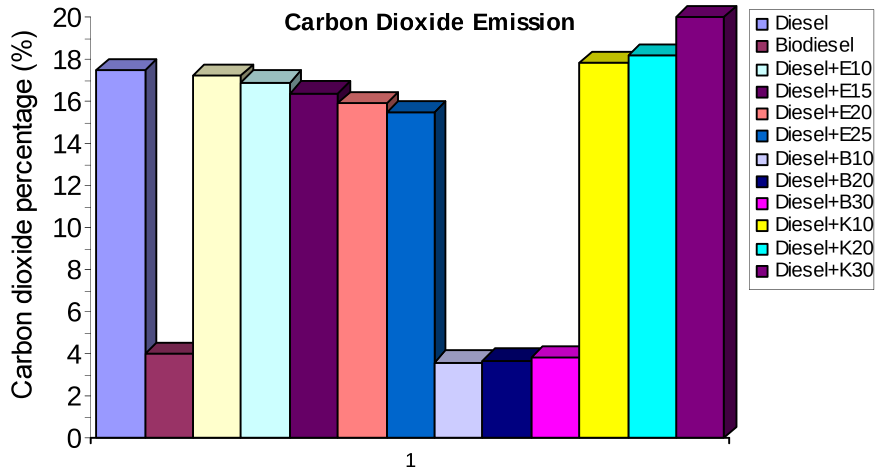

Figure 9. Variation of carbon dioxide emission at constant speed and full load when the engine tested with different pure and blended fuels

IV. CONCLUSIONS

The twin cylinder compression ignition engine designed to run on mineral diesel has been tested with pure bio diesel, and mineral diesel mixed with bio diesel, ethanol and kerosene at different proportions without any engine modifications. Break thermal efficiency variation and specific fuel consumption is compared at all loads. It is observed that the bio diesel is the promising fuel at all loads if the carbon monoxide emission can be controlled. Using ethanol as a fuel additive to the mineral diesel, (up to 30% by volume) without any engine modification and without any loose of efficiency. It has been observed that the variation in thermal efficiency for all the tested fuels is approximately 7%, and well within the experimental error. At medium loads, the efficiency variation is small.

REFERENCES

[1] He, Y; Bao, Y.D; *Study on rapeseed oil as alternative fuel for a single cylinder diesel engine,* Renewable Energy, (2003), Vol. 28, pp1447–1453.

[2] Altin, R; Cetinkaya, S; Yucesu, H.S; *The potential of using vegetable oils as fuel for diesel engine,* Energy Conversion and Management, (2001), Vol.42, pp529–538.

[3] Agarwal, AK; Das, L.M; *Biodiesel development and characterization for use as a fuel in compression ignition engine,* Transactions of ASME, (2001), Vol. 123, pp 440–447.

[4] Nwafor, O.M.I; *Emission characteristics of diesel engine operating on rapeseed methyl ester,* Renewable Energy, (2004), Vol.29, pp 119–129.

[5] Kalligeros, S; Zannikos, F; Stournas, S; Lois, E; Anastopoulos, G; Chteas Sakellaropoulos, F; *An investigation of using biodiesel/marine diesel blends on the performance of a stationary diesel engine,* Biomass and Bioenergy, (2003), Vol.24, pp141–149.

[6] Crookes, R.J; *Comparative Bio fuel performance in Internal combustion Engines,* Biomass and Bioenergy; Vol.30, issue 5, (2006), pp 461-468.

[7] Agarwal, A.K; *Bio fuels (alcohols and bio-diesel) applications as fuels for* ***internal combustion engines,*** Progress in Energy and Combustion Science, (2006) pp 1-39.

[8] Yecesu, H.S; Sozen, A; Topgul, T; Arcaklioglu, E; *Comparative study of Mathematical and Experimental analysis of spark ignition engine performance using ethanol-gasoline blend fuel,* Applied Thermal Engineering, Vol.27; (2007); pp 358-368

[9] Topgul, T; Yecesu, H.S; Cinar, C; Koca, A; *Effect of ethanol-unleaded gasoline blends and ignition timing on engine performance and exhaust emissions;* Renewable Energy; Vol.31,(2006); pp 2534-2542.

[10] Yecesu, H.S; Topgul, T; Cinar, C; Okur, M; *Effect of ethanol-gasoline blends on engine performance in different compression ratios,* Applied Thermal Engineering Vol.26; (2006); pp 2272-2278.

[11] Mustafi, N.N; Miraglia, Y.C; Raine, R.R; Bansal, P.K; Elder, S.T; *Spark ignition engine performance with power gas fuel (mixture of Co/H2) a comparison with gasoline and natural gas*, Fuel Journal, Fuel 85, (2006), pp 1605-1612

[12]. Ravikumar,P; Srinivas, P.N; Nelson, J.E.B; Rao, S.S; *Experimental studies on energy appropriation in a single cylinder diesel engine*, Journal of The Institution of Mechanical Engineers (India); Vol. 85, (2004), pp 45-49.

[13] Tzeng, G.H; Lin, C.W; and Opricovic, S; *Multi-criteria analysis of alternative-**fuel** buses for public transportation,* Energy Policy, Vol. 33, (2005), pp 1373-1383.