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Experimental Investigation of Twin Cylinder Diesel Engine Using Diesel & Methanol

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Abstract: *In view of increasing pressure on crude oil reserves and environmental degradation as an outcome, fuels like methanol may present a sustainable solution as it can be produced from a wide range of carbon based feedstock. The present investigation evaluates methanol as a diesel engine fuel. The objectives of this report is to analyze the fuel consumption and the emission characteristic of a twin cylinder diesel engine that are using Methanol & compared to usage of ordinary diesel that are available in the market. This report describes the setups and the procedures for the experiment which is to analyze the emission characteristics and fuel consumption of diesel engine due to usage of the both fuels. Detail studies about the experimental setup and components have been done before the experiment started. Data that are required for the analysis is observed from the experiments. Calculations and analysis have been done after all the required data needed for the thesis is obtained. The experiment used diesel engine with no load which means no load exerted on it. A four stroke Twin cylinder diesel engine was adopted to study the brake thermal efficiency, brake specific energy consumption, and emissions at zero load & full load with the fuel of methanol. In this study, the diesel engine was tested using 100% methanol. By the end of the report, the successful of the project have been started which is Diesel engine is able to run with Methanol but the engine needs to run by using diesel fuel first, then followed by methanol and finished with diesel fuel as the last fuel usage before the engine turned off. The performance of the engine using Methanol fuel compared to the performance of engine with diesel fuel. Experimental results of Methanol and Diesel fuel are also compared.*

Keywords: *Diesel, Methanol, Performance, Emissions.*

I. INTRODUCTION

Since the inception of industrial revolution in eighteenth century, the search for portable prime movers to run machines for both industrial and transportation purpose became intense. Steam engines took a lead role in the beginning, but could not pass the test of time as they were bulky, less efficient and required huge quantity of low energy density solid fuels like coal. In the later part of nineteenth century, diesel engine was invented. Since then these engines have become an integral part of modern human civilization and mostly replaced the steam engines which became obsolete. These 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 [1,2]. These wide fields of global usage of diesel engines lead to ever increasing demand of petroleum derived fuels. Petroleum fuels are exhaustible sources of energy and hence an over reliability on these fuels is not sustainable in long run. Besides, the rising crude oil prices and increasing pollution due to excessive use of these engines is another grey area. The exhaust emissions of diesel engines, particularly soot, oxides of nitrogen and carbon monoxide are extremely harmful to natural environment and living beings [3].Projections for the 30-year period from 1990 to 2020 indicate that vehicle travel, and consequently fossil-fuel demand, will almost triple worldwide and the resulting emissions will pose a serious problem [4].

Therefore on a nutshell it can be stated that concerns about long-term avail-ability of petroleum diesel, stringent environmental norms and environmental impacts due to extensive use of diesel engines, have mandated the search for a renewable alternative of diesel fuel [5]. In these context alcoholic fuels as a partial or complete substitute of diesel is an area of interest. Reports on the use of alcohol as a motor fuel were published in 1907 and detailed research was conducted in the 1920s and 1930s. Historically, the level of interest in using alcohol as a motor fuel has followed cycles of fuel shortages and/or low feed-grain prices [6].

Among the alcohols, methanol has the lowest combustion energy. However, it also has the lowest stoichiometric or chemically correct air-fuel ratio. Therefore, an engine burning methanol would produce the maximum power. A lot of research has been done on the prospect of methanol as an alternative fuel. Methanol, CH3OH, is the simplest of alcohol and originally produced by the destructive distillation of wood. However, methanol can be produced from many fossil and renewable sources which include coal, petroleum, natural gas, biomass, wood landfills and even the ocean [7].

Today it is produced in very large quantities from natural gas by the reformation of the gas into carbon monoxide and hydrogen followed by passing these gases over a suitable catalyst under appropriate conditions of pressure and temperature [8].

In energy deficit countries like India, Methanol can provide a sustainable solution against petroleum crisis due to the following reasons.

- Methanol can be manufactured from a variety of carbon based feedstock such as natural gas, coal and biomass (e.g., wood). As India is rich in all these reduce its dependence on imported petroleum.
- Methanol is much less flammable than the gasoline and results in less severe fires when it does ignite. So far fire safety purpose it is better than petroleum.
- Methanol has a higher laminar flame propagation speed, which may make combustion process finish earlier and thus may improve engine thermal efficiency [9].
- Methanol is a high-octane fuel that offers excellent acceleration and vehicle power [10].
- With economies scale, methanol could be produced, distributed, and sold to consumers at prices competitive with petroleum.

Due to high octane rating and similarities with gasoline. Methanol has always considered as a good SI engine fuel. But bulk of the transport fuel consumed worldwide is diesel. Ironically courtiers like India hugely subsidized diesel fuel to regulate inflation which in turn reduces Government's ability to fund welfare schemes. Above all major contribution to pollution also comes from diesel engines. Therefore, substitution of diesel by potential fuels like methanol (Which can be produced from locally available raw material by any carry out further study on the effects of methanol, & its fraction on CI engine performance.

1.1Objectives of the project

- It is proposed to use Methanol Fuel in the diesel engine (CI engine).
- The emissions like CO, HC, CO_2, NOx, SOx in the exhaust gases are proposed to reduce during the combustion itself.
- To study the performance evaluation of the using Methanol as fuel in the diesel engine.
- Analyze the exhaust emissions and measurement, reduction in the exhaust gas.

Table-1Properties of Diesel and Methanol

Sl. No	Properties	Diesel	CH_4O
1	Density(kg/m2)	850	796.6
2	Calorific value (kJ/kg)	46,500	23,800
3	Kinematic viscosity @ 40C (cst)	3.05	1.04
4	Cetane number	55	4
5	Flash point ºC	52	12
6	Fire point ºC	56	97.6
7	Specific gravity	0.84	0.79
8	Sulphur content (%)	<0.035	-

1.2 Sources of Methanol

Methanol is a renewable energy source because the energy is generated by using a resource, sunlight, which cannot be depleted. Creation of Methanol starts with photosynthesis causing a feed stock, such as sugar cane or a grain such as maize (corn), to grow. These feed stocks are processed into methanol.

Following are the methods to produce the methanol:-

- Fermentation
- Distillation
- Dehydration

II. EXPERIMENTAL SETUP

The experimental test set up Figure-1 consisted of twin cylinder diesel engine, four stroke, Forced cooling system, crank start. The setup is provided with a resistance load bank, Multi gas analyzer made by testo and Stack monitoring kit for particulate matter & formaldehyde as HCHO…etc for performance and emissions analysis. The engine is cooled using the water jackets on the engine block and cylinder head using a Forced Feed System. While the recommended injection timing given by the manufacturer is 27º BTDC (static), the opening pressure of the nozzle was set at 1800 bar and the engine speed at 1500rpm.There are a number of transducers used in the engine such as piezoelectric pressure transducer flush with the cylinder head surface to measure cylinder pressure. Specifications of engine are shown in Table 2.

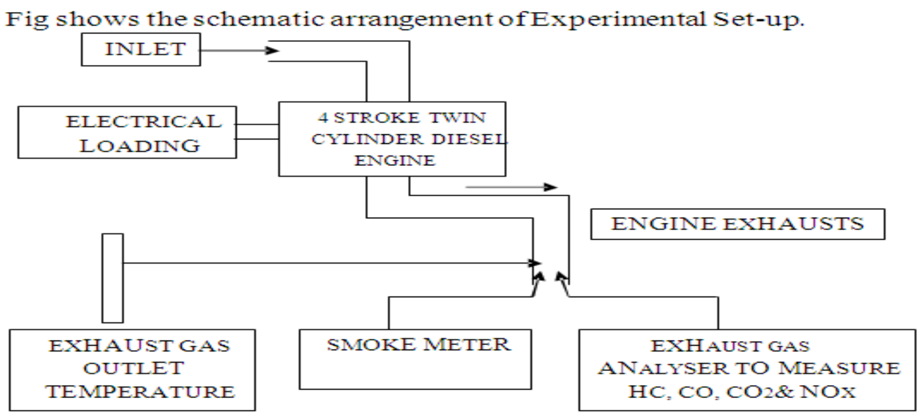

Fig 1: Schematic arrangement of Experimental Set-up

Fig 2: Test engine

Table-2 Test Engine specification	
Engine type	Four stroke Twin cylinder diesel engine
No. of cylinders	02
Stroke	100 mm
Bore Diameter	87 mm
Engine power	19 KW
Compression ratio	17.5:1
RPM	1500
Type of starting	Crank starting
Load type	Electric load bank

Table-3 Load bank specification	
Max. Output	15 KVA / 12.06 KW
Generator type	1 Phase
Amps	63
RPM	1500
PF	0.8
Volts	240

III. PRECAUTION OBSERVED BEFORE STARTING OF THE ENGINE

At the time of starting the engine for each of the tests it was measured that the engine level was in the safe zone and its condition is also good in case the condition was bad, then fresh SAE 40 was introduced into the pump after draining the old . The foundation and mounting bolts were checked periodically as they may go loose due to high speed operations and vibrations.

In the course of experiments the following precautions were observed:

- The ambient temperature variations during the experiment should not be more than 6°Cand this was observed as far as possible.
- After each load is applied the engine in allowed to settle before further loads are applied.

Before stopping the engine, it was allowed to run on pure diesel for some time. This is done so that the engine can be restarted easily.

IV. EXPERIMENTAL PROCEDURE

Experiments were initially carried out on the engine using diesel as fuel in order to provide base line data. The methanol were prepared and made to run on the engine.

1st Case:-The engine was started using neat diesel and allowed to run for at least 30 minutes before taking observations. After engine conditions stabilized and reached to steady state, the base line data were taken. Load was varied (Zero load & full load condition) using the alternator load bank and the same was recorded. Gaseous emissions, fuel consumption were also recorded from the respective sensor.

2nd Case:-The engine was started on diesel and when engine became sufficiently heated; the supply of diesel was slowly substituted by 100 % Methanol for which a two way valve was used. After engine conditions stabilized and reached to steady state, the base line data were taken. Load was varied (Zero load & full load condition) using the alternator load bank and the same was recorded. Gaseous emissions, fuel consumption were also recorded from the respective sensor.

V. RESULTS AND DISCUSSION

The performance and exhaust emission parameters of the engine with diesel and methanol at zero and full load condition are presented and discussed below.

5.1Performance parameter

Table-3 Diesel readings							
Load in Kw		LOAD in %	TORQUE in NM	SPEED IN RPM (N)	SFC Mg/stroke	BP in KW	□bth in %
V	I						
230	0	0	8.297	1500	7.5	1.303	16.54
	52	100	76.484	1500	33	12.01	34.67

5.1.1Specific fuel consumption

Table-4 Methanol readings

Load in Kw		LOAD in %	TORQUE in NM	SPEED in RPM (N)	SFC Mg/stroke	BP in KW	η_{bth} in %
V	I						
230	0	0	8.297	1500	8.0	1.303	28.7
	52	100	88.517	1500	39	13.90	62.82

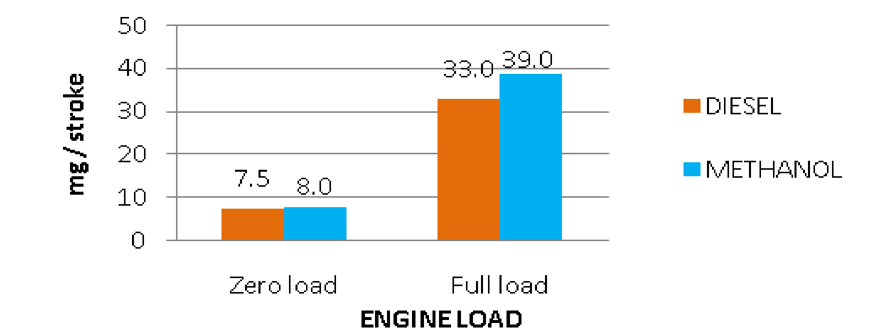

Fig-3 Specific fuel consumption mg / stroke

At higher temperature the effect of methanol on specific fuel consumption (SFC) are shown in figure3. From that figure-3 it is clear that at different loads the SFC of Methanol is more than the diesel. The reasons behind this results are lower energy value substitute methanol thus engine responds to the load by increasing the fuel flow. Thus SFC decreases with the increase in thermal efficiency.

5.1.2 Brake thermal efficiency

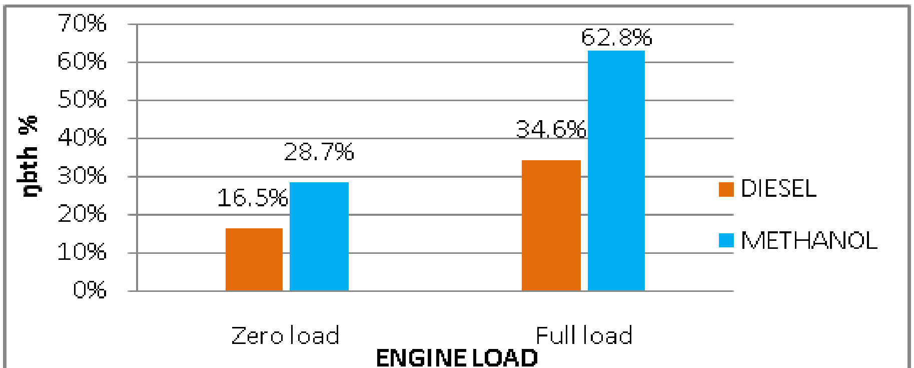

Fig-4 Brake thermal efficiency %

Figure 4, shows the variation of brake thermal efficiency with respect to methanol & Diesel at different loads. From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel as well as Methanol. At full load condition, the brake thermal efficiencies obtained are 34.7% & 62.8% for the diesel & Methanol respectively. Among these two fuels Methanol has maximum BTE i.e 62.8% which is obtained from 100 % Methanol at full load. The BTE using Methanol is increased by 32.1% as compared to the diesel at full load condition. The increment in Brake thermal efficiency is due to low heat value of methanol as compared to diesel & better combustion because of less viscosity of Methanol.

5.2 Emission parameters

Table-5 Emission parameters of the engine with diesel and methanol at zero and full load

Parameter	Unit	Diesel Zero load	Diesel full load	Methanol Zero load	Methanol full load
Exhaust gas Temperature	K	375	393	307	310
Particulate Matter	mg/Nm^3	47.00	134.0	10.0	12.60
Sulphur Dioxide(SOX)	ppm	15.00	26.0	1.0	6.00
Nitrogen Dioxide (NOX)	mg/m^3	1986.00	2431.0	859.0	930.00
Carbon monoxide	ppm	38.00	44.0	83.0	98.00
Oxygen(O2)	%	14.40	12.3	17.8	15.80
Carbon Dioxide(CO2)	%	6.40	8.4	3.4	4.2
Non Methane Hydrocarbon	ppm				
Ethane		<2.00	<2.00	<2.00	<2.00
Propane		<2.00	<2.00	<2.00	<2.00
n _ Butane		<2.00	<2.00	<2.00	<2.00
iso _Butane		<2.00	<2.00	<2.00	<2.00
Pentane		<2.00	<2.00	<2.00	<2.00
Formaldehyde as HCHO	mg/Nm^3	<0.10	<0.10	<0.10	<0.10

5.2.1 Particulate Matter

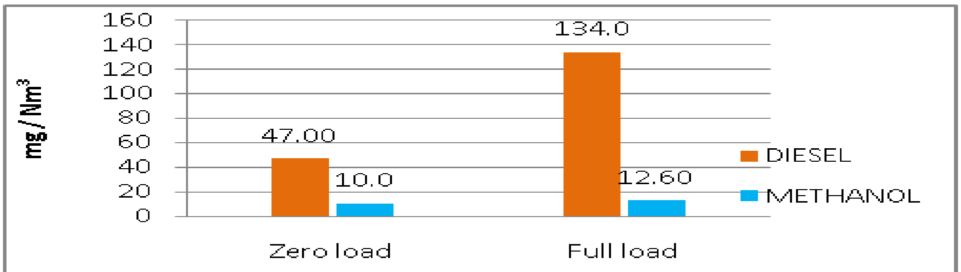

Fig-5 Particulate Matter mg/Nm³

Figures 5, shows the variation of Particulate Matter level with respect to diesel and methanol at different loads. Particulate Matter tends to increase with load, this increase in Particulate Matter is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the Particulate Matter emissions. Result shows that Particulate Matter is comparatively lower with Methanol. It is found that Particulate Matter emission increases with increase in load in Diesel as fuel but in methanol as fuel minor increase with increase load. 100% Diesel has higher Particulate Matter level when compared to 100% methanol. This is due to rise in exhaust temperature. Particulate Matter is decreased (80 to 90%) when using Methanol as fuel in diesel engine compared to diesel fuel.

5.2.2 SOx Concentration

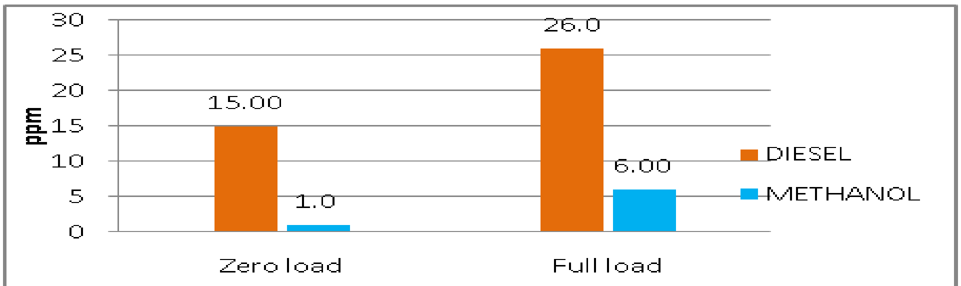

Fig-6 Sulphur Dioxide(SOx) ppm

Figures 6, shows the variation of SOx level with respect to Diesel and methanol at different loads. SOx tends to increase with load, this increase in SOx is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the SOx emissions. Result shows that SOx is comparatively higher with Diesel. It is found that SOx emission increases with increase in load. At full load condition 100% Methanol and 100% Diesel has higher SOx level when compared to zero load condition. SOx is decreased (75 to 90%) when using Methanol as fuel in diesel engine compared to diesel fuel. Result shows that Sox emission is lower with Methanol as fuel.

5.2.3 CO Concentration

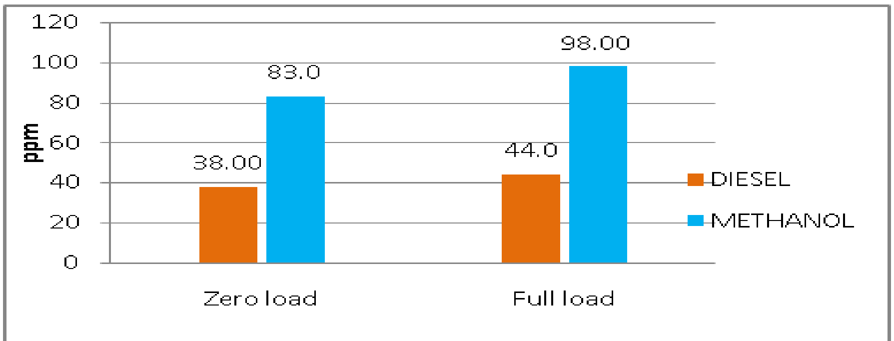

Fig-7 Carbon monoxide ppm

Figures 7, shows the variation CO level with respect to Diesel and methanol at different loads. From the graph it is clear that the CO level increases when Methanol has a fuel. This is due to the fact that engine is not optimized to run with Methanol, so there is a large possibility of rich fuel-air mixture in the cylinder and the higher specific fuel consumption resulting in a higher CO level. Carbon monoxide occurs in engine exhaust. It is a product of incomplete combustion due to insufficient amount of air in the air fuel mixture or insufficient time in the cycle for the completion of combustion. CO level is comparatively More when compared to diesel& can be reduce by increasing the compression ratio.

5.2.4 NOx Concentration

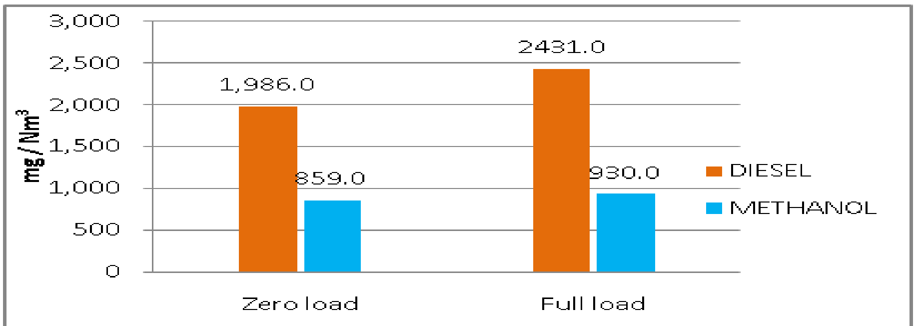

Fig-8 Nitrogen Dioxide (NOX)

Figures 8, shows the variation of NOx level with respect to Diesel and methanol at different loads. NOx tends to increase with load, this increase in NOx is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the NOx emissions. Result shows that NOx is comparatively higher with Diesel. It is found that NOx emission increases with increase in load. 100% Diesel has higher NOx level when compared to 100% methanol. This is due to higher exhaust temperature of Diesel i.e 375 & 393 K. Methanol Nox emission is decreased (55 to 60%) when compared to diesel.

5.2.5 Oxygen (O_2) Concentration

Figures 9, shows the variation of O_2 level with respect to Diesel and methanol at different loads. From the graph it is clear that the O_2 level increases when Methanol has a fuel. This is due to the fact that engine is not optimized to run with Methanol, so there is a large possibility of lean / reach fuel-air mixture in the cylinder and the lower compression ratio resulting in a higher O_2 level. Oxygen(O_2)occurs in engine exhaust. It is a product of incomplete combustion due to insufficient time in the cycle for the completion of combustion.

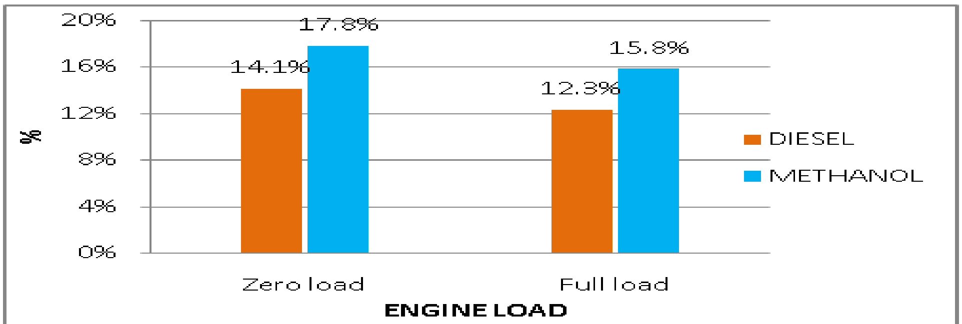

Fig-9 Oxygen (O2) %

5.2.6 Carbon Dioxide (CO_2) Concentration

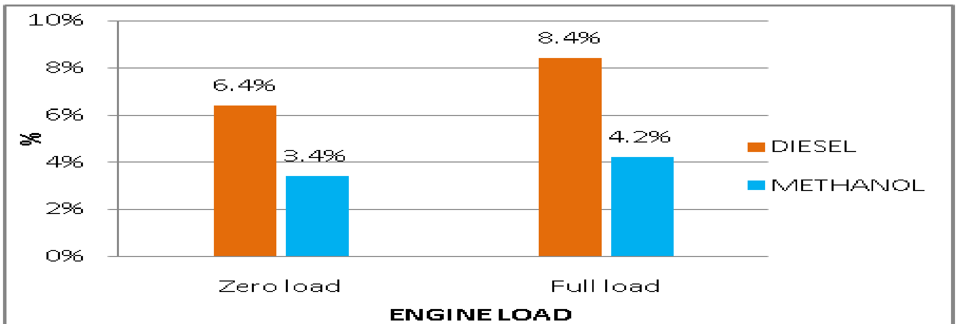

Fig-10 Carbon Dioxide(CO2) %

Figures 10, shows the variation of CO_2 level with respect to Diesel and methanol at different loads. From the graph it is clear that the CO_2 level decreases when Methanol has a fuel. This is due to the fact that engine is not optimized to run with Methanol, so there is a large possibility of lean / reach fuel-air mixture in the cylinder and the lower compression ratio & temperature resulting in a higher CO_2 level.CO_2 occurs in engine exhaust. It is a product of incomplete combustion due to insufficient time in the cycle for the completion of combustion.

VI. Conclusion And Future Scope

Based on the performance and emissions of Methanol, it is concluded that the Methanol oil represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the above analysis the Methanol shows better performance compared to the Diesel in the sense of better performance characteristics like Brake thermal efficiency, Specific fuel consumption and decrease in the emission parameters like NOx, Sox, Particulate matter ,CO_2 but CO , O_2 is little higher than the diesel which can be reduced by increasing the compression ratio. Hence the 100% methanol can be used as a substitute for diesel.

REFERENCES

[1] Chauhan BS, Kumar N, Cho H.MCho (2009). Performance and emission studies on an agriculture engine on neat Jatropha oil. Journal of Mechanical Science and Technology 24 (2) (2010) 529-535.

[2] Ciniviz M., Köse H., Canli E. and Solmaz O (2011).An experimental investigation on effects of methanol blended diesel fuels to engine performance and emissions of a diesel engine. Scientific Research and Essays Vol. 6(15), pp. 3189-3199,ISSN 1992-2248. [3] Yao C, Cheung CS, Chan TL, Lee SC(2008). Effect of diesel/methanol compound combustion on diesel engine combustion and emission.Energy conversion and management. 49:1696-1704.

[4] Mishra C, Kumar N, Sidharth, Chauhan B. S (2012).Performance and Emission Studies of a Compression Ignition Engine on blends of Calophyllum Oil and Diesel.Journal of biofuels. Volume 3, Issue 1, Online ISSN : 0976-4763.

[5] Chauhan BS, Kumar N, Pal SS, Jun YD. Experimental studies on fumigation of ethanol in a small capacity diesel engine. Energy 2011; 36:1030-8.

[6] “Alcohols for motor fuels” by J.L. Smith and J.P. Workman,Colorado State University and U.S. Department of Agriculture. Fact sheet no. 5.010.

[7] Sayin C (2010). Engine performance and exhaust gas emissions of methanol and ethanol diesel blends. Fuel 89:3410-3415.

[8] Hydrogen and Methanol: University Kebangsaan Selangor, Malaysia, 1993.

[9] Liao S.Y., Jiang D.M., Cheng Q., Huang Z.H., Wei Q., Investigation of the cold start combustion characteristics of ethanol–gasoline blends in a constant-volume chamber, Energy and Fuels 19 (2005) 813–819.

[10] Shenghua L., Clemente E. R., Tiegang H., Yanjv W.(2007), Study of spark ignition engine fuelled with methanol/gasoline fuel blends, Applied Thermal Engineering 27-1904–1910.

[11]. Q.A. BAKER ―Use of alcohols in Diesel Fuel Emulsions and Solutions in a Medium Speed Diesel Engine - SAE 810254.

[12]. D.HARA GOPALA RAO ―Partial Substitution of Alcohols for Diesel Fuel. BHU.

[13]. H.A.HAVEMANN et al ―The Utilization of Pure Alcohol in Combination with Normal and Heavy Fuels in High Speed diesel Engines - Journal of IISc, XXXV, No. 4, 1953.

[14]. RANGIAH et al ―Performance of Ceramic Coated diesel Engines with Methanol – Diesel Mixtures. 9th National Conference in I.C.Engines and Combustion, 1985.

[15]. B.NAGALINGAM etal―Surface Ignition Initiated combustion of Alcohol in Diesel Engines -A New Approach. SAE 800262, SAE TRANS 1980, Vol 89, Section 2,1217-29.

[16]. M.R.K. RAO and N.SRINIVASA MURTHY ―Alcohol as Fuel in Diesel Engines ----Chemical Age of India, Vol – 14, No. 1 Jan 1964.

[17]. C.M.VARAPRASAD ―Performance Evaluation of a High speed light weight diesel engine with Methanol-Diesel mixtures.

[18] F. PISCHINGES, C. HAVENTH ―A New of direct injection of Methanol in a diesel engine ―Abstract, Int. Symposium. Alcohol Fuel Tech. May 1979.

[19] Dr. HiregoudarYerrennagoudar et.al ―Oxidation of Aldehydes from the Exhaust Gases of C.I. Engine using Alcohol blends with Diesel in Semi-Adiabatic Air-Gap Copper Crown Piston as Unconventional Catalytic Converter .7th Asia-Pacific Conference on Combustion, National Taiwan University, Taipei, Taiwan ,24-27 May 2009.

[20]. MurariMohon Roy, Hideyuki Tsunemoto,HiromiIshitani et.al, ―Influence of Aldehyde and Hydrocarbon Components in the Exhaust on Exhaust Odor in DI Diesel Engines

[21]. P. E. Oberdorfer" the Determination of Aldehydes in Automobile Exhaust Gas" 670123, 1967, doi:10.4271/670123.

[22] S. Sumiyaet.al "Catalytic Reduction of NOx and Diesel Exhaust," SAE Technical Paper 920853, 1992, doi:10.4271/920853.

[23] Erlandsson.O "Hydrocarbon (HC) Reduction of Exhaust Gases from a Homogeneous Charge Compression Ignition (HCCI) Engine Using Different Catalytic Mesh-Coatings," SAE. Technical Paper 2000-01-1847, 2000, doi:10.4271/2000-01-1847.

[24] Magdi K. Khair "Design and Development of Catalytic Converters for Diesels," SAETechnical Paper 921677, 1992, doi:10.4271/921677.

[25] Kenneth T. Menzies "Comparison of Aldehyde Methods," SAE Technical Paper 820965, 1982, doi:10.4271/82096.