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International Journal Of Modern Engineering Research (IJMER)

Performance & emission of Twin Cylinder Diesel Engine Using Diesel & Ethanol

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Abstract: *In view of increasing pressure on crude oil reserves and environmental degradation as an outcome, fuels like ethanol may present a sustainable solution as it can be produced from a wide range of carbon based feedstock. The present investigation evaluates Ethanol 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 Ethanol & 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 Ethanol. In this study, the diesel engine was tested using 100% Ethanol. By the end of the report, the successful of the project have been started which is Diesel engine is able to run with Ethanol but the engine needs to run by using diesel fuel first, then followed by Ethanol and finished with diesel fuel as the last fuel usage before the engine turned off. The performance of the engine using Ethanol fuel compared to the performance of engine with diesel fuel. Experimental results of Ethanol and Diesel fuel are also compared.*

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

I. INTRODUCTION

Rising petroleum prices, increasing threat to the environment from vehicle exhaust emissions and fastly depleting stock of fossil fuels have generated an intense international interest in developing alternative renewable fuels for IC engines. Ethanol is an oxygenated fuel which increases the combustion and makes reduce exhaust emission. It can be produced from crops with high sugar or starch content. Some of these crops include; sugarcane, sorghum, corn, barley, cassava, sugar beets etc. Besides being a biomass based renewable fuel, ethanol has cleaner burning and higher octane rating than the various vegetable oils [1-5]. Jason and Marc (2002) presented the exergetic environmental assessment of lifecycle emissions from M-85, E-85 (used for the gasoline engine) and other alternative fuels[6]. Diesel exhaust is a major contributor to various types of air pollution, including particulate matter (PM), oxides of nitrogen (NOx), and carbon monoxide (CO) [7]. It has been demonstrated that the formation of these air pollutants can be significantly reduced by incorporating or blending oxygenates into the fossil fuels matrix [8]. Diesel engines are an important part of the public and private transportation sector and their use will continue and grow into the future. But their smoke has become biggest threat to health and environment [9]. Keeping in mind the higher octane number of the ethanol, variable compression ratio engine is a good option in this direction using the ethanol diesel blend as fuel; Shaik et al. (2007) demonstrated VCR engine has great potential for improving part-load thermal efficiency and reducing greenhouse gas emissions [10].

There were many attempts made to use ethanol in compression ignition (CI) engine. Huang et al. (2008) carried out tests to study the performance and emissions of the engine fuelled with the ethanol diesel blends [11]. They found it feasible and applicable for the blends with n-butanol to replace pure diesel as the fuel for diesel engine. Bhattacharya and Mishra (2002) evaluated the feasibility of preparing diesel-ethanol blends using 200° (anhydrous ethanol) and ethanol lower proof [12]. They found that ethanol blends indicated power producing capability of the engine similar to that of diesel. Hansen et al. (2001) found that the properties of ethanol-diesel blends have a significant effect on safety, engine performance, durability and emissions [13]. Wang et al. (2003) analysed that the most noteworthy benefits of E-diesel use lie with petroleum fuel reductions and reductions in urban PM_{10} and CO emissions by heavy vehicle operations [11]. Ajav and Akingbehin (2002) experimentally determined some fuel properties of local ethanol blended with diesel to establish their suitability for use in compression ignition engines [14]. Eckland et al. (1984) presented, State-of-the-Art Report on the Use of Alcohols in Diesel Engines [15].

Techniques that have been evaluated for concurrent use of diesel and alcohols in a compression-ignition engine include (1) alcohol fumigation, (2) dual injection (3) alcohol/diesel fuel emulsions, and (4) alcohol/diesel fuel solutions. Heisey and Lestz (1981) reported significant reductions in particulate generation; however, NOx generation increases [16]. Likos et al. (1982) reported increased NOx and hydrocarbon emissions for diesel-ethanol emulsions [17]. Khan and Gollahalli (1981) reported decreased NOx and hydrocarbon emissions with increased particulate emissions for diesel-ethanol emulsions [18]. Lawson et al. (1981) reported increased NOx and decreased particulate emissions with diesel methanol emulsions [19]. This type of inconsistent performance is what has hindered the use of ethanol in diesel. Baker (1981) reported diesel-ethanol emulsions produce similar NOx, hydrocarbon, and particulate emulsions as compared to baseline runs with straight diesel [20]. Ahmed (2001) found Diesel engines are major contributors of various types of air polluting exhaust gasses such as particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NOx), sulfur, and other harmful compounds [21]. Ethanol blended diesel (e-diesel) is a cleaner burning alternative to regular diesel for both heavy-duty (HD) and light-duty (LD) compression ignition (CI) engines used in buses, trucks, off-road equipment, and passenger cars. Karabektas and Murat Hosoz (2009) reported the increase of fuel consumption with increase in percentage of ethanol in the blends [22]. Rao et al. (2008) carried out experiment in order to found out optimum compression ratio, experiments were carried out on a single cylinder four stroke variable compression ratio diesel engine [23].

1.1Objectives of the project

- It is proposed to use Ethanol 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	759
2	Calorific value (kJ/kg)	46,500	26,800
3	Kinematic viscosity @ 40C (cst)	3.05	1.4
4	Cetane number	55	8
5	Flash point ºC	52	13
6	Fire point ºC	56	111
7	Specific gravity	0.84	0.79
8	Sulphur content (%)	<0.035	-

1.2 Sources of Ethanol

Ethanol is a renewable energy source because the energy is generated by using a resource, sunlight, which cannot be depleted. Creation of Ethanol 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 Ethanol.

Following are the methods to produce the Ethanol:-

- 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.

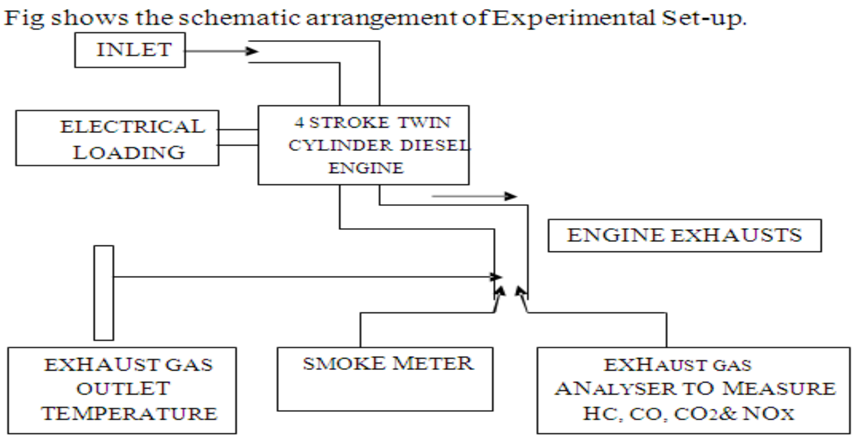


Fig 1: Schematic arrangement of Experimental Set-up

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 % Ethanol 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. 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-4 Ethanol 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	24.39
	52	100	120.065	1500	47.5	18.86	55.74

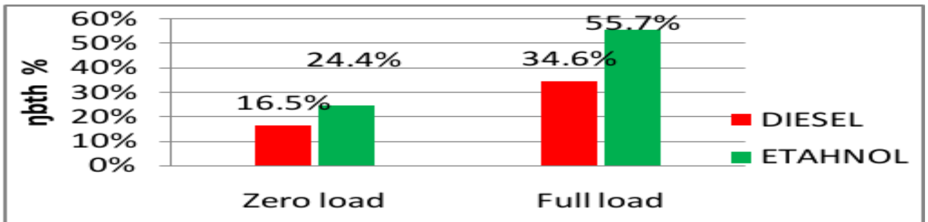
5.1.1Specific fuel consumption

Table-4 Ethanol 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	24.39
	52	100	120.065	1500	47.5	18.86	55.74

ENGINE LOAD
Fig-3 Specific fuel consumption mg / stroke

At higher temperature the effect of Ethanol on specific fuel consumption (SFC) are shown in figure3. From that figure 6.7 it is clear that at different loads the SFC of Ethanol is more than the diesel. The reasons behind this results are lower energy value substitute Ethanol 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



ENGINE LOAD
Fig-4 Brake thermal efficiency %

Figure 4, shows the variation of brake thermal efficiency with respect to Ethanol & 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 Ethanol. At full load condition, the brake thermal efficiencies obtained are 34.6% & 55.7% for the diesel & Ethanol respectively. Among these two fuels Ethanol has maximum BTE i.e 55.7% which is obtained from 100 % Ethanol at full load. The BTE using Ethanol is increased by 31.3% as compared to the diesel at full load condition. The increment in Brake thermal efficiency is due to low heat value of Ethanol as compared to diesel & better combustion because of less viscosity of Ethanol.

5.2 Emission parameters

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

Parameter	Unit	Diesel Zero load	Diesel full load	Ethanol Zero load	Ethanol full load
Exhaust gas Temperature	K	375	393	310	315
Particulate Matter	mg/Nm^3	47.00	134.0	14.10	17.80
Sulphur Dioxide(SOX)	ppm	15.00	26.0	2.0	10.00
Nitrogen Dioxide (NOX)	mg/m^3	1986.00	2431.0	743.0	1048.00
Carbon monoxide	ppm	38.00	44.0	178.0	201.00
Oxygen(O2)	%	14.40	12.3	19	18.40
Carbon Dioxide(CO2)	%	6.40	8.4	1.20	2.0
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

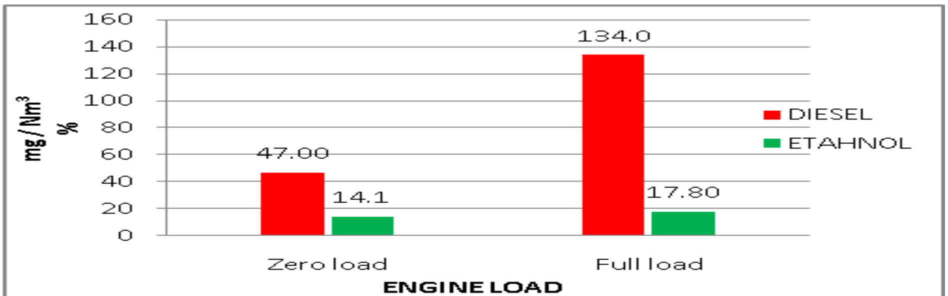


Fig-5 Particulate Matter mg/Nm³

Figures 5, shows the variation of Particulate Matter level with respect to diesel and Ethanol 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 Ethanol. It is found that Particulate Matter emission increases with increase in load in Diesel as fuel but in Ethanol as fuel minor increase with increase load. 100% Diesel has higher Particulate Matter level when compared to 100% Ethanol. This is due to rise in exhaust temperature. Particulate Matter is decreased (80 to 90%) when using Ethanol as fuel in diesel engine compared to diesel fuel.

5.2.2 SOx Concentration

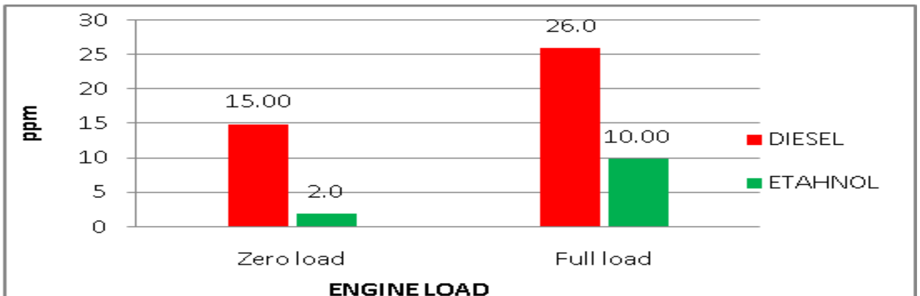


Fig-6 Sulphur dioxide (SOx) ppm

Figures 6, shows the variation of SOx level with respect to Diesel and Ethanol 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% Ethanol and 100% Diesel has higher SOx level when compared to zero load condition. SOx is decreased (75 to 90%) when using Ethanol as fuel in diesel engine compared to diesel fuel. Result shows that Sox emission is lower with Ethanol as fuel.

5.2.3 CO Concentration

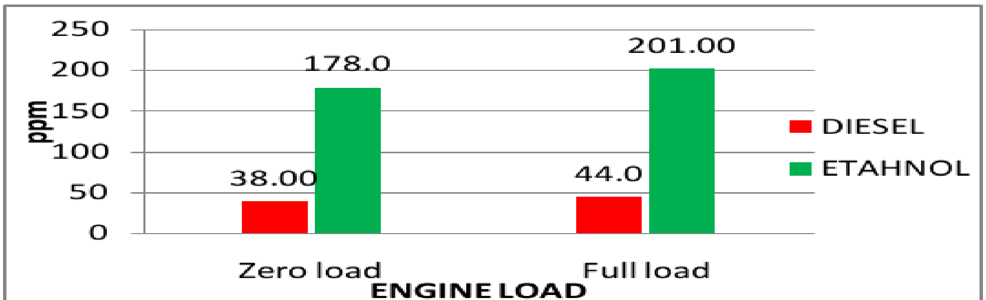


Fig-7 Carbon monoxide ppm

Figures 7,shows the variation CO level with respect to Diesel and Ethanol at different loads. From the graph it is clear that the CO level increases when Ethanol has a fuel. This is due to the fact that engine is not optimized to run with Ethanol, 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

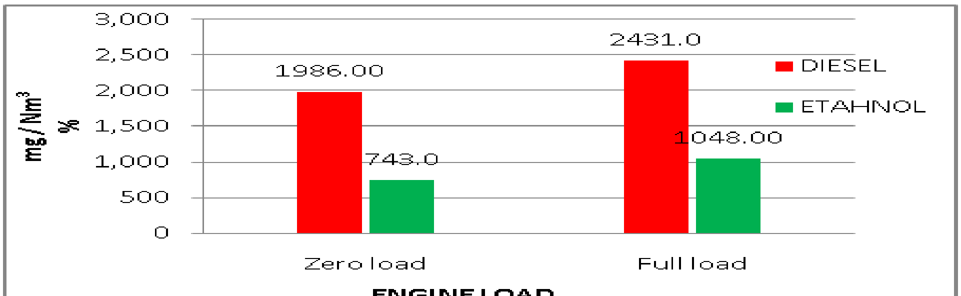


Fig-8 Nitrogen Dioxide (NOX)

Figures 8, shows the variation of NOx level with respect to Diesel and Ethanol 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% Ethanol. This is due to higher exhaust temperature of Diesel i.e 375 & 393 K. Ethanol 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 Ethanol at different loads. From the graph it is clear that the O_2 level increases when Ethanol has a fuel. This is due to the fact that engine is not optimized to run with Ethanol, 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.

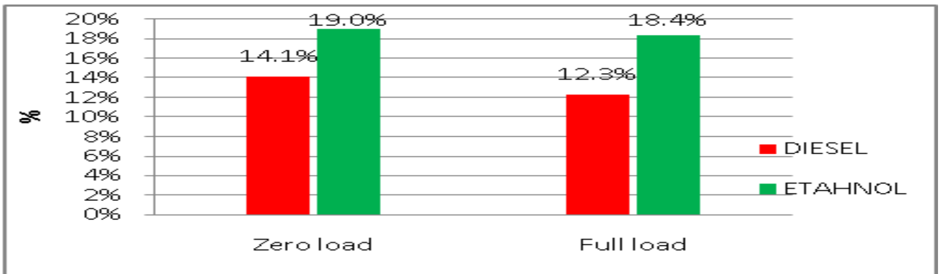


Fig-10 Oxygen (O2) %

5.2.6 Carbon Dioxide (CO_2) Concentration

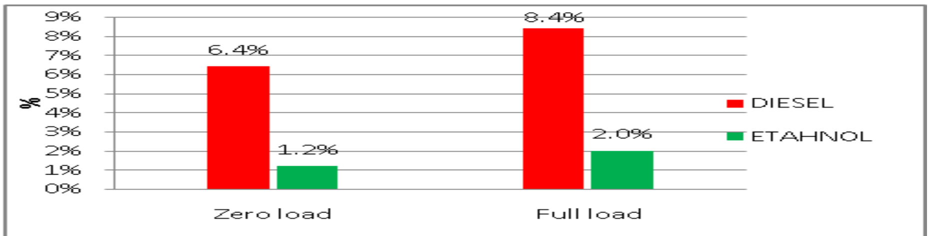


Fig-9 Carbon Dioxide(CO2) %

Figures 10, shows the variation of CO_2 level with respect to Diesel and Ethanol at different loads. From the graph it is clear that the CO_2 level decreases when Ethanol has a fuel. This is due to the fact that engine is not optimized to run with Ethanol, 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 Ethanol, it is concluded that the Ethanol oil represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the above analysis the Ethanol 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% Ethanol can be used as a substitute for diesel.

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