Experimental Analysis of Single Cylinder Four Stroke Diesel Engine with Ethanol & Diesel Blends

Ajith K[1], Gavudhama Karunanidhi S[2], Prince M G[3], Subba Rao G[4]

[1]PG Scholar, MES College of Engineering Calicut University

[2, 3]Associate professor, Department of Mechanical Engineering, MES College of Engineering

[4]Principal, Geethanjali Institute of Science and Technology, Nellore
Jawaharlal Nehru Technological University

Abstract: ***Rising petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum fuels for engines. Ethanol has been identified as one of the possible alternative fuel. In this work, comparison of combustion in diesel engine with various blends is carried out. The blends subjected to comparison include ethanol. The experiment targeted on a single cylinder four stroke diesel engines. The experiment comprises of load and performance testing of single cylinder four stroke diesel engine with diesel fuel and various blend of ethanol.***

Keywords: specific fuel consumption, brake power, mechanical efficiency, indicated power

1. Introduction

Increasing worldwide concern over combustion-related pollutants, such as particulate matter (PM), oxides of nitrogen (NOx), carbon monoxide (CO), total hydrocarbon (THC), acid rain, photochemical smog and depletion of the ozone layer, has led regulatory agencies to implement stringent emission regulations. Diesel engines are one of the major contributors to the pollutant emissions since they are widely used due to high combustion efficiency, reliability, adaptability and cost effectiveness. Soot and NOx are formed during diesel combustion, the required levels of PM, NO_x are difficult to achieve through the improvement of combustion chamber and injection design. It is commonly accepted that clean combustion of diesel engines can be fulfilled only if engine development is coupled with diesel fuel reformulation. In the name of energy security, regional air quality, greenhouse gas emission reduction and even economic savings, oxygenated fuels were advocated to reduce particulate emissions. The reduction of particulate emissions due to the introduction of oxygenated compounds depends on the molecular structure, oxygen content of the fuel. And local oxygen concentration in the fuel plume. Due to the increase and fluctuation in prices of diesel fuel and petrol, a growing environmental conscience and the shortage of petroleum, an alternative to fossil fuels is needed. Government policies in different countries are motivating the use of substitute fuels for petroleum-based ones.

The concept originally applied solely to those materials storing energy in the form of chemical energy that could be released through combustion. Almost all fuels are chemical fuels. The user employs this fuel to generate heat or perform mechanical work, such as powering an engine.

1.1 Ethanol as a fuel

Ethanol fuel is ethanol (ethyl alcohol), the same type of alcohol found in alcoholic beverages. It is most often used as a motor fuel, mainly as a biofuel additive for gasoline. Ethanol fuel is widely used in Brazil and in the United States, and together both countries were responsible for 87.1% of the world's ethanol fuel production in 2011. Most cars on the road today in the U.S. can run on blends of up to 10% ethanol, and ethanol represented 10% of the U.S. gasoline fuel supply in 2011. Since 1976 the Brazilian government has made it mandatory to blend ethanol with gasoline, and since 2007 the legal blend is around 25% ethanol and 75% gasoline (E25). Bioethanol is a form of renewable energy that can be produced from agricultural feedstock's [1]. It can be made from very common crops such as sugar cane, potato, manioc and corn. There has been considerable debate about how useful Bioethanol will be in replacing gasoline. Cellulosic ethanol offers promise because cellulose fibers, a major and universal component in plant cells walls, can be used to produce ethanol [2]. According to the International Energy Agency, cellulosic ethanol could allow ethanol fuels to play a much bigger role in the future. During ethanol fermentation, glucose and other sugars in the corn (or sugarcane or other crops) are converted into ethanol and carbon dioxide [3].

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2 + \text{heat}$$

Like any fermentation reaction, the fermentation is not 100% selective and other side products such a acetic acid, glycols and many other products are formed to a considerable extent and need to be removed during the purification of the ethanol. The fermentation takes place in aqueous solution and the resulting solution after fermentation has an ethanol content of around 15%. The ethanol is subsequently isolated and purified by a combination of adsorption and distillation techniques [4]. The purification is very energy intensive. During combustion ethanol reacts with oxygen to produce carbon dioxide, water, and heat:

$$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O + \text{heat}$$

Starch and cellulose are molecules that are strings of glucose molecules. It is also possible to generate ethanol out of cellulosic materials. However, a pretreatment is necessary that splits the cellulose into glycose molecules and other sugars which subsequently can be fermented. The resulting product is called cellulosic ethanol, indicating its source. Ethanol may also be produced industrially from ethane (ethylene), by hydrolysis of the double bond in the presence of catalysts and high temperature [5].

Table 1: Properties of Ethanol-Diesel Blends

Fuel	*Density*	*Calorific value*
Diesel	820 kg/m^3	44514 kj/kg
E5 (ethanol5%-diesel95%)	818.99 kg/m^3	43631 kj/kg
E10 (ethanol10%-diesel90%)	811.60 kg/m^3	43192 kj/kg
E15 (ethanol15%-diesel85%)	806.3 kg/m^3	42744 kj/kg
E20 (ethanol20%-diesel80%)	803.4 kg/m^3	41874 kj/kg
E25 (ethanol25%-diesel75%)	796.35% kg/m^3	41004 kj/kg
E30 (ethanol30%-diesel70%)	783.10% kg/m^3	40577kj/kg

2. Experimental Setup

The experiment targeted on a single cylinder four stroke diesel engines. The experiment comprises of load and performance testing of single cylinder four stroke diesel engine with diesel fuel and various blends.

Figure 1: Single stroke four cylinder diesel engine

The engine specification of the experimental setup is given below.

Table 2: Engine Specification

Bore diameter	80 mm
Stroke length	110mm
No. Of strokes	4
No. Of cylinders	1
Rated power	5 hp
Rated speed	1500 rpm
Type of cooling	Water cooled
Type of loading	Electrical type
Alternator efficiency	80%
Energymeter constant	300rev/kwhr

3. Results and Discussion

The performance characteristic of a single cylinder four stroke diesel engine at various loads from no load to full load fueled with ethanol and its diesel are discussed below as per the results obtained.

3.1 Specific Fuel Consumption (SFC)

The variation of brake specific fuel consumption with brake power is shown in fig.1.the plot it is reveals that as the load increases the fuel consumption decrease. At full load condition specific fuel consumption obtained are 0.336 kg/kwhr, 0.316 kg/kwhr, 0.301 kg/kwhr, 0.287 kg/kwhr, 0.282 kg/kwhr, 0.273 kg/ kwhr, and 0.267 kg/kwhr for fuels of diesel, E5, E10, E15, E20, E25, E30 respectively.

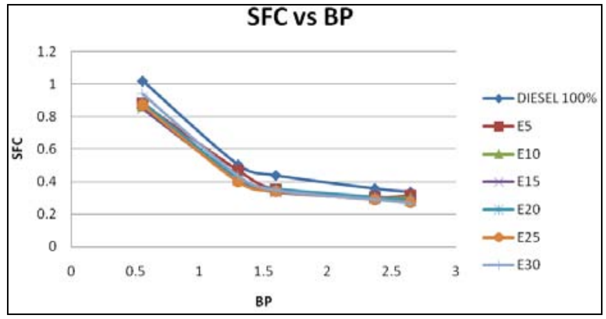

Figure 2: SFC vs BP

3.2 Brake Thermal Efficiency (BTE)

The variation of brake thermal efficiency with brake power is shown in fig. 2.from the plot it is observed that as the load increases the brake thermal efficiency increases. At full load condition the brake thermal efficiency obtained are 24.08%, 26.11%, 27.69%, 29.25%, 30.46%, 32.13%, and 33.18% for fuels of diesel, E5, E10, E15, E20, E25, E30 respectively.

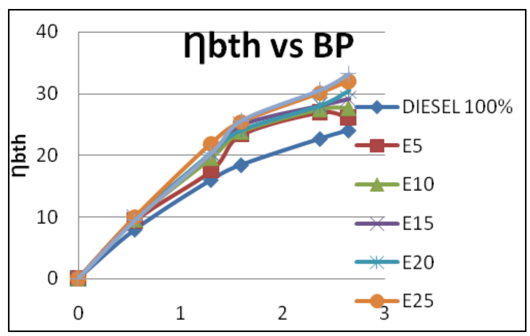

Figure 3:ηbth vs BP

3.3 Indicated Thermal Efficiency (ITE)

The variation of indicated thermal efficiency with brake power is shown in fig.3.the plot it is reveals that as the load increases the indicated thermal efficiency increases. At full load condition the indicated Thermal efficiency obtained are 35.90%, 33.92%, 36.02%, 37.89%, 39.36%, 41.46%, and 42.82% for fuels of diesel, E5, E10, E15, E20, E25, E30 respectively

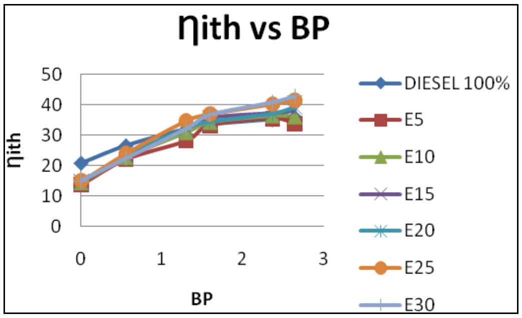

Figure 4:ηith vs BP

3.3 Mechanical Efficiency (ME)

The variation of mechanical efficiency with brake power is shown in fig.4.the plot it is reveals that as the load increases the mechanical efficiency increases. At full load condition the brake thermal efficiency obtained are 67.06%, 76.98%, 76.88%, 77.18%, 77.38%, 77.49%, and 77.49% for fuels of diesel, E5, E10, E15, E20, E25, E30 respectively.

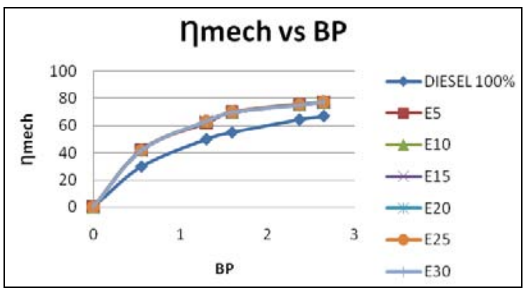

Figure 5:ηmech vs BP

4. Conclusion

The conclusions derived from present experimental investigations to evaluate performance characteristics on four stroke single cylinder diesel engine fueled with diesel Ethanol blends are summarized as follows.

1. Brake thermal efficiency increased with all blends when compared to the conventional diesel fuel.
2. The Brake specific fuel consumption is decreased with the blends when compared to diesel.
3. From the above analysis the blend E25 shows the better performance compared to other blends (E5, E10, E15, E20, and E30).

References

[1] Ajav, E. A (1997). Studies on the Use of Ethanol – Diesel Blends and Fumigated Ethanol in a Stationary Constant Speed Compression – Ignition engine. Unpublished Ph.D. Thesis Department of Farm Machinery and Power Engineering, G.B.P.U.A. & T, Pantnagar, India.)

[2] Ali, Y., and Hanna, M. A. (1996). Durability Testing of a Diesel Fuel: Methyl Tallowate; and Ethanol Blend in a Cummins N14-410 Diesel Engine, Transactions, of the ASAE Vol. 39(3). Pp 793-797.

[3] Boruff, P. A., Schwab, A. W., Goering, C. E. and Pryde, E. H. (1982). Evaluation of Diesel Fuel-Ethanol Micro emulsion. Transactions, of the ASAE Vol. 30 (3) pp 47-51.

[4] Bilgin, A. Durgun, O., and Sahin, Z. (2002). The Effects of Diesel-Ethanol Blends on Diesel Engine Performance.

[5] Lapuerta M, Armas O, Herreros M. Emissions from a diesel-bioethanol blend in an automotive diesel engine. Fuel 2006.

Authors Profile

Ajith k received his B-TECH degree in Mechanical engineering from Calicut University. He worked as a Graduate Engineering Trainee in Fluid Control Research Institute (FCRI), Palakkad, Kerala (an autonomous R&D institute under Ministry of Heavy Industries and Public Enterprises, Government of India).Now he is doing his M-TECH in Thermal systems from MES College of engineering under Calicut University.

Gavudhama Karunanidhi S received his BE degree in Automobile engineering. And he received his M-TECH in Mechanical engineering from IIT Chennai. Now he is working as Associate professor in MES College of engineering, kuttippuram.

Prince M G received his B-TECH degree in Mechanical Engineering. And he received his M-TECH in Thermal systems from Calicut University. Now he is working as assistant professor in MES College of engineering, kuttippuram.

Subba Rao G received his B-TCH degree in Mechanical engineering and received his M. Tech in Heat Power –R & A/C from JNTU Hyderabad. He did his Ph. D in vapour absorption refrigeration from SCSVMV, Kancheepuram. Now he is working as principal in Geethanjali Institute of Science and Technology, Nellore.