Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 4, Issue 7; October-December, 2017, pp. 567-570

http://www.krishisanskriti.org/Publication.html

Combustion Comparison between Pure Diesel and 5% Butanol blended Diesel in a multi-cylinder Engine

Gaurav Arora[1], Irwin Osmond Toppo[2] and Rishu Sharma[3]

[1]Student, G. B. Pant Government Engineering College
[2]G. B. Pant Government Engineering College
E-mail: [1]arora.grv1996@gmail.com, [2]irwinosmond@gmail.com, [3]sharma.rishu@gmail.com

Abstract—*In this paper, the combustion characteristics of Pure Diesel and 5% Butanol blended Diesel (5% n- butanol by volume and 95% Diesel) were compared when used as fuel for amulti-cylinder engine. The IC engine test rig chosen was TATA Turbo Engine 226 having power 52 kW, 4-stroke, four cylinder, water cooled, variable speed, Compression Ignition (CI) engine using ICEngineSoft_9.0software. The combustion reports for both the fuels were obtained under constant pre-defined ambient conditions.The engine was run at a specified steady speed of approximately1050 revolutions per minute. The comparison graphs were generated at constant-load engine conditions. In this study, the curves for cylinder pressure, rate of pressure rise, net heat release and mean gas temperature were analyzed. From the acquired results, it was concluded that the 5% butanol blended diesel advances the combustion process in comparison to pure diesel fuel. It was also inferred that the butanol blended fuel would ensure a sustainable and progressive use of biodegradable fuels. Thiswork is an attempt to promote the use of bio-fuels as an alternative for the conventionally used fossil fuels.*

Table 1. Keywords

IC engine	Internal Combustion engine
CI	Compression Ignition
TDC	Top Dead Centre
BDC	Bottom Dead Centre
CN	Cetane Number
CA	Crank Angle
SOC	Start Of Combustion
EOC	End Of Combustion
HC	Hydrocarbons
rpm	Revolutions Per Minute

1. INTRODUCTION

As with the increase in number of vehicles on road, the demand for adequate fuel infrastructure is escalating at an extremely high rate. With the elevation in requirement for conventional fuel (Diesel) the major Green House Gas contributor (fossil fuels) are getting exhausted day by day. These fossils are also the prime cause for uncertainty in climatic conditions worldwide [1]. In order to overcome the deficiency of fuel resources, switching towards alternate fuels is very much necessary. Bio-degradable fuels are the one which can act as the best suitable alternate fuels. Oxygenated fuels such asalcohols are the bio fuels to be used, as they combust much cleaner than the traditionally available conventional fuels [2]. Alcohols as fuel has a number of advantages [3], i) Less viscous than diesel, leading to much better atomization, injection, and vaporization of fuel, ii) better stoichiometric air-fuel ratio in comparison to diesel makes alcohols to release less harmful gases, iii) shortens and enhances the entire combustion process, due to higher laminar flame propagation than diesel fuel. Ethanol has a wider set of applications [4-7], however its poor auto ignition quality makes the fuel inappropriate to be used in CI engines [8]. From the higher order HC's, Butanol can be used as a blend with pure diesel fuel as it, has higher CN, is less hydrophilic [9]; and has a higher miscibility factor in pure diesel than ethanol [10]. Hence, the possible use of butanol blended diesel as fuel remains to be determined. The properties of Butanol and Pure Diesel are mentioned in Table 2[11-14].

This study was done for evaluating the combustion curves of 5% Butanol blended Diesel in a multi-cylinder engine and compare with the results for Pure Diesel.

2. EXPERIMENTAL SETUP

Figure 1 illustrates the experimental setup used. The study was conducted on a four-cylinder, four stroke, 1404.88 cc, 52.0 kW, Variable speed, Water cooled TATA Turbo Engine 226. Pure Diesel was used as a reference fuel for comparing the combustion curves of 5% Butanol blend diesel with it. The engine was run on a steady speed of approximately 1050 rpm before generating the reports. The engine and fuel specifications are mentioned in Table 3.

Firstly, the engine was run with Pure Dieseland thereafter, 5% Butanol blend Diesel was used as fuel for the engine. The combustion reports for both the fuels were obtained under

constant pre-defined ambient conditions. The combustion parameters for both the fuels are listed in Table 4.

The graphs for comparison between both the fuels were generated using ICEngineSoft_9.0 software.

Table 2: Properties of n-butanol and pure diesel [11-14]

Fuel Properties	Butanol (C4H9OH)	Diesel (C12H24)
Density @ 20 (degree C, kg/m^3)	810	837
CN	~25	~51
Boiling Point (degree C)	118	180-360
Latent heat of evaporation, kJ/kg	585	250
Oxygen, %wt	21.6	0
Stoichiometric air-fuel ratio	11.2	15
Molecular weight	74	170
Auto-ignition temperature (degree C)	355 (Source [13])	204 (Source [14])

Figure 1: Experimental setup

3. RESULTS AND DISCUSSIONS

An experimental study was done on a multi-cylinder, four stroke, diesel engine with compression ratio of 18.5:1 and bore x stroke as 75.0mm x 79.5mm. The combustion curves for 5% Butanol blended Diesel and Pure Diesel used as a fuel were procured.

Table 3: Engine and fuel specifications

Engine Type	4-stroke, four cylinder, water cooled, variable speed, CI engine
Make	TATA
Rated Power	52.0 kW @ 4000rpm
Bore X Stroke	75.0mm X 79.5mm
Compression Ratio	18.5:1
Swept Volume	1404.88 cc
Connecting rod length	141.0mm
Ambient Temperature	27 degree C
Fuel Density (Pure Diesel)	830 kg/m^3
Calorific Value (Pure Diesel)	42000 kJ/kg

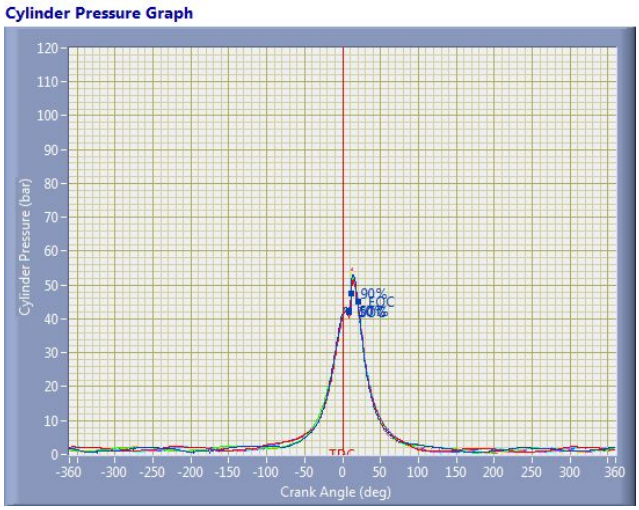
Table 4. Combustion parameters

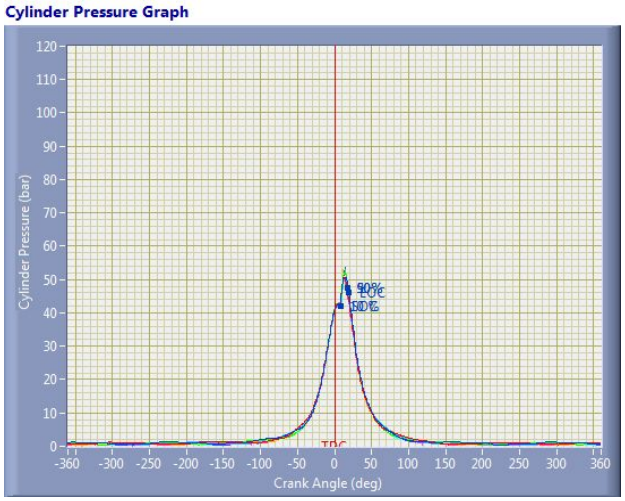
Specific Gas Constant	1 kJ/kg-K
Air Density	1.17 kg/m^3
Adiabatic Index	1.41
Polytrophic Index	-0.22
Number Of Cycles	10
TDC reference	0

Figure 2& 3 depicts the comparison of cylinder pressure and rate of pressure rise for both, Pure Diesel and 5% Butanol blended Diesel. The cylinder pressure graph shows the pressure variation within the cylinder during the complete cycle with CA. From the graphs, it can be inferred that, a) the SOC& 50% combustion for both the fuels takes place at a similar pressure i.e.42 bar, b) the 90% combustion for pure diesel occurs before reaching the peak cylinder pressure, whereas in case of 5% butanol blended diesel it takes place after reaching the peak cylinder pressure, c) after the completion of 90% combustion process the EOC occurs instantly at a constant CA of 20 degrees for 5% butanol blended fuel, whereas for pure diesel fuel there exists a delay of approximately 10 degrees between the occurrence of these two stages,d) the rate of pressure rise reaches its positive peak value within 10 degrees of crank rotation, the maximum value for rate of pressure rise for pure diesel and 5% butanol blended diesel lies below and above 5 bar/degree respectively.

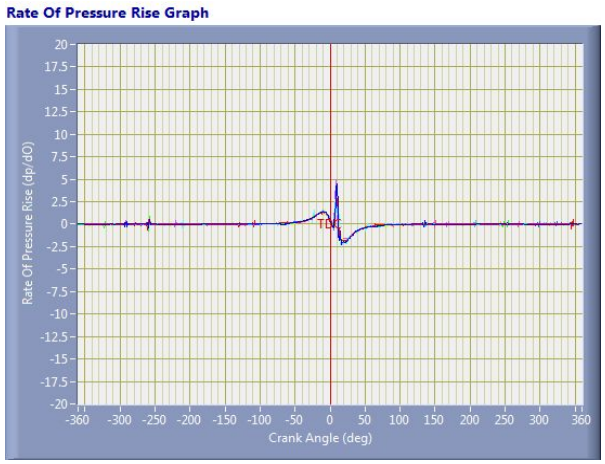
Figure 4 illustrates that, i) there is a significant decrease (approximately 12J/degree) in the maximum value of net heat release from engine when butanol blended diesel is used as fuel, ii) The process of heat release for 5% butanol blended diesel starts and reaches its peak value earlier than pure diesel.

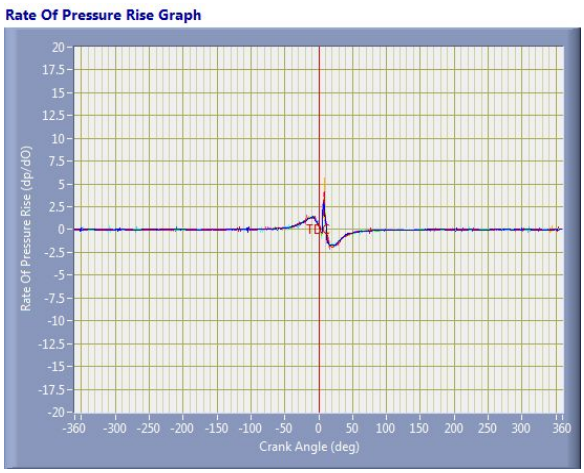
From figure 5, it can be obtained that there is a slight





(Pure Diesel) (5% Butanol blended Diesel)Figure 2. Cylinder pressure vs crank angle





(Pure Diesel) (5% Butanol blended Diesel)

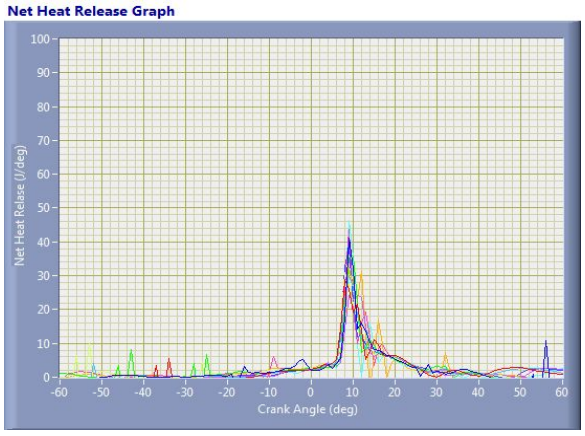
Figure 3. Rate of pressure rise vs crank angle

dropin mean gas temperature of combustion gases during the initial and peak stages of graph, whereas for final stage the observed mean gas temperature is moderately higher for 5% butanol blended fuel than pure diesel.

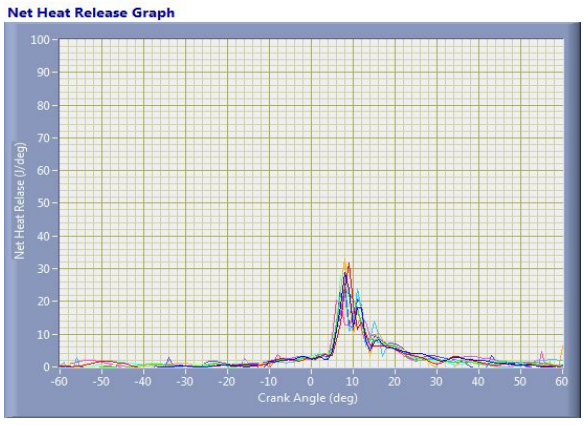
4. CONCLUSIONS

The motive of this study was to compare the combustion of 5% Butanol blended Diesel with Pure Diesel as a fuel for 4-cylinder, variable speed, water cooled, four stroke, compression ignition engine.

- The 5% butanol blended diesel advances the combustion process in comparison to pure diesel fuel.
- There is an increment in the peak value of rate of pressure rise, upon the addition of a small quantity of n-butanol in diesel fuel.
- With the use of butanol blended diesel as a fuel, the peak value of net heat release from the engine decreases.
- The butanol blended fuel caused the mean gas temperature to vary slightly in the proximity of TDC, when compared with pure diesel.

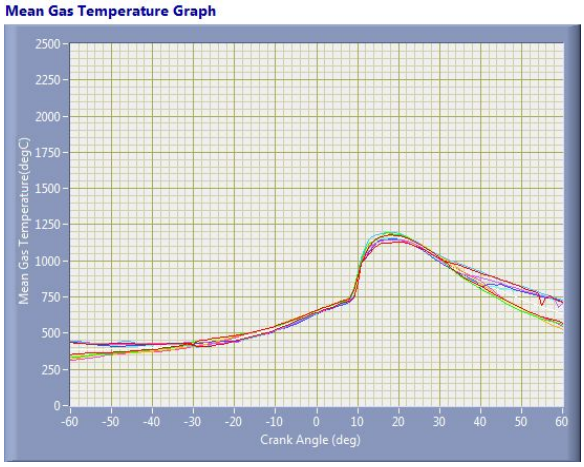


(Pure Diesel)

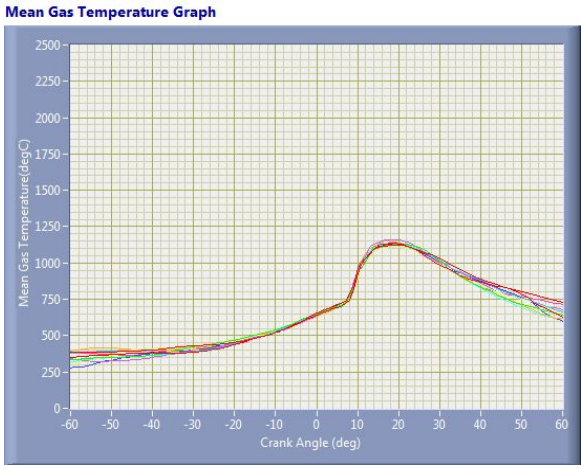


(5% Butanol blended Diesel)

Figure 4. Net heat release vs crank angle



(Pure Diesel)



(5% Butanol blended Diesel)

Figure 5. Mean gas temperature vs crank angle

REFERENCES

[1]P. Singh and A. Singh., "Production of Liquid Biofuels from Renewable Sources," Progress in Energy and Combustion Science, Vol. 37, 2011, pp. 52-68. http://dx.doi.org/10.1016/j.pecs.2010.01.003.

[2] D. Oguzhan, "The Influence of n-Butanol/Diesel Fuel Blends Utilization on a small Diesel engine Performance and Emissions," Fuel, Vol. 90, No. 7, 2011, pp. 2467- 2472. http://dx.doi.org/10.1016/j.fuel.2011.02.033.

[3]C. Sayin, "Engine Performance and Exhaust Gas Emissions of Methanol and Ethanol-Diesel Blends," Fuel, Vol. 89, No. 11, pp. 3410-3415. http://dx.doi.org/10.1016/j.fuel.2010.02.017.

[4]S. Szwaja and J. D. Naber, "Combustion of n-Butanol in a Spark-Ignition IC Engine," Fuel, Vol. 89, No. 7, 2010, pp. 1573-1582. http://dx.doi.org/10.1016/j.fuel.2009.08.043.

[5]P. D'urre, "Fermentative Butanol Production Bulk Chemical and Biofuel," Annals of the New York Academy of Science, Vol. 1125, 2008, pp. 353-362. http://dx.doi.org/10.1196/annals.1419.009.

[6] J. Dernotte, M. Rouselle, F. Halter and P. Seers, "Evaluation of Butanol-Gasoline Blends in a Port Fuel-Injection, Spark-Ignition Engine," Oil Gas Science Technology. Re- view, Vol. 65, No. 2, 2010, pp. 345-351.

[7] M. D. M. Singliar, "Emerging Technologies for Second Generation of Biofuels," MOL Scientific Magazine, SD and HSE special, 2008, pp. 67-80.

[8] C. Murat, F. Yuksel and H. Hus, "Emission Characteristics of a Converted Diesel Engine using Ethanol as Fuel," Energy for Sustainable Development, Vol. 13, 2009, pp. 250-254. http://dx.doi.org/10.1016/j.esd.2009.10.001.

[9] W. Bryan, K. Kumar,Y. Zhang and J. Sung-chin., "Auto ignition of n-Butanol at Elevated Pressure and Low-to- Intermediate Temperature," Combustion and Flame, 2011, Vol. 158, pp. 809-819. http://dx.doi.org/10.1016/j.combustflame.2011.02.005.

[10] D. C. Rakopoulos, C. D. Rakopoulos, E. G. Giakoumis, A. M. Dimaratos and D. C. Kyritsis, "Effects of Butanol- Diesel Fuel Blends on the Performance and Emissions of a High-Speed DI Diesel Engine," Energy Conversion and Management, Vol. 51, No. 10, 2010, pp. 1989-1997. http://dx.doi.org/10.1016/j.enconman.2010.02.032.

[11] Y. Liu, W. Jiao and G. Qi, "Preparation and Properties of Methanol-Diesel Oil Emulsified Fuel under High-Gravity Environment," Renewable Energy, Vol. 36, No. 5, 2011, pp. 1463-1468.

[12] S. Pukalskas, Z. Bodanovicius, V. Makareviciene, E. Send-zikiene and P. Janulis, "The Mixture of Biobutanol and Petrol for Otto Engines," Transport, Vol. 24, No. 4, 2009, pp. 301-307. http://dx.doi.org/10.3846/1648-4142.2009.24.301-307.

[13] The DOW chemical company, "Technical Data Sheet",2012. http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_08ac/0901b803808ac9ed.pdf?filepath=oxysolvents/pdfs/noreg/327-00014.pdf&fromPage=GetDoc.

[14]Cafe, Tony. "PHYSICAL CONSTANTS FOR INVESTIGATORS". http://*tcforensic.com.au*.