International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 8, August - 2013

Analyzing The Effect Fuel Reformer in CI Engine

M. Kannan, C. G. Saravanan

Department of Mechanical Engineering, Annamalai University, Annamalainagar, Tamilnadu – 608 002, India

Abstract: Diesel engines, due to their dominant advantages of high thermal efficiency, rigid and simple structure, and fuel economy, are the major power sources for marine and inland transportation and industrial power plants. But at the same time pollutions from the diesel engine is appreciably marked. The present investigation is aimed to reduce the emission and to improve the performance of diesel engine, the fuel reformer technique has been employed. This investigation relates to fuel reformer used in diesel engine. The fuel is also supplied through alumina balls which kept in the fuel reformer and heated upto 400^{o}C. Based on the experimental investigation it is observed that the maximum reduction of 22% in NOx, 18% in hydrocarbon and around 7% in the smoke density and performance wise there is slight increase in the brake thermal efficiency.

Keywords: Fuel Reformer, Alumina Ball

1. Introduction

Diesel engines, due to their dominant advantages of high thermal efficiency, rigid and simple structure, and fuel economy, are the major power sources for marine and inland transportation and industrial power plants. They are the most fuel combustion efficient engines known and are expected to remain widely used in the foreseeable future. However, the pollutants in solid, liquid, or gas phase emitted from diesel engines which affect to human health and to the ecological environment. Hence, diesel engines have been considered one of the major air-pollution sources in metropolitan regions.

The diesel engine emits major pollutants like particulate matter, smoke, nitrogen oxides (NOx), hydrocarbon (HC), carbon monoxide (CO), and sulfur oxides (SOx). These pollutants cause damage to the ozone layer, enhance greenhouse effect, and produce acid rain. The photochemical smog formed from the reaction of HC and NOx with ultra-violet sunlight might also damage the respiratory system, throat, and eyes and hinder environmental field of vision. Inhalation of particulate matter laden with polycyclic aromatic hydrocarbon (PAH) or metallic compounds may even cause carcinogen diseases.

There are many techniques being adopted to control the above emissions and to improve the performance of the diesel engines. Fuel modification technique like fuel additives, modified fuel, bio diesel, hybrid vehicles and diesel emulsion for reducing engine emissions. Engine Design changes like intake system modification for better mixing of air and fuel, pre-chamber injection aims to reduce the NOx emission and increase the engine performance.

Rong-Fang Horng et al[2]., had studied that the required energy for fuel processing was provided by heat released through the oxidation of the air-fuel mixture. The conversion efficiency of the fuel increased with increasing temperature. Panfeng Han et al[4]., had investigated that a preheated cylindrical combustion chamber was used to measure the laminar burning velocity of methane/air mixture with variations of EGR diluent, reformer gas, temperature and pressure. Reformer gas was introduced to raise the burning velocity of methane/EGR mixture to the undiluted level. And reformer gas has potential to improve the burning velocity while reducing the nitric oxide emission. Young. N. Chun et al[5]., had stated that the change of steam to carbon ratio, catalyst bed temperature, total gas flow rate, input electric power, and biogas component ratio, i.e., CH_4:CO_2. The hydrogen concentration increased up to specific limit, and then maintained almost constant values for the same steam to carbon ratio and catalyst bed temperature. L. Bromberg et al[6]., had studied that plasmatron fuel converters provide a rapid response, compact means to transform a wide range of hydrocarbon fuels (including gasoline, natural gas and diesel fuel) into hydrogen-rich gas. Rong-Fang Horng et al[7]., had investigated that hydrogen was produced through the reformation of ionized hydrocarbon fuel and air mixture by means of spark discharge. The reaction chamber can increase the concentration of the produced hydrogen and that under a given methane supply rate, a low O_2/C ratio resulted in high hydrogen production concentration reduced while the hydrogen volume flow rate increased.

The present investigation is aimed to reduce the emission and to improve the performance of diesel engine. This investigation relates to fuel reformer technique used in diesel engine. The fuel is also supplied through alumina balls which kept in the fuel reformer and heated upto 400^{o}C. The fuel reformed is placed before the intake air manifold.

2. Fuel Reforming In CI Engine

1. It requires a minimum of modification to the engine, since reformer is placed at the intake air manifold. Fuel flow control can be managed by a simplified device and fuel supply system.
2. The reformer fuel system is separate from the diesel system. This flexibility enables diesel engines, equipped with the reformer system, to be operated with diesel fuel only. The engine can switch from dual fuel to diesel fuel operation and vice-versa by disconnection and connection of the reformer source.
3. The fuel reformer is filled with catalyst. The catalyst enrich the fuel performance.

2.1. Experimental Section :

Experiments were carried out on a single cylinder, four stroke, Direct Injection Engine. The engine was coupled to an eddy current Dynamometer for load measurement. The smoke density was measured using a Hartridge smoke meter. Other emissions were measured using five gas analyzer. Experiments were carried out into two different phases. In the first phase, base reading was obtained using neat Diesel fuel. In the second phase of the work the fuel reformer is employed. The fuel is allowed to pass through the heated alumina balls which kept in the fuel reformer. The results of the fuel passed through the fuel reformer have been compared with that of the base fuel.

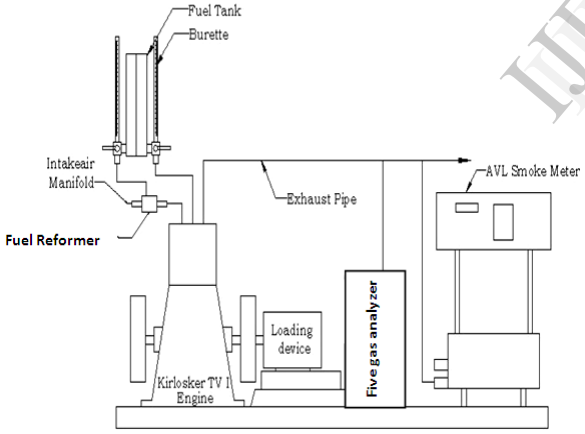

Figure1. Experimental Setup

3. Engine Specification

Kirloskar TV 1 Engine
Engine Specification

Type of Engine:		Vertical
		Four stroke
		Single acting
		Water cooled
Rated power	:	5.2 Kw @ 1500 rpm
Cylinder dia	:	0.0875 m
Stoke length	:	0.11 m
Compression ratio	:	17.5:1

The experiment is conducted as per the following procedure with the base fuel that is diesel. The engine is allowed to run at the rated speed of 1500 rpm for the period of about 30 minutes to reach steady state condition at no load. Smoke readings were measured using the AVL smoke meter at the exhaust outlet. The amount of other emissions were measured by using five gas analyzer. The exhaust temperature was measured by indicator using a sensor. The experiments was repeated for different loads.

3.1. Results and Discussion :

Based on the experimental investigation the following results are obtained.

3.2. Brake Thermal Efficiency :

The effect of fuel reformer with diesel fuel over the brake thermal efficiency is shown in the figure 2.

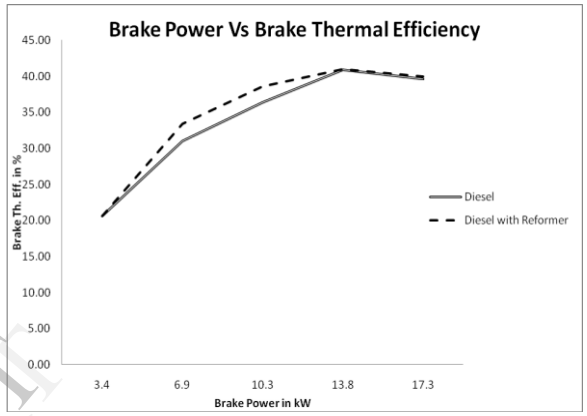

Figure2 : Brake thermal efficiency Vs Brake Power

Brake thermal efficiency is higher upto 75 percentage of load when compare to diesel fuel. A marginal increase in brake thermal efficiency is observed for fuel reformer particularly upto 75% of brake power of the engine beyond that there is no appreciable change in the brake thermal efficiency. This is due to significant improvement in the oxidation process because of the catalytic reaction of the fuel reformer.

3.3. Oxides of Nitrogen :

The performance of the fuel reformer with diesel fuel over oxides of nitrogen is shown in the figure 3.

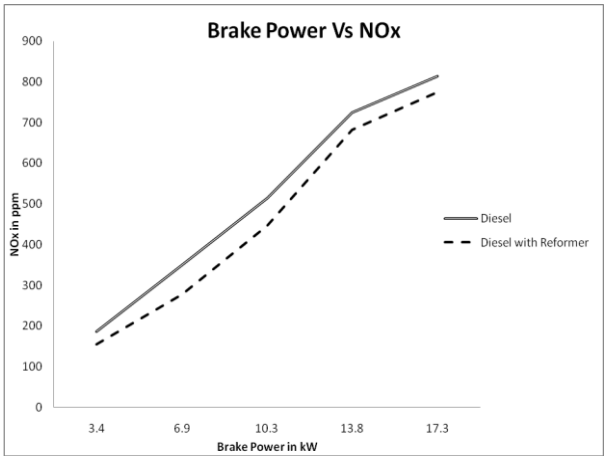

Figure3 : NOx Vs Brake Power

The experimental results shows that remarkable reduction of NOx in all the loads compare to that of the diesel fuel. The maximum reduction of NOx is of 22%. This is may be due to effect of alumina ball used in the fuel reformer.

3.4. Hydrocarbon :

The effect of the fuel reformer with diesel over hydrocarbon is shown in the figure 4.

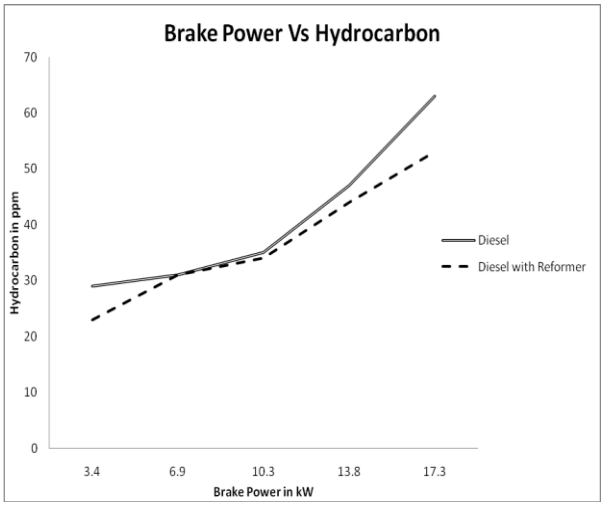

Figure4 : Hydrocarbon Vs Brake Power

The experimental investigation results shows that the hydrocarbon is reduced in all the loads remarkably compare to that the base fuel diesel. The maximum reduction of hydrocarbon is of 18%.

3.5. Smoke Density :

The effect of the fuel reformer with diesel fuel over the smoke density is shown in the figure 5.

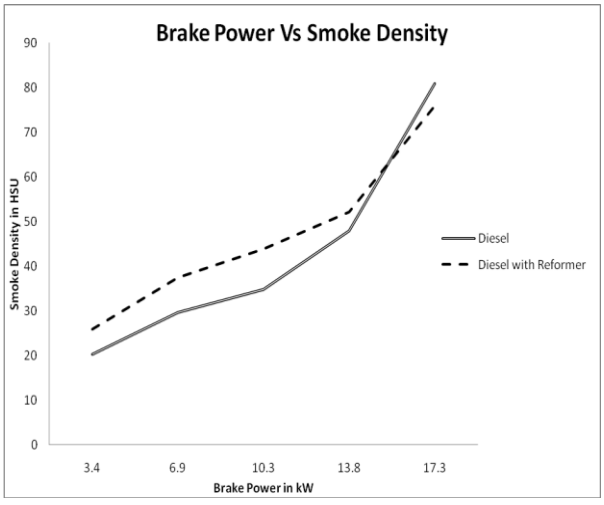

Figure5 : Smoke Density Vs Brake Power

The investigation result shows that there is a slight increase in the smoke density upto 75% of the brake power of the engine beyond to that it decreases upto 7% of ppm when compare to that the base fuel.

4. Conclusion

From the above experimental investigation, the following conclusion arrived.

While using the fuel reformer, the brake thermal efficiency is slightly increased. The average reduction of NOx is around 22% and the hydrocarbon is reduced by 18%. Smoke level is reduced by 6.72% in the maximum load only. It is concluded that the fuel reformer is reducing the emission as well as increasing the performance of the engine.

References

[1] A. Tsolakis, et al., "Exhaust gas assisted reforming of rapeseed methyl ester for reduced exhaust emissions of CI engines", Biomass and Bioenergy 27 (2004) 493-505.

[2] Rong-Fang Horng et al., "Reforming performance of a plasma-catalyst hybrid converter using low carbon fuels", Energy conversion and management 50 (2009) 2632 – 2637.

[3] P. Han et al., "Hydrogen from reformer gas a novel fuel and bridging technology a combustion perspective", International Journal of Hydrogen Energy, Vol. 32, 1416 - 1420 , 2007.

[4] Panfeng Han et al., "Burning velocity of methane/diluent mixture with reformer gas addition", Fuel 86 (2007), 585 – 596.

[5] Young. N. Chun et al., "Hydrogen generation from biogas reforming using a gliding arc plasma catalyst reformer", Catalysis Today 148 (2009) 283-289.

[6] L. Bromberg et al., "Emissions reductions using hydrogen from plasmatron fuel converters", International Journal of Hydrogen Energy, Vol. 26, 1115 - 1121 , 2001.

[7] Rong-Fang Horng et al., "A study of the hydrogen production from a small plasma converter", Fuel 86 (2007) 81- 89.

[8] Abu Jrai et al., "The influence of H_2 and CO on diesel engine combustion characteristics, exhaust gas emissions, and after treatment selective catalytic NOx reduction", International Journal of Hydrogen Energy, 2007.

[9] G. Mutaf Yardimci et al., "Employing plasma as catalytic in hydrogen production", International Journal of Hydrogen, 1109 – 1111, 1998.