International Journal of Mechanical Engineering (IJME)
ISSN(P): 2319-2240; ISSN(E): 2319-2259
Vol. 5, Issue 4, Jun - Jul 2016; 29-36

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations
IASET

EMISSION CHARACTERISTICS OF A HIGH SPEED DIESEL ENGINE

R T NAIK & NILESH CHAVAN

Department of Mechanical Engineering, Indian Institute of Science, Bangalore, India

ABSTRACT

The investigation of emission characteristic of single cylinder using normal diesel and high speed diesel is done. The engine is run at different loading conditions and time required for the consumption of metered quantity of fuel is measured which the emission readings were taken to avoid ambiguity and to achieve consistency in results. The loading of the engine is done with the help of an alternator coupled with it. The output of this alternator is fed to the series of light-bulbs of different wattages. Before taking any measurements the engine is allowed to run for 5 to 7 minutes and then by gradually putting each bulb on the engine is made to run on a particular load. The engine emissions were recorded by MRU GMBH DELTA 1600 L exhaust gas analyzer. The HC, NOx, CO_2 emissions characteristics shown by the engine for both fuels are diverging indicating better combustion efficiency at higher loads for high speed diesel than normal diesel. The results show that the use of high speed diesel is recommended in automotive applications.

KEYWORDS: High Speed Diesel (HSD), Normal Diesel (ND), Exhaust Gas Analyzer (EGA), Hydrocarbon (HC), Direct Initiation (DI), Exhaust Gas Recirculation (EGR)

INTRODUCTION

Due to low rate of fuel consumption diesel engine has a high thermal efficiency and lower greenhouse gas emissions (co2, methane-ch4 etc) compared to the gasoline engine. However because of diffusion combustion characteristic which causes air to be used at low rates and localized high temperatures generates NOx which is a major air polluting agent in suburban areas. The effects of the air pollution have begun to affect environment severely since last few decades. The awareness about the air pollution is increasing when issues like global warming and ozone layer depletion are getting more attention. The ability to burn different fuel types (such as light and heavy fuel oil and also others) has become a characteristic but also major design target for large-scale medium speed diesel engines. For modern engines these parameters include fuel injection timing, compression ratio, fuel injector design, and more. These parameters are important for the control of fuel economy and exhaust emissions (NOx, CO, HC (hydrocarbon), soot (smoke) and particulate matter, while maximizing power output, efficiency and performance [2-3].

There is an increasing urgency in finding ways to improve fuel economy of motor vehicles while controlling tailpipe emissions to meet ever-tighter standards. Diesel engines have the advantages of better fuel economy, lower emissions of HC and CO. However, diesel engines suffered from high emissions of PM and NOx, and it is hard to reduce them simultaneously [8]. Methods to reduce PM and NOx emissions include high-pressure injection, turbo charging and exhaust after treatments, Diesel particulate matter (PM) is defined for regulatory purposes as any material (with the exception of water) that collects on a filter operated in an air-diluted exhaust stream. It consists mainly of combustion-generated soot plus adsorbed or condensed hydrocarbons, i.e. carbonaceous matter resulting from incomplete heterogeneous combustion in the cylinder. The presence of sulphur and other elements in the fuel and lube oil contributes to the formation of sulphate and oxidized metallic elements in the PM. Finally, high boiling point hydrocarbons and their derivatives may be also included in the PM, as the separation between various types of condensed matter (droplets and particles) is not perfectly sharp[2]. In diesel engines, the liquid fuel is normally injected at high velocity through one or more small orifices (nozzles) into the cylinder [3]. Atomization, vaporization, fuel/air mixing and combustion continue until all fuel is burned. The rapidly changing temperature, pressure, density and composition of the cylinder gases as well as injection timing and injector type have a direct effect on combustion and emission formation processes for a given fuel. It is generally known that changes in engine operating/control parameters affect the emissions: higher combustion temperatures promote complete fuel oxidation and reduce emissions of CO, HC, soot and often also PM, while increasing NOx emissions, and vice versa[13].

Because the cetane rating of HSD is higher than the ND it can effectively reduce the HC emissions which impedes self ignition in diesel engine. Diesel emission problems in cold start are the same as that of the case of gasoline. Diesel engine has low exhaust gas temperature which is an advantage over gasoline operated engine. The poorer combustion characteristics of ND can however be increased using cetane improvers, EHN (ethylhexyl nitrate.) but cost analysis of ND with such cetane improvers has to be done before putting them in commercial use and should be justifiable over the HSD in terms of exhaust emissions.

Experimental Set Up

Following figure is the diagram of the main experimental device for studying the engine emission characteristics. The engine used in this experiment was a single cylinder, air cooled, 4-stroke, DI diesel engine with a bore of 95mm and a stoke of 110mm with a compression ratio of 18:1.The engine was a commercial diesel engine and it was coupled with an alternator of 7.5 kVa with the help of a flexible coupling which helps to negotiate small vibrations and minute shaft misalignment. The specification of engine is shown in table 1 and table 2 respectively. All experiments were conducting at standard temperature and pressure. The engine speed was kept constant i.e. 1500 rpm and is measured by an electronic tachometer. The engine emissions were recorded by MRU GMBH DELTA 1600 L exhaust gas analyzer. The exhaust gas emissions were measured directly by putting EGA probe into the exhaust manifold of the diesel engine.

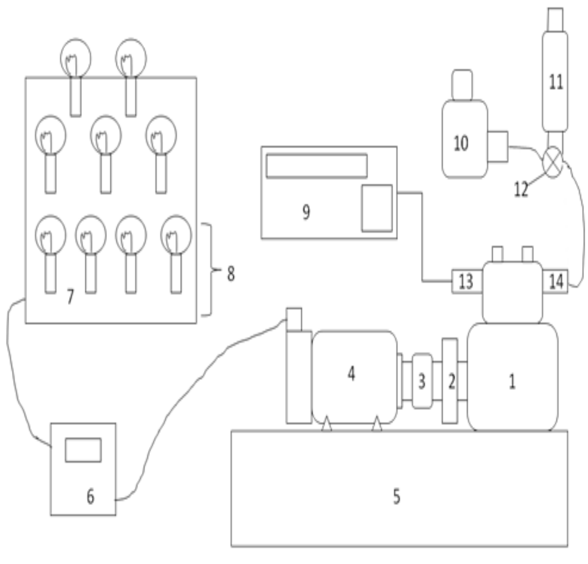

Figure 1: Experimental Set Up

1. Engine	**6. Wattmeter**	**11. Fuel metering device (test tube)**
2. Engine flywheel	**7. Load panel**	**12. Fuel control valve**
3. Flexible coupling	**8. Series of light Bulbs**	**13. Exhaust manifold**
4. Alternator	**9. Exhaust gas analyzer**	**14. Inlet manifold**
5. Engine bed	**10. Fuel tank**	

Table 1: Specification of Test Engine

Item	Specification
Engine type	DI single cylinder 4-stroke, air cooled
Bore × stoke(mm)	95×110
Displacement(cc)	780
Compression ratio	18:1
Power output(kW)	5.9 kW
Rpm	1500
Bhp	8
Make	kirloskar

Experimental Procedure

The engine was operated on a metered quantity (20ml) of ND. The metered quantity of fuel is obtained by the measuring burette which is connected to the fuel injector through a valve. The engine was allowed to run for 5 to 7 minutes on the required load before taking the emission measurements. This was done to have a fixed time scale for every loading conditions after which the readings are taken because the emission characteristic of a fuel is function of load on the engine and time taken by it to consume a fixed amount of fuel [1]. The load on the engine was varied with the help of the load panel which consists of series of light-bulbs of different wattage to which output of the alternator is fed. Then by gradually putting each light-bulb ON the engine is made to run on a particular load. Before loading the engine with a particular load the engine was allowed to run for 3 to 5 minutes on the same load. The engine emissions were recorded by inserting the probe of the EGA into the exhaust manifold and through which the gases were sent to the analyzer. The procedure was repeated for HSD from no load to the full load.

RESULTS AND DISCUSSIONS

CO Emission

Following figure shows the CO emissions of the neat ND and HSD. CO is an intermediate combustion product and is formed mainly due to incomplete combustion of fuel. If combustion is complete CO is converted to CO2. If the combustion is incomplete due to shortage of air or due to low gas temperature CO will be formed. Carbon oxide (CO) burnout is not always complete and its content in exhaust gases mainly depends on combustion air excess; subsequent oxidation of CO happens after air is entrained into the spray region where it mixes and burns. Combustion of fuel-rich mixtures usually produces high amounts of CO emissions. But, otherwise since diesel combustion is usually lean, CO emissions are typically very low as a result of high combustion temperature, high oxygen content and high mixing rates [7]. At low load, the role of mixing is more important than that of temperature, which gives bad burnout especially for the propulsion mode with relatively little air present (compared with generator mode). CO burn-out is a balance between temperature, available oxygen and water for oxidation, and mixing. Usually high diesel CO emissions formed with fuel rich mixtures. As the fuel becomes rich the flame velocity becomes higher and it reaches to combustion walls and gets quenched consequently leads to incomplete combustion. This phenomenon is called flame quenching. The cetane number of HSD is higher than ND, the ignition delay in case of former is smaller than that of later which results in better combustion and hence lesser emissions[13].

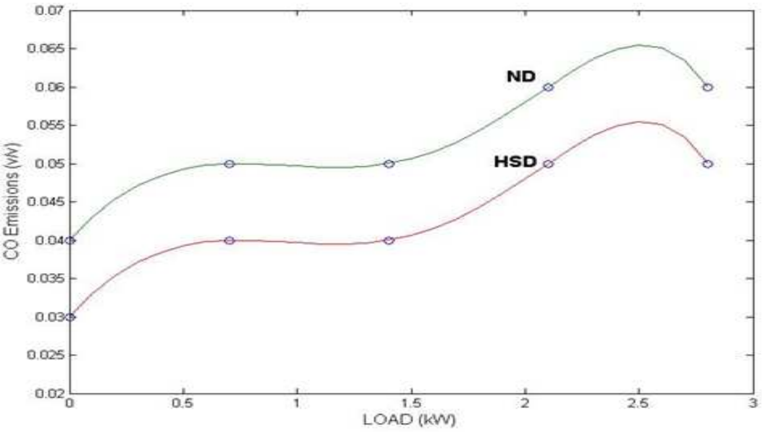

Figure 2: Load V/S CO Emissions

NOx Emissions

Following fig. shows the effect of engine load on NOx emission. Nitrogen oxide emissions depend strongly on the maximum local conditions of temperature of combustion composition, which means that it also depends on air excess (air ratio: AR >1) Naturally NOx emission increases with the increase in engine load. It is well known that nitrogen is an inert gas, but it remains inert up to a certain temperature (1100 ^{0}C) and above this level it does not remain inert and participate in chemical reaction. At the end of combustion, gas temperature inside cylinder arises around 1500 ^{0}C [2]. At this temperature oxidation of nitrogen takes places in presence of oxygen inside the cylinder. On the other hand, since the formation of nitrogen oxides do not attain chemical equilibrium reaction; then after the end of expansion stroke when the burned gases cool and the formation of NOx freeze, the concentration of the formed NOx in the exhaust gas remain unchanged [13]. The fig. also shows that NOx level was higher for ND than for HSD. Reduction of NOx with ND may be possible with the proper adjustment of injection timing and introducing to exhaust gas recirculation (EGR).

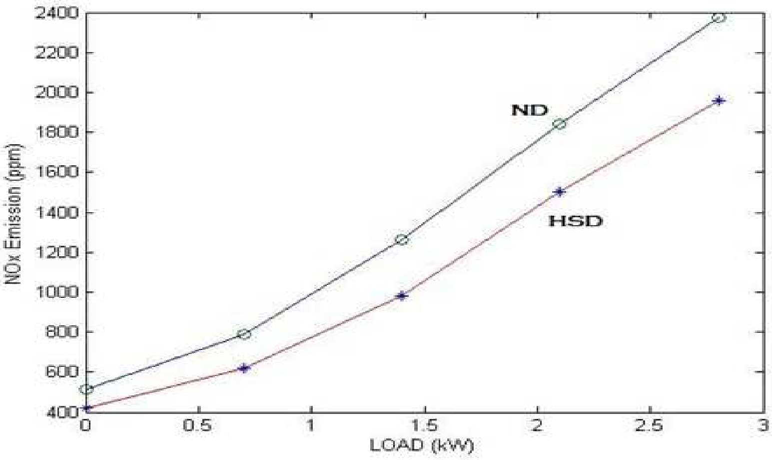

Figure 3: Load V/S Nox Emissions

HC Emissions

Following figure shows the effect of engine load on HC emissions. HC are the final product of complete combustion. The formation of HC mainly depend upon combustion efficiency, ignition delay i.e. cetane number. They are also generated where air excess dilution of fuel with air results in incomplete combustion, giving molecules of decomposed fuel and lubricating oil, and recombined intermediate compounds [4-5]. Fuel that vaporizes from the injector volume after injection at a later stage of combustion is a source of HC emissions also. As engine load increases, the somewhat decreasing air ratio produces At high loads, however, HC may increase again if the amount of fuel in regions is too rich to burn during primary combustion process. There is not enough oxygen present to react with all the carbon resulting in high HC emissions [13]. The difference in the emissions between ND and HSD is because of difference in cetane number.

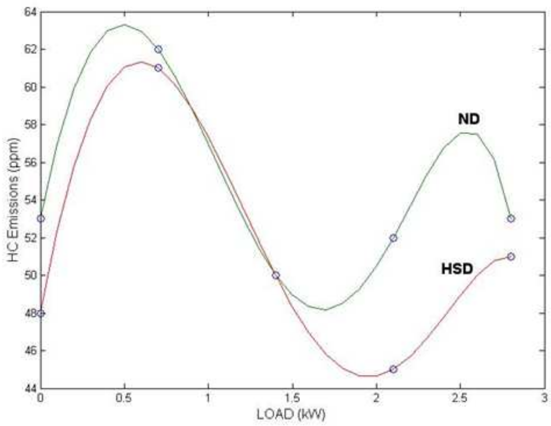

Figure 4: Load v/s HC Emissions

CO_2 Emissions

Following figure shows the comparison of the emission characteristics between ND and HSD. CO_2 is the product of complete combustion. It is formed when enough oxygen is present inside the combustion chamber which suppresses the formation of CO as mentioned in case of CO emission. The difference in the emission characteristics of both the fuel is because the complete combustion and reduced effect of flame quenching in case of HSD.

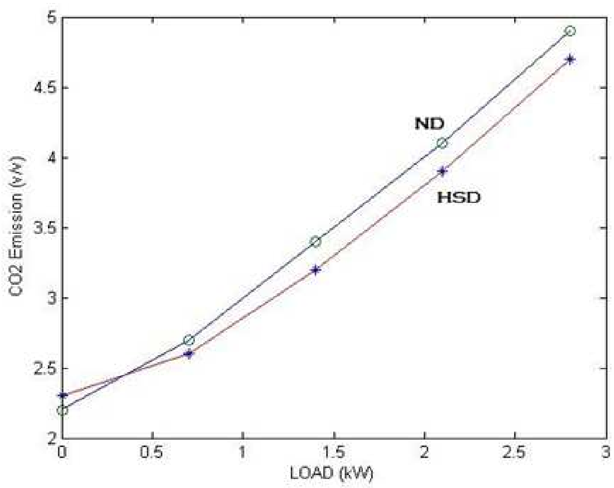

Figure 5: Load v/s CO_2 Emissions

CONCLUSIONS

This work investigated the emission characteristics of diesel engine with normal diesel and high speed diesel. The results of this report are summarized as follows:

- The HC, NOx, CO, CO_2 emissions in case of HSD are lower than ND for the entire loading conditions.
- Combustion efficiency increase for the fuels having higher cetane number which is the reason for lower emissions.
- Because of lower viscosity HSD atomizes and vaporizes more effectively as compared to ND hence better heat release rate and combustion efficiency.
- The combustion output performance and exhaust emissions of a turbocharged diesel engine are largely related to the engine intake air boost variables such as intake manifold air pressure and temperature. As intake manifold air temperature changes in a turbocharger engine under full load, manifold air pressure would change as well and thereby the change-air density, affecting engine efficiency, and CO and soot (smoke) emissions would vary less significantly, besides a relatively significant change in NOx.

REFERENCES

1. Engine Performance and Emission Characteristic of CRDI Diesel Engine Equipped with WCC and DOC using Ethanol blended Diesel Fuel. Hwanam Kim, Byungchun Choi, Seongho Park and Yong-Kil Kim. Automobil Research center Chonnam National University, Gwangju, 500-757, Korea.
2. Large-scale diesel engine emission control parameters A. Sarvi, R. Zevenhoven Heat Engineering Laboratory, Abo Akademi University, Biskopsgatan 8, FI-20500 Abo/Turku, Finland
3. Karonis D, Lois E, Stournas S, Zannikos F. Correlation of exhaust emissions from a diesel engine with diesel fuel properties. Energy & Fuels 1998; 12:230–8.
4. Aaronson AE, Matula RA. Diesel odor and the formation of aromatic hydrocarbons during the combustion of pure cetane in a single-cylinder diesel engine. In: 13th Symp. (Int.) on Combustion. Pittsburgh (PA): The Combustion Institute; 1971. p. 471–81.
5. Hurn RW. Air pollution and the compression–ignition engine. In: 12^{th} Symp. (Int.) on Combustion. Pittsburgh (PA): The Combustion Institute; 1969. p. 677–87.
6. B.C. choi “the state of the art of Automotive Diesel Engine Technology”, KSPSE, Vol.6, N0.1, pp.1-9, 2002.
7. R. Udayakumar, S. Sundaram and K. Sivakumar “Engine Performance and Exhaust Characteristics of Dual Fuel Operation in DI Diesel Engine with Methanol”, SAE Paper No. 2004-01-0096.
8. J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw-Hill Book Company, New York, 1988, pp. 569–573.
9. T.V. Johnson “Diesel Emission Control Technology-2003 Review”, SAE paper No. 2004-01-0070.

10. Lee R, Hobbs CH, Pedley JF. Fuel quality impact on heavy duty diesel emissions: a literature review. SAE Paper 1998; no. 982649.
11. Patterson DJ, Henein NA. Emission from combustion engines and their control. Ann Arbor (MI): Ann Arbor Science Publishers Inc.; 1972; 551.
12. Scott WM. Looking in on diesel combustion. SAE Paper 1968; no. SP-345.
13. X-C Lu, J-G Yang, W- Gzang and Z. Huang "Effect of Cetane Number Improver on Heat Release Rate and Emissions of High Speed Diesel Engine fueled with Ethanol-Diesel Blend Fuel", Fuel , Vol.83, Issues 14-15, pp.2013-2020, 2004.
14. D.G. Li, H Z., L. Xingcai, W.G. Zang "Physico –Chemical Properties of Ethanol Blend Fuel and its Effect on Performance and Emissions of Diesel Engines", renewable energy Vol.30, pp. 967-976, 2005.