International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 3 Issue 11 || November 2014 || PP.63-66

"Genset Engine Development to Meet Current Emission Norms" (Conversion from CPCB-I to CPCB-II)

Mr. Prashant Ghogare[1], Prof. S.R. Patil[2], Asst. Prof. J.N. Kajale[3]
[1,2,3,] *(Sinhgad Academy of Engineering, Kondwa / Pune University, India)*

ABSTRACT : *The major challenge that is faced by most of the engine manufacturers nowadays is to meet the stringent emission norms with least modification in the engine design. In achieving the emission norms simplicity of the design has to be maintained as far as possible by optimizing the available emission control techniques. This paper deals with such optimal technique with reduced cost and up gradation of the engine from CPCB I to CPCB II (Current Emission Norms applicable w.e.f. July'14 for Genset/Stationery Engines in India) in minimum time with minimum design changes. This difficult task is achieved by adopting EGR and intercooler with appropriate injection timing and optimizing the fuel injection pump & Injectors in a cost effective manner. The experiment is carried out on 3.8liter turbocharged engine giving power output 67 kW @1500 rpm. In order to achieve the NOx emission norms A2000 FIP is used, EGR (Exhaust Gas Re-circulation) is used to further reduce the NOx Emission and Intercooler is used to reduce the BSFC.*

KEYWORDS: *CPCB, EGR, BSFC, Nox.*

1. INTRODUCTION

The direct injection diesel engine is one of those efficient thermal engines known to man. The use of diesel engines for road applications has been widely extended during the last decade due to their relatively lower fuel consumption when compared to spark ignition engines. For this reason DI diesel engines are widely used for heavy-duty applications and especially for the propulsion of Generators & Tractor. Even though the efficiency of these engines is currently at a high level there still exist possibilities for further improvement. On the other hand there are problems associated with its use that result from the relatively high values of particulate emissions and NOx values. Furthermore it is found that NOx also contributes to the green house effect. Environmental concerns have led to progressively more stringent emission regulation for diesel engine. Keeping this in view, the government of India keeps regulations on the exhaust emission level of engines from time to time. Currently applicable emission norms for GENSET in India are Central Pollution Control Board (CPCB)- 1 and proposed CPCB - 2 emission norms will be applicable from July 2014, for Generator up to 19kw, >19kw to 75kw, >75kw to 800kw. The current and future emission norms applicable for GENSET Engines are shown in Table-1.

Table 1

Emission Norms for Genset Engines									
Emission Norms	Category (KW)	Date of Implementation	Pollutants (g/KWh)				Smoke	Test Cycle	Test Equipment
			CO	HC	Nox	PM	m-1		
CPCB - I	0 - 19	Implemented from 2003 - 2005 depending upon Power band	3.5	1.3	9.2	0.3	0.7	ISO 8178 D2-5 Mode Cycle	Steady State dynamometer, Partial Flow SPC(PM), Raw Emission Measurement Systems.
	>19 - 36								
	37 - 75								
	>75 - 129								
	130 - 560								
	561 - 800								
CPCB - II	0 - 19	Jul. 2014	3.5	HC+Nox=7.5		0.3	0.7		
	>19 - 36			HC+Nox=4.7		0.3			
	37 - 75								
	>75 - 129			HC+Nox=4.0		0.2			
	130 - 560								
	561 - 800								

The purpose of the present work is to present a theoretical and experimental investigation aiming towards a possible solution to this problem in cost effective way so that the minimum design modification is required in the existing engine and to reduce the lead-time. Tests were conducted under various operating conditions like Full / part throttle performance test, 5 mode cycle Emission test (as per ISO 8178 Type D2). The Central Pollution Control Board (CPCB)-2 configuration results reveal that the reduction in exhaust emission (NOx+HC, CO and PM) levels was achieved without sacrificing in brake specific fuel consumption at full load.

II. STRATEGY TO MEET CPCB II EMISSION NORMS.

BASE ENGINE: For optimization, turbocharged engine for genset application was considered. The engine specification is mentioned in the Table 2. The base engine was already optimized for CPCB-I and is to be upgraded to CPCB-II norms. The challenges occurred

i) Improvement in NOx + HC

ii) Similar fuel consumption

iii) Minimal modification and cost impact.

Table-2: Engine Specification

Configuration	Base Engine	Upgraded Engine
Power	59KW	67KW
Type of Aspiration	Turbocharged without EGR	Turbocharged with EGR
No. of Cylinder	4	4
Swept Volume	3.8 Ltr	3.8 Ltr
Bore/Stroke	97/128	97/128
FIP	Bosch, A3500	Bosch, A2000
Injector	P-Type	P-Type With K-Factor

Development Work: To get minimum cost effect and less lead-time; EGR, Intercooler and FIP are carefully selected and optimization of Injection timing, EGR rate, EGR pipe diameter has done to meet stringent emission norms.

III. FUEL INJECTION EQUIPMENT

The fuel injection equipment must be able to achieve precise control of fuel metering. Bosch, A2000 FIP is used instead of existing A3500 FIP in order to reduce the pump end pressure & indirectly reducing the peak combustion temperature, which helps in reducing the Nox emission from the engine exhaust. Changing other parameter like after treatment devices but these devices increases the cost and lead-time of the system can also decrease Nox.

IV. DIRECT CONTINUOUS EGR

EGR reduces the Nox emission by four ways: A) Dilution Effect: The dilution of the intake charge with EGR reduces the mass fraction with oxygen. This reduction in oxygen mass fraction is the dilution effect. Adding EGR to the intake airflow also affects average properties of the intake charge such as the specific heat capacity and molecular mass introducing other effects. B) Thermal Effect: - EGR contains water and CO2, both of which have higher specific heat capacities than fresh air. The effect of increased heat capacity is the thermal effect. The nitrogen in the air is replaced with inert gas helium to study the effect in isolation. Intake air dilution with EGR simultaneously introduces the dilution and thermal effect. The oxygen mass fraction in the intake air needs to be held constant to avoid interference from dilution effect.C) Chemical Effect: - Some of the diluents gases may dissociate or actively participate in chemical reactions during the combustion process this is the chemical effect. One way to isolate the chemical effects is to replace nitrogen in the air with argon while the diluents is present this maintains a constant average charge heat capacity and oxygen concentration in the intake charge relative to the undiluted. This avoids interference from the thermal and dilution effect. However it is not used in this project.

D) Add mass effect: - If adding diluents to the intake charge results in an increased mass flow rate, an additional effect is introduced. This added flow has an additional heat capacity due to its mass.
The EGR used is 18 mm diameter EGR tube in which the exhaust gases flows from the exhaust to intake due to pressure difference between Exhaust and Inlet. This EGR has a drawback that at full load EGR is not required but due to pressure difference the exhaust gases flows to the inlet and reduces the power at full load.

V. INTERCOOLER

Intercooler is simply a heat exchanger, which reduces the temperature of the compressed intake gas, as a result of this volumetric efficiency of the engine is increased. Due to Retard in fuel injection timing & EGR the power is reduced and specific fuel consumption is increased. Intercooler is used to regain the reduction in power and decrease in fuel consumption. In the Base engine, air after the compressor outlet (Turbocharger Outlet / Boost Air) is at about a temperature of 140 deg. C because of this high temperature volumetric efficiency is decreased drastically but with the use of intercooler the temperature puts down to 45 deg. C which increase the volumetric efficiency which intern increases the air density and fuel consumption remains more or less equal to base engine even though after retarding the injection timing & introduction of EGR.

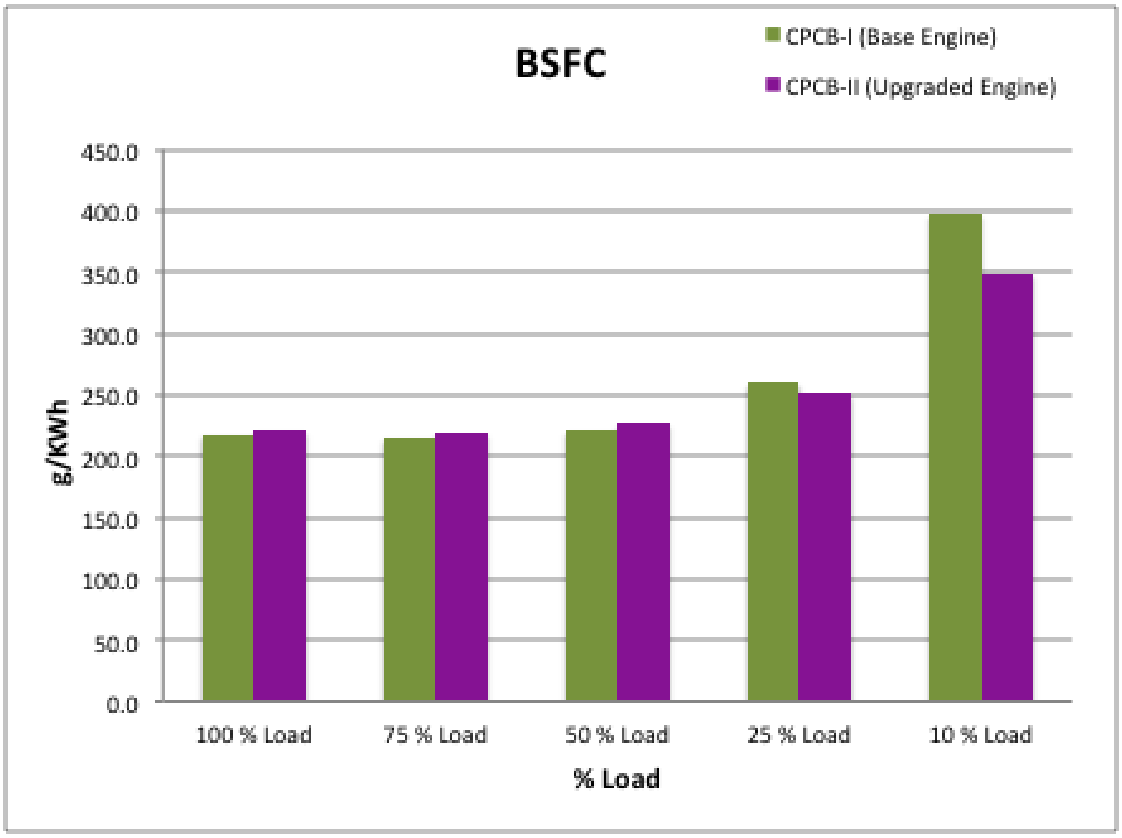

Figure 1: BSFC Comparison between CPCB-I & CPCB-II

VI. RESULTS AND CONCLUSION

Results obtained on an 67 kW rating power rating engine during engine optimization are given below

Emission Parameter	CPCB-II Limits	Baseline Results	Optimized Results
Nox + HC (g/KWh)	4.7	7.56	4.33
CO (g/KWh)	3.5	0.83	0.18
PM (g/KWh)	0.3	0.135	0.161
Smoke (m-1)	0.7	0.415	0.184

From the Figure 2 it can be clearly seen that NOX + HC emissions are well within the limits CPCB II Emission norms. Emission limits for NOX + HC are decreased by 55.23 % as compared to baseline limits. The reason to decrease of NOX is due to combined effect of A2000 pump i.e. Low pump end pressure, retardation in fuel injection timing and EGR; EGR decreases availability of oxygen in the combustion chamber.

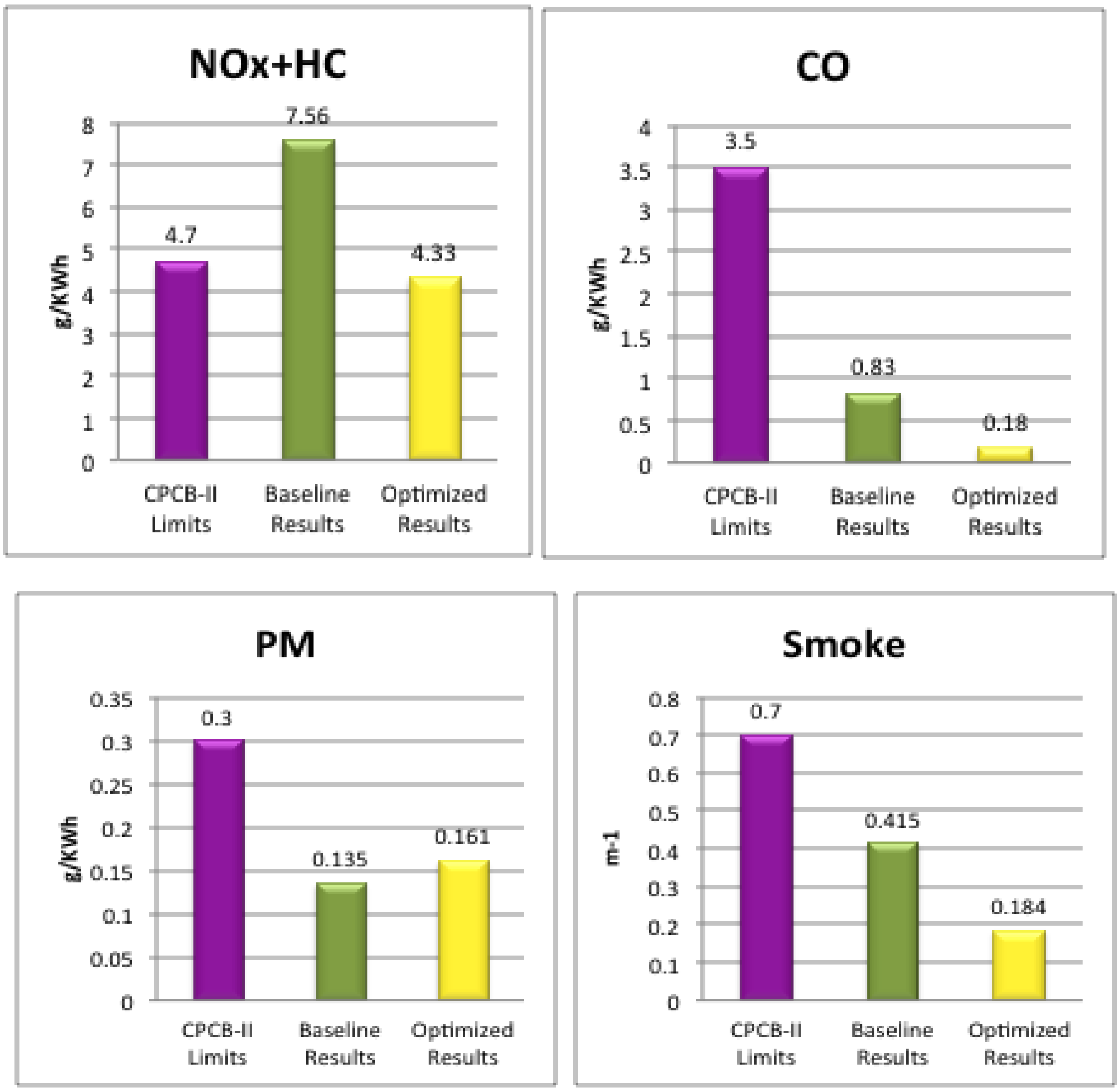

Figure 2: Limits V/s Actual Results Comparison

From the Figure 2 it can be concluded that the Smoke, HC and CO emission are reduced by use of K-Factor injector and PM emission are increased due to retarded injection timing, some of the Particulate matter is oxidized during exhaust stroke but the amount of oxidation of fuel is very less. However due to use of K-factor injector the PM is well within engineering targets of CPCB-II emission norms.

REFERENCES

[1] http://www.dieselnet.com/tech/engine_egr .html.

[2] MuraliManmohan,Kiran M Karanjikar, Vikas V Patil and Ravindra M Koli, "Development of Common Rail Engine for LCV BSIII and a Step Towards BS IV Emission Compliance", SAE Paper No. 2011-26-0032, 2011 doi:10.4271/2011-26- 0032.

[3] K Nandkumar, R kirankumar, DaithankarParag and R Velusamy,"Innovative Method of Calibration to Meet BS4 Emission with Optimized Fuel Economy and Noise in MPV with 2.5Lit Common Rail Diesel Engine",SAE Paper No. 2011-26-0028, 2011, doi:10.4271/2011-26- 0028

[4] P. A. Laxminarayanan, "A Cost –Efficient EGR Technology for off-road diesel engines with mechanical fuel injection equipment to satisfy advanced emission standard", Ashok Leyland, SAE Paper No: 2010-01- 1958, 2010 doi:10.4271/2010- 01-1958.

[5] K. S. Kalsi and N. Collings, "Study of Steady State and Transient EGR Behavior of a Medium Duty Diesel Engine", University of Cambridge, M. Heaton and S. A.Faulkner Caterpillar UK, SAE Paper

[6] Pulrabek williams. "Fundamental of I.C Engine," Mc Graw Hill Book Co. NY

[7] Pundir B.P "I. C. Engine Emission and their control," NPTEL Education.

[8] Heywood J. B. "I. C. Engine Fundamentals," Mc Graw Hill Book Co. NY

[9] Ganeshan.V "I. C. Engine ," Mc Graw Hill Book Co. NY