

# Feasibility Trials to Achieve BS4 Emission Norms on 130 Hp Engine With Low Cost EGR

P.Sathya Narayanan<sup>1</sup>, M.Yoganandham<sup>1</sup>, D.Samuelraj<sup>2</sup>, G.Gowtham<sup>3</sup>

Ashok Leyland, VVC, Chennai, Tamilnadu, India<sup>1</sup>

Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science & Technology, Chennai, Tamilnadu, India<sup>2</sup>

**ABSTRACT:** In this contemporary automobile generation achieving emission legislation in low cost is a big deal. Emission regulation for BS4 is really stringent & to clear the emissions is a big challenge & hence feasibility study is required to finalize the products H4 engine has been developed to meet the BSIV emission norms with EGR and exhaust after-treatment using DOC-POC system with CPN2.2 FIE system. However, to reduce the overall cost of the product, it is decided to develop the engine with low cost FIE system and low cost EGR system.

Major objectives are as follows,

- 1) To check the feasibility of implementing low cost EGR system by engine calibration
- 2) To meet BS-IV emission norms
- 3) To achieve performance targets
- 4) To finalize hardwares like Turbocharger, piston bowl, cylinder head swirl ratio & after treatment like DOC.

## 1. INTRODUCTION

Engine power is proportional to the amount of air and fuel that can get into the cylinders & hence requires good combustion characteristics. But good combustion characteristics will pave the way for increase in combustion temperature & hence NO<sub>x</sub> emission will increase which in turn affects BS IV emission norm. So, EGR is used for reducing NO<sub>x</sub> emission. Simple lay out given below,

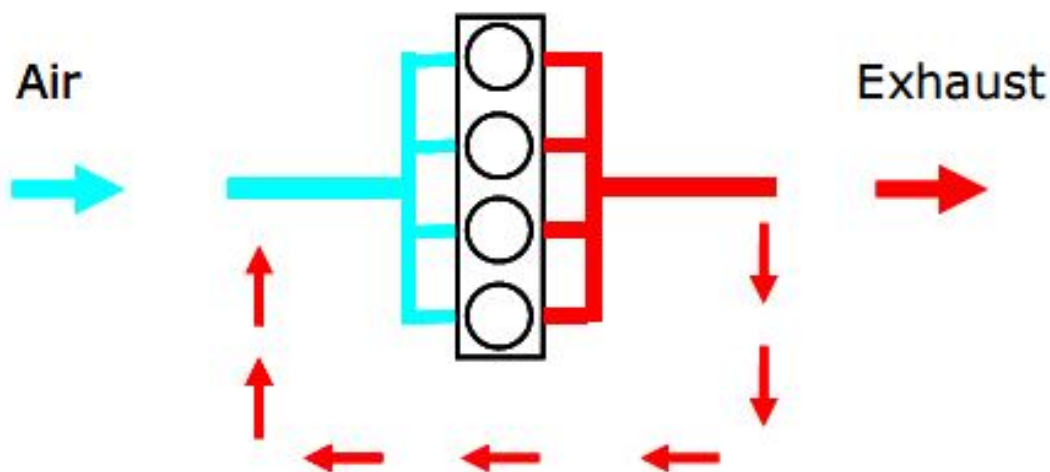


Fig 1.1 EGR LAYOUT

In diesel engines, NO<sub>x</sub> formation is temperature dependent phenomenon & forms @ 2000k. Therefore in order to reduce NO<sub>x</sub> emissions in the exhaust we are in need of reducing peak combustion temperature.

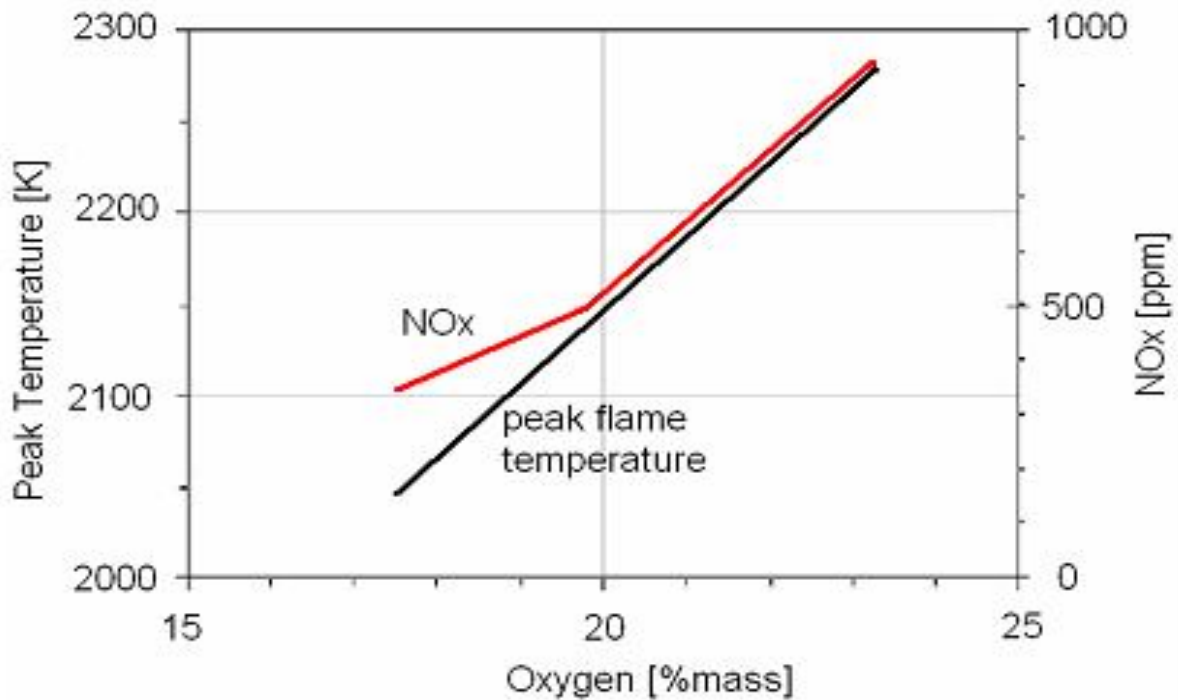


FIG 1.2 OXYGEN (% MASS) VS PEAK TEMP.

One simple way of reducing Nox emissions is by late injection of fuel in to the combustion chamber. This technique is effective but increases fuel consumption by 10 – 15%.So we look for another alternative called as EGR

EGR is a useful technique for NOX reduction.Exhaust consists of CO<sub>2</sub>,N<sub>2</sub>&watervapour mainly. When this exhaust is sent as circulation to combustion chamber it act as a diluents to the combustion chamber.Also this reduces the oxygen concentration in the combustion chamber. The specific heat of EGR is greater than the fresh air, hence EGR increases the heat capacity of intake charge & thus decreasing the temperature rise for the same heat release in the combustion chamber.

$$\% \text{ EGR} = (\text{Volume of EGR})/(\text{Intake charge in to cylinder}) * 100$$

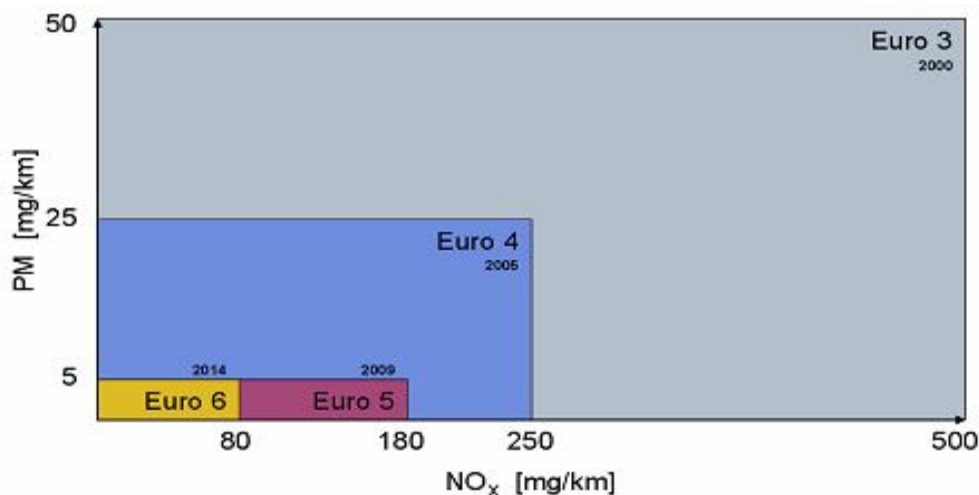
$$2) \text{ EGR Ratio} = ((\text{CO}_2)_{\text{inlet}} - (\text{CO}_2)_{\text{ambient}})/((\text{CO}_2)_{\text{exhaust}} - (\text{CO}_2)_{\text{ambient}})$$

Three popular explanations for NOX reduction by EGR are

- Increased ignition delay
- Increased heat capacity
- Dilution of intake charge with inert gas

## 2. Existing & Development EGR setup

Firstly we must know the euro limits for understanding the objective of the project,so to understand the euro limit & the need of EGR system for BSIV emission norm.



**Figure 2: Development of Soot and NO<sub>x</sub> emission limits**

To meet the above specifications we are in need of EGR systems which help us to reduce the NO<sub>x</sub> emission in great deal. Here is the existing & current method of EGR system.

2.1) Existing method

Internal EGR systems:

- This system is used predominantly in constant speed engines where constant EGR flow rate is required.
- It is also called as TINDER (Technique of incylinder NO<sub>x</sub> emission reduction) camshaft. Here the inlet lobe of the camshaft is machined for TINDER lift @ full exhaust valve open position & tiner lift helps in dilution of exhaust gas in to fresh air paving the way for reduction of combustion temperature & hence NO<sub>x</sub> emission.

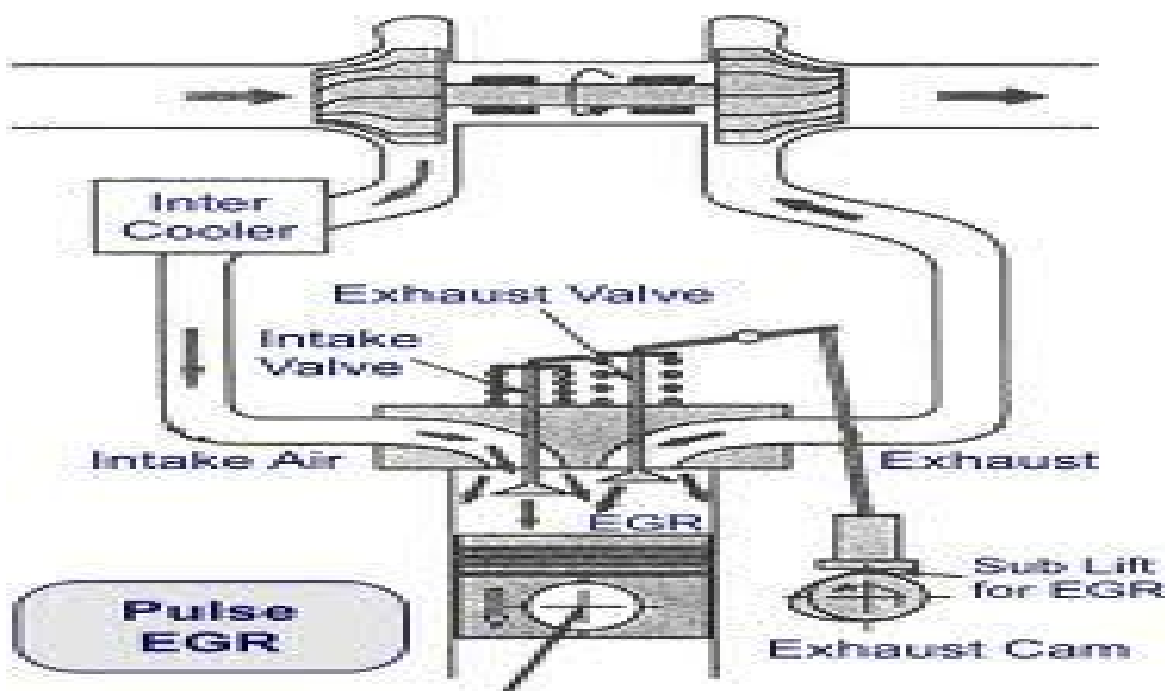


Fig 2.1

2.2) Development method:

External EGR:

- This is called as external exhaust gas regulation with the help of EGR valve actuator especially solenoid type actuator which works in PWM for both steady & transient zone working.
- This system will be incorporated with EGR cooler for reducing the temperature of exhaust gas. This will increase EGR efficiency of a system.
- It is mainly used in automotive applications where both steady state and transient state are really crucial.

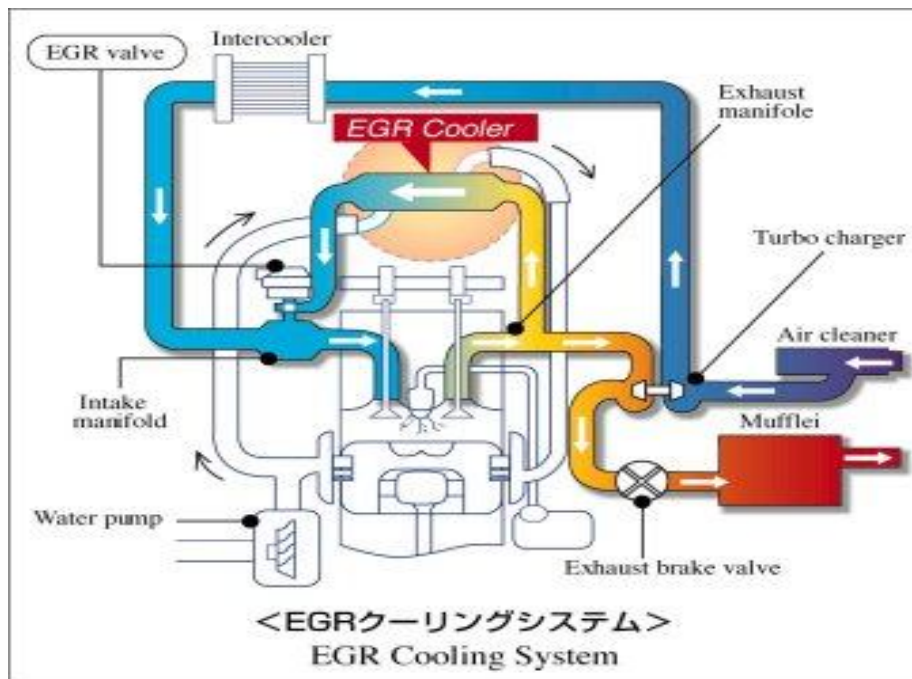


FIG 2.2 External EGR

**III. EXPERIMENTAL SETUP**



Fig 3.1 Smart Sampler Particulate Matter



Fig 3.2 Coolant Conditioner System



Fig 3.3 Fuel Conditioner System



Fig 3.4 Inlet blower System



Fig 3.5 Transient Dynamometer

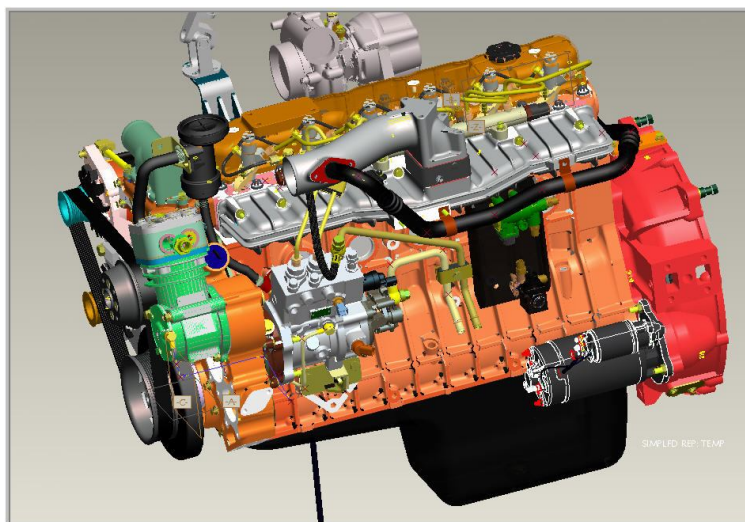


Fig 3.6 EGR Engine

**IV. PERFORMANCE & EMISSION RESULTS**

TC Trials

Table 4.1

ESC	5.88 Housing	4 Housing
NOx (g/kWh)	3.43	3.167
HC (g/kWh)	0.184	0.191
CO (g/kWh)	0.480	0.479
Soot (g/kWh)	0.067	0.044

Piston bowl trials

Table 4.2

ESC	17.5 CR Piston	16.5 CR Piston
NOx (g/kWh)	3.167	3.024
HC (g/kWh)	0.191	0.174
CO (g/kWh)	0.479	0.448
Soot (g/kWh)	0.044	0.032

Cylinder head swirl trials

# International Journal of Innovative Research in Science, Engineering and Technology

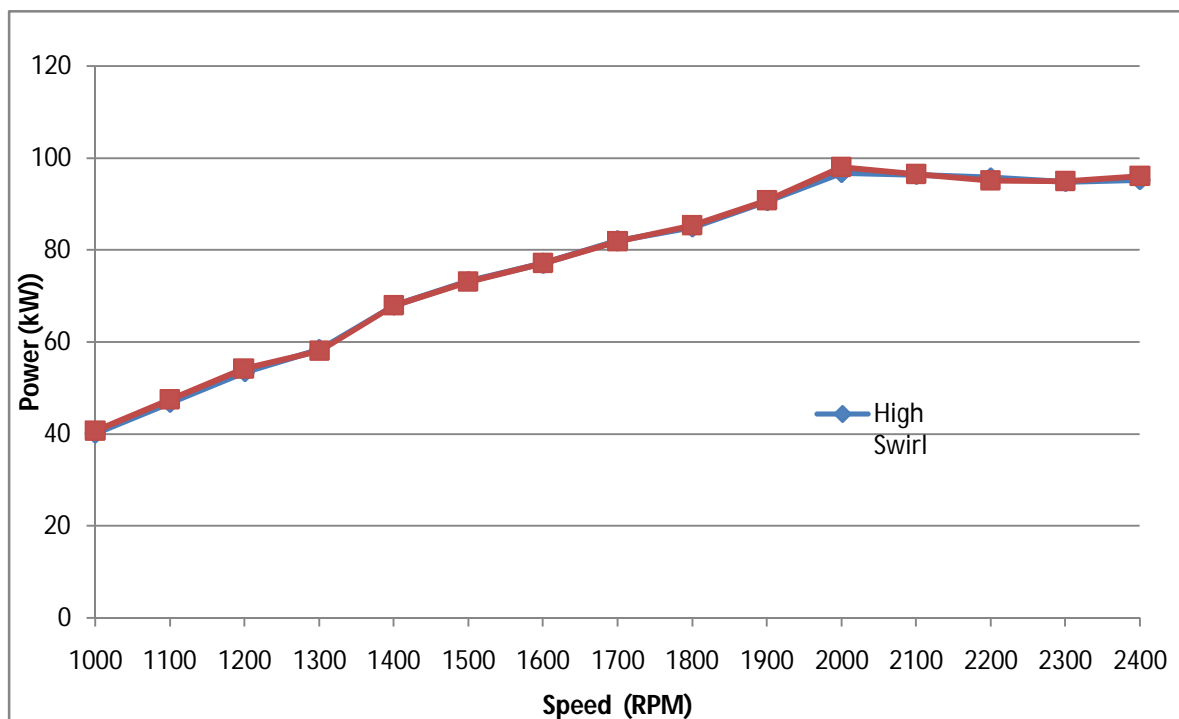
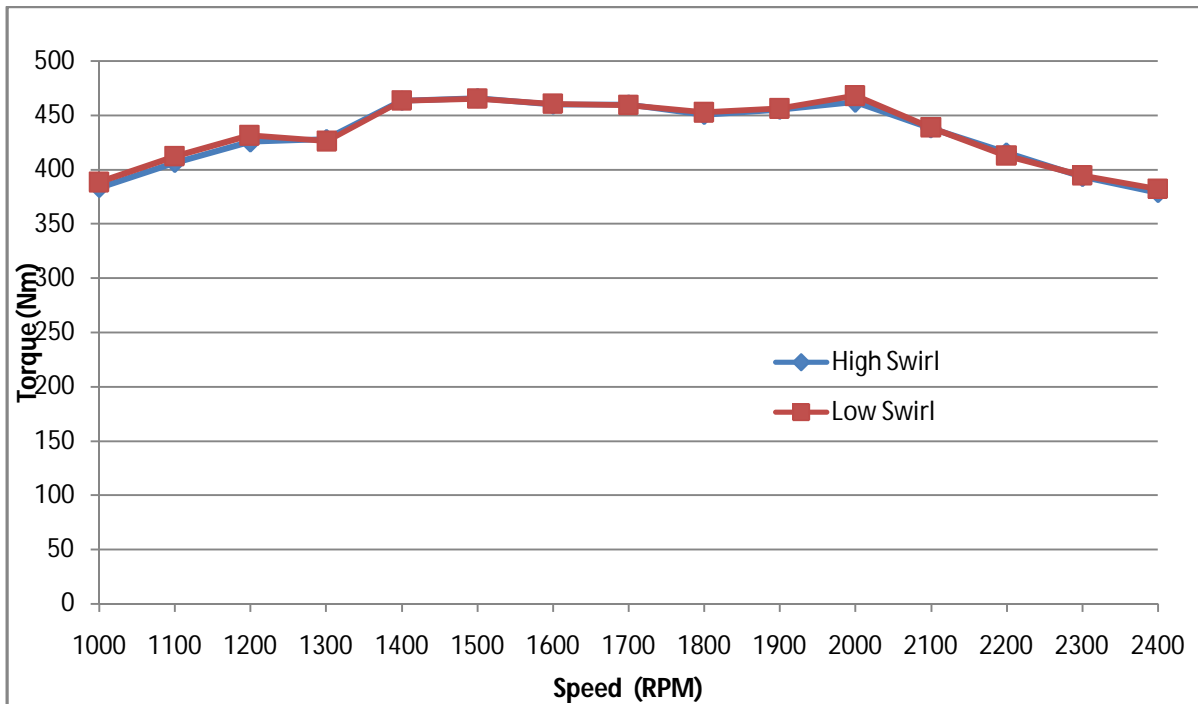
An ISO 3297: 2007 Certified Organization

Volume 4, Special Issue 3, March 2015

First National Conference on Emerging Trends in Automotive Technology (ETAT-2015)

Organized by

SAE INDIA Velammal Collegiate Club, Velammal Engineering College, Chennai, India on 20<sup>th</sup> March 2015





**International Journal of Innovative Research in Science, Engineering and Technology**

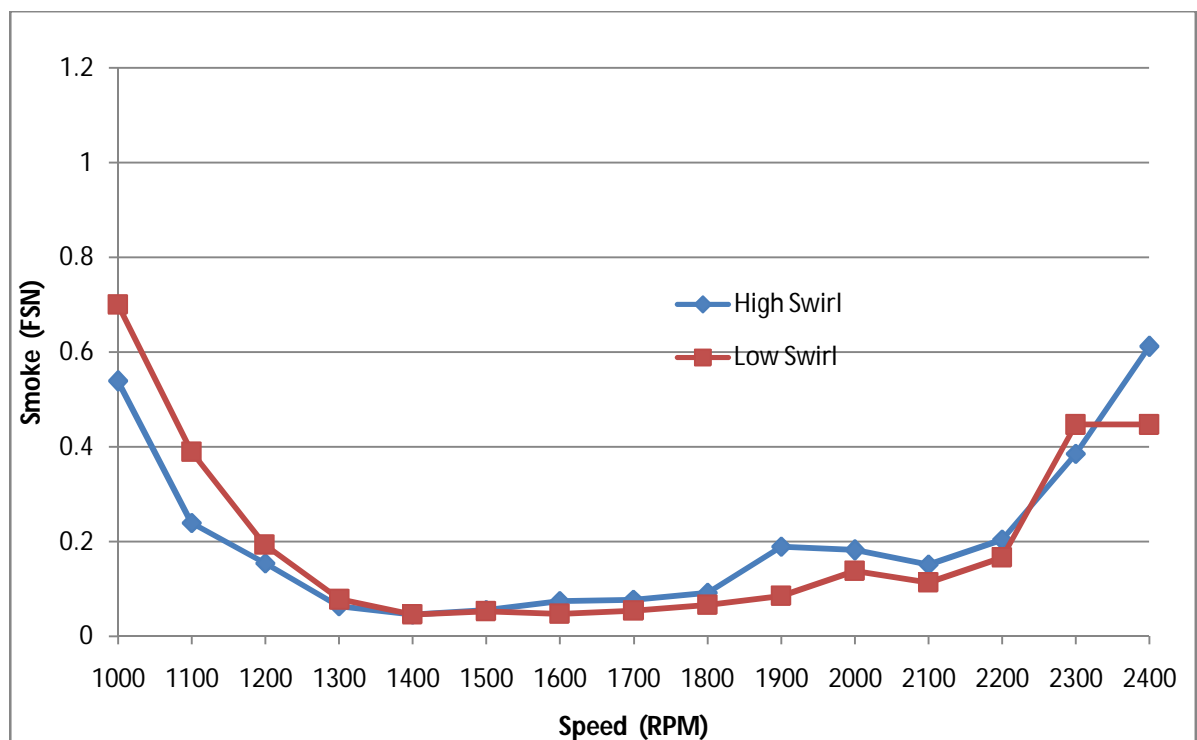
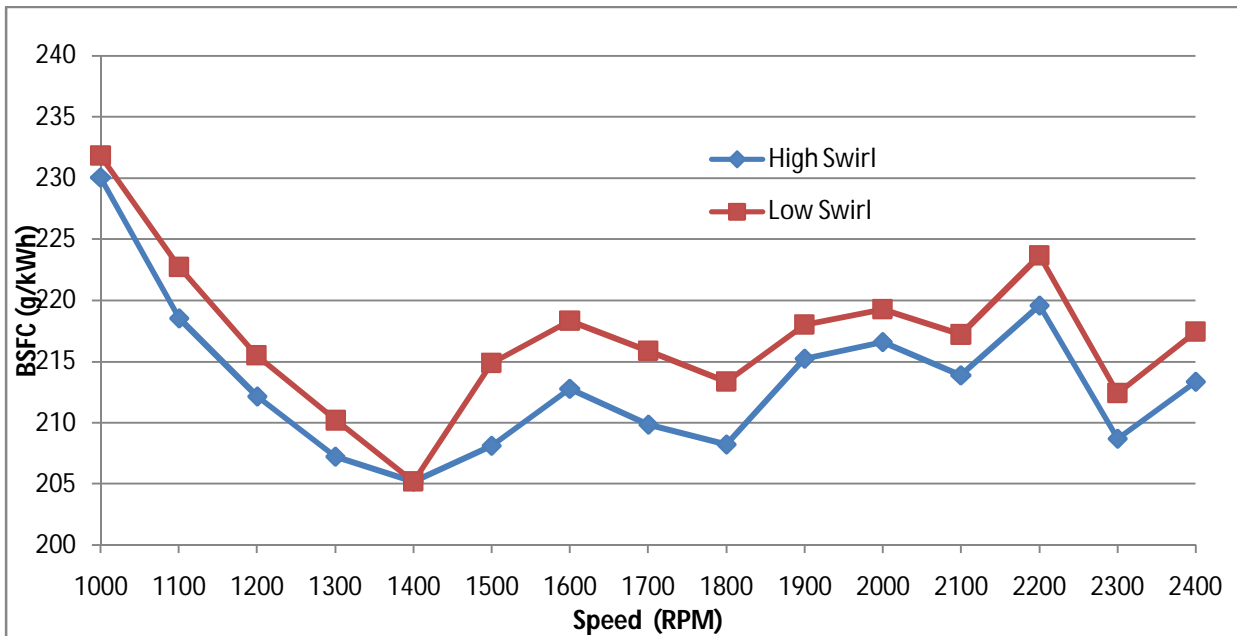
An ISO 3297: 2007 Certified Organization

Volume 4, Special Issue 3, March 2015

First National Conference on Emerging Trends in Automotive Technology (ETAT-2015)

Organized by

SAE INDIA Velammal Collegiate Club, Velammal Engineering College, Chennai, India on 20<sup>th</sup> March 2015



ESC

Table 4.3

	Swirl-1.2	Swirl -1.4
NO <sub>x</sub> (g/kWh)	3.413	3.601
HC (g/kWh)	0.163	0.164
CO (g/kWh)	0.34	0.339
Soot (g/kWh)	0.0084	0.0083
PM (g/kWh)	0.026	0.024

ETC

Table 4.4

	Swirl-1.2	Swirl -1.4
NO <sub>x</sub> (g/kWh)	3.918	3.84
HC (g/kWh)	0.213	0.183
CO (g/kWh)	0.76	0.716
Soot (g/kWh)	-	-
PM (g/kWh)	0.053	0.065

Remarks:

- Higher swirl head resulted in better performance, but emission levels are not appreciably different
- Further trials continued with Swirl -1.2 cylinder head

ESC with DOC OUT

Table 4.5

	Engine Out	DOC-Out
NO <sub>x</sub> (g/kWh)	2.791	2.898
HC (g/kWh)	0.113	0.032
CO (g/kWh)	0.42	0.047
Soot (g/kWh)	0.0081	0.01
PM (g/kWh)	0.020	0.013

ETC with DOC out

Table 4.6

	Engine Out	DOC-Out
NO <sub>x</sub> (g/kWh)	3.288	3.36
HC (g/kWh)	0.145	0.054
CO (g/kWh)	0.733	0.154
Soot (g/kWh)	--	--
PM (g/kWh)	0.029	0.022

## V. CONCLUSIONS

Conclusions:

- 16.5 CR piston and 4 Housing TC gave better performance and emissions
- 480HTF Nozzles are found to be more suitable for emission reduction

## International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization

Volume 4, Special Issue 3, March 2015

First National Conference on Emerging Trends in Automotive Technology (ETAT-2015)

Organized by

SAE INDIA Velammal Collegiate Club, Velammal Engineering College, Chennai, India on 20<sup>th</sup> March 2015

- No appreciable difference found between the emission and performance with 1.2 and 1.4 swirl heads
- DOC system used in reduction of soot or PM
- A higher swirl head (1.6 or 1.8 swirl) provided significant variation in emissions and performance
- New DOC system used in reduction of PM because of SOF Conversion
- DC Motor EGR valve used for improved response
- BS4 Emission is successfully clearing.

### REFERENCES

1. John B. Heywood, "Internal Combustion Engine Fundamentals" McGraw-hill Education, 1988
2. Kolchin Demidov, "Design of automotive engines" MIR Publishers Moscow, 1984
3. Yushu Wang, "Introduction to engine valvetrains" SAE International, 2007
4. Kovach, J., Tsakiris, E. and Wong, L., "Engine Friction Reduction for Improved Fuel Economy" SAE Paper No. 820085, Society of Automotive Engineers, Warrendale, PA, 1982