

Initial Development of a E85 Fueled, Multi Cylinder, Turbocharged, Spark Ignited, Heavy Duty Engine

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ABSTRACT

E85 (85% Ethanol + 15% Gasoline), as an alternative fuel has been widely used in spark ignited engines used in light duty vehicles. However, they are rarely used in spark ignited heavy duty engines. In this study, we used E85 in a 5.8 litre, multi cylinder, turbocharged, multi point - port injected, spark ignited heavy duty engine, to analyze the performance capability. As E85 has higher octane rating, the compression ratio was increased to 11.5:1. Experimental investigation of In-cylinder pressure was done and the engine's ignition timing and injection duration was calibrated to operate the engine below peak firing pressure limits, without knocking. The experimental results showed that exhaust gas recirculation resulted in lower peak firing pressure and rate of heat release.

The results of the engine test showed that E85 can be used in heavy duty spark ignited engines. The scope for future work is on addressing the higher BSFC and cold start from subzero temperature levels.

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INTRODUCTION

Ethanol, is a renewable source of energy and have lesser carbon footprint when used as an automotive fuel. Higher blends of ethanol with gasoline is used as a fuel in spark ignited engines due to its high octane rating and high combustion speeds [1, 2, 3, 4].

Usage of ethanol blends on heavy duty spark ignited engines is limited, motivating us to study the effect of E85 on a 5.7 litre multi cylinder engine. The base CNG fuelled engine was modified to run with E85 Blend with significant modifications being the change of fuel injectors, intake manifold to accommodate injectors and cold start aids, addition of Exhaust Gas Recirculation (EGR) circuit, high compression ratio pistons and E85 compatible fuel pump and pipelines.

Steady state engine testing was then carried out in an eddy current dynamometer. Calibration activities like start and idle calibration, closed loop fuel calibration and injection and ignition calibration were carried out. Cylinder peak firing pressures and rate of heat release were measured and analyzed. Experimental trials were conducted with and without EGR.

This Project demonstrates that with minimal changes, a CNG engine can be converted to run with E85 as fuel, to obtain maximum power output with carbon foot print reduction potential.

ENGINE SPECIFICATION

A 5.7L 6 cylinder CNG fuelled base engine with the below specification mentioned in [Table 1](#) was chosen for carrying out the conversion for Ethanol E85 engine.

Table 1. Specifications of Base CNG Engine

Engine Type	Inline, Four stroke, Spark Ignition, CNG Engine
Bore x Stroke	104 mm x 113 mm
Displacement	5.76 litre
No. of cylinders	6
Compression Ratio	11.5:1
Rated Power	180 hp @ 2400 rpm
Peak Torque	600 Nm @ 1600-2000 rpm
Method of Air aspiration	Turbocharged, Intercooled
Fuel Injection System	Multi Point Fuel Injection (MPFI)
Ignition System	Distributor less, Coil on Plug type
Spark Plug	Resistive
Combustion	Stoichiometric

The selection of CNG engine as base engine is due to the following considerations:

- High compression ratio of CNG engines
- The existing MPFI system layout in the CNG engine could be used for E85 fuel as well with only change of fuel injectors.
- High energy ignition coil and spark plugs
- Wear resistant engine valves

DETAILS OF MODIFICATION

The base engine as stated in Table 1 was taken for E85 conversion. Injector selection was carried out based on flow requirement obtained from theoretical calculations and validated based on the thermodynamic simulation results. Flow dynamics was studied to avoid wall wetting and the injector position in intake port was modified accordingly.

High energy spark plugs were already available on stock engine. Exhaust manifold and flanges were modified for provisioning of additional lambda sensor for external monitoring of air fuel ratio. Flange heater to heat the intake air was included in the setup to cope up with the icing effect on the intake manifold caused by the high latent heat of vaporization of E85 fuel.

The schematic of the engine is provided in Figure 1.

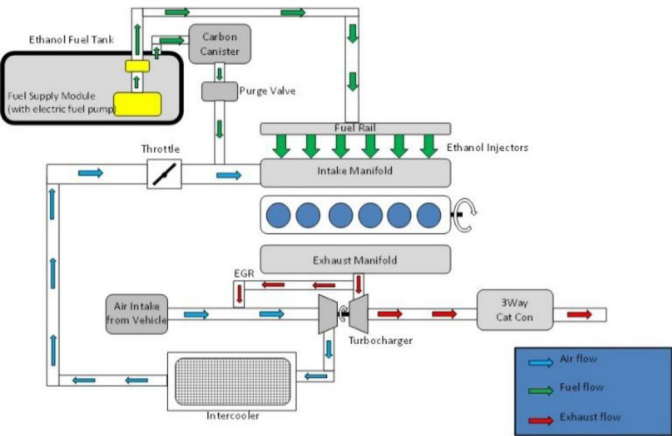


Figure 1. Engine Schematic

EXPERIMENTAL SETUP

The engine was mounted on eddy current dynamometer to study the engine performance with ethanol fuel. The schematic of engine instrumentation used during the engine testing is given in Figure 2

The various instruments used for measuring engine testing parameters are given in Table 2.

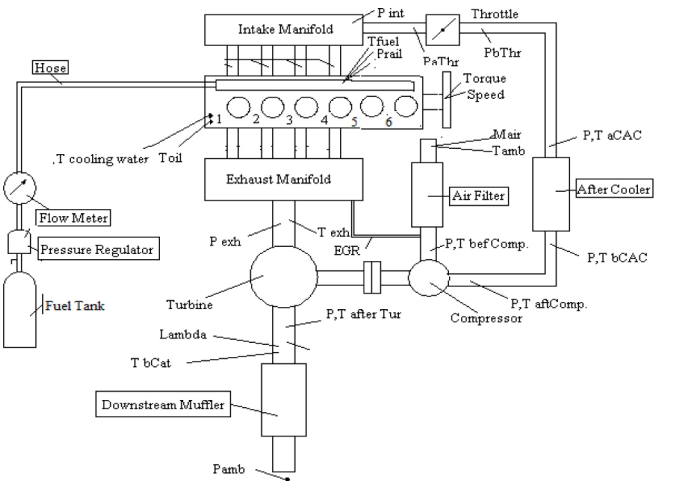


Figure 2. Engine Test Bed Instrumentation Schematic

Table 2. Specifications of Base CNG Engine

S.No	Measurement parameters	Instruments used
1	Engine speed, torque	Eddy current dynamometer
2	Air mass flow	Thermal mass flow meter
3	Fuel mass flow	Coriolis’s flow meter
4	Peak firing pressure	Instrumented spark plug
5	Temperatures	Thermo couples
6	Pressures	Pressure sensors

The engine was mounted on dynamometer (as shown in Figure 3) and optimization trials were initiated. The engine performance with E85 fuel at full load steady state conditions and the effect of various parameters were studied. The engine control parameter values were calibrated on engine ECU by using CAN communication and INCA software interface.

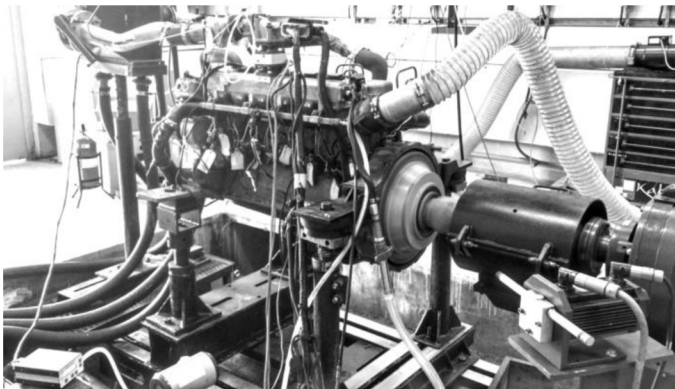


Figure 3. Engine Instrumentation

ENGINE CALIBRATION

Start Calibration

The engine starting was calibrated by adjusting the air fuel ratio to lambda = 1 (AFR : 9.8:1) and ignition timing was retarded to 9 deg. BTDC. The starter cranking speed was around 200rpm. With the