A single cylinder gasoline direct injection engine (HMC Seta 0.5 L, Mobiltech) consists of a pent-roof cylinder head and toroidal piston cavity with a side mounted injector. A 36 kW transient AC dynamometer (Dynomerk Controls; 6-2013) is coupled with the engine. The engine can be operated either with a thermal cylinder head (Fig 1) or with an optical cylinder head (Fig 2).

Fig 1: Experimental Setup of GDI Engine with thermal head

Fig 2: Experimental Setup of GDI Engine with optical head

Detailed specifications of the test engine and dynamometer are shown in table 1 and table 2 respectively.

Table 1

Parameter	**Detail**
Engine type	Single cylinder gasoline direct injection engine
Displaced volume	500 cc
Bore/ Stroke	86 mm/ 86 mm
Valve system	Double overhead camshaft operated valves
Connecting Rod length	146 mm
Compression ratio	10.5:1
MBT (ST)	24^{o} bTDC
Rated torque	30 Nm @ 2000 rpm
Maximum engine speed	3000 rpm

Table 2

Parameter	**Detail**
Manufacturer	Dynomerk Controls, India
Rated speed	2500 rpm
Maximum speed	7000 rpm
Maximum torque	137.5 Nm
Motor type	AC Servo-motor
Encoder	2500 PPR
Motoring ability	Yes
Inertia	Lower than DC dynamometer
Control stability	Excellent
Speed capability	High

It employs a 6-hole GDI injector (Bosch, GDI HDEV5). A fully programmable MOTEC open ECU (M400) controls the fuel injection quantity, fuel injection timing and spark timing. A peak and hold injector driver module (ZB-5100G, Zenobalti) connected to engine via open ECU, is used to operate the injector upon triggered by the encoder signal. For combustion analysis, a spark plug pressure transducer (ZI31_Y5S, AVL) is connected to a data acquisition (DAQ) system (Indi-micro, AVL). This DAQ system has an in-built charge amplifier, which converts the charge into voltage and provides the in-cylinder pressure signal. Crank angle position is measured by an optical crank angle encoder (365C, AVL) which gives 720 pulses per revolution.

Sensors for lubricating oil pressure and temperature, barometric pressure, coolant in and coolant out temperatures, exhaust gas temperature and engine speed (rpm) are installed on the engine. Connections of the ECU include sensors for reference trigger, synchronization trigger, throttle position, manifold pressure, engine temperature, intake air temperature and narrow band lambda sensor. Various sensors and actuators connected to engine via ECU are shown in Fig 3.

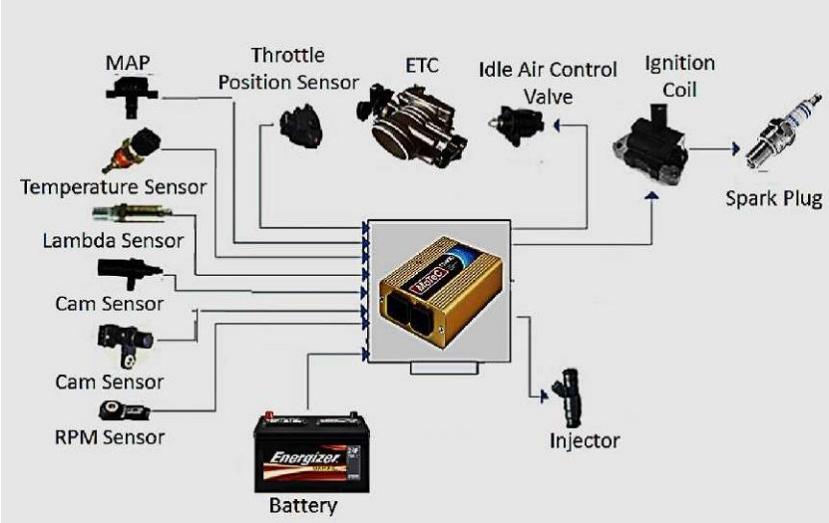

Fig 3: Open ECU with sensors and wiring harness (Motec M400)

Two surge tanks are used at inlet and outlet side of engine to damp the pulsation created by the intake and exhaust strokes in a combustion cycle. The setup also includes fuel conditioning and metering unit, lubricating oil and coolant conditioning unit.

Research work on GDI setup

Performance, Combustion and Emission Analysis of Gasoline Direct Injection Engine

Gasoline direct injection engines have become popular powertrains for passenger car segment worldwide. The technology is known for its characteristics of high power output, greater thermal efficiency and improved fuel economy. Due to its capability of being operated under two combustion mode by varying the fuel injection timing, it is emerging as a widely adopted engine technology. GDI has two combustion concepts: stratified charge operation (Part load) and homogeneous stoichiometric operation (Full load). In stratified charge operation, fuel is injected late in the compression stroke creating a rich mixture near the spark plug and overall the mixture is lean. In homogeneous stoichiometric operation, fuel is injected early in the intake stroke so that homogeneous mixture is created inside the combustion chamber. We can use homogenous mode during high torque requirement and stratified charge mode during low torque requirement.

A comprehensive set of experiments were conducted to understand the inter-relationships between gasohols and baseline gasoline in a GDI engine. In this context, three gasohols (15% (v/v) blends of methanol/ethanol/butanol with 85% (v/v) gasoline were investigated.

- Macroscopic and microscopic spray characteristics of gasohols and baseline gasoline were carried out.
- Engine performance, combustion and emission characteristics of GDI engine were investigated at different operating conditions.

- Detailed particulate morphology characterization was carried out which included ICP-OES, FE-SEM, HETEM, FTIR and Raman Spectroscopy.
- Implementation of Phase Doppler Interferometry (PDI) in an optical engine to find real time spray droplet velocity-diameter distributions at optimum engine operating conditions.
- Different primary alcohols were compared for combustion, performance and emissions characterisation in dual fuel injection mode, where alcohols were injected in port and gasoline was injected directly into the cylinder.

Optical investigation for combustion analysis in homogeneous and stratified mode of operation can be done for further detailed investigation and optimizing the engine performance.