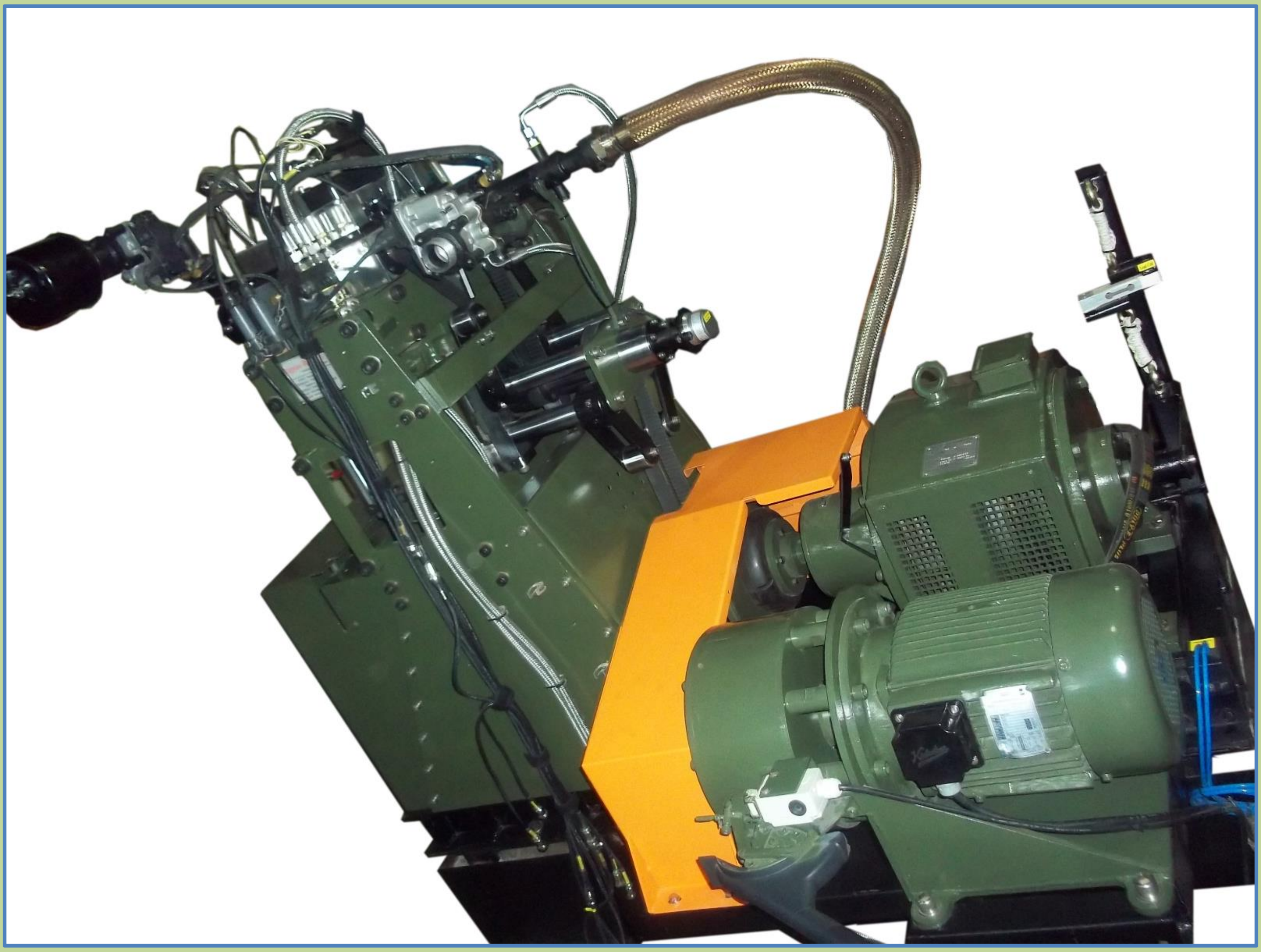
Legion Brothers
Obsessed with innovations

Optical Multi Fuel Research Engine Test Rig (Product Code: R&DU09)



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Optical Engine Specification

Single Cylinder Optical Research Engine Specification	
Bore	87.5mm (Sizes may change)
Stroke	80mm (Sizes may change)
Capacity	481cc (Sizes may change)
Compression Ratio	18:1 (in CI Mode)
Engine Speed	800-1500 rpm
Valve train	4 valves – (VVT Exhaust)
Combustion System	Legion Brothers port and combustion chamber
Fuel System	Common Rail Diesel injection (CRDI)
Fuel Type	CI Engine: Diesel and Diesel blends
Power	3HP
Lubrication	Forced
Starting	Electric start
Sapphire Liner length	15 x 35mm
Transparent Synthetic quartz window	25mm Diameter 45 deg. Mirror location in the piston for illumination or viewing
CI Fuel injection Type	Common Rail Fuel injection. Injection pressure up to 1600 bar. The fuel injection timing and length is controlled by the ECU




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DYNAMOMETER

Dynamometer Specification	
Type	Eddy Current
Cooling	Air
Load Measurement method	Strain Gauge
Max Speed	3000 rpm
Power	10 HP
Coupling Type	Cardin Shaft
Loading	Auto loading System The engine loading is automatically done through the computer.

Description of the Individual Engine Components

There are several different ways of visually accessing the combustion chamber in an internal combustion engine. Optical access is provided through a 15mm length fused silica liner and a sapphire window in the piston crown. An extended piston allows a 45° mirror to be located between the upper and lower piston crowns allowing illumination or viewing into the cylinder from below. A maximum engine speed of 1500 rpm can be achieved through the use of lightweight materials for the piston components and the use of primary and secondary balance shafts in the crankcase. The piston is manufactured from aluminium while the piston crown is made from titanium, chosen due to the similarity in thermal expansibility between titanium and sapphires.

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Engine Stationary parts

CRANKCASE

The crank case is made of cast iron and designed to withstand all condition. The crank case houses a pair of bearing, called main bearing which supports the crank shaft of the engine. The crankcase is provided with air breathing system (Backpressure valve), oil level measurement (deep stick) and oil removal provision.

CYLINDER BLOCK

The cylinder block is the main body of the engine, between the cylinder head and the crank case. The cylinder block serves as an enclosure for the cylinder and crank case. The cylinder block is made of a cast ferrous alloy. The cylinder block contains the cylinder and water jacket. The upper part of the cylinder linear of 15mm height is made of transparent Fused silica cylinder liner. This facility enables for visualizing the combustion.

MANIFOLDS

The inlet manifold is made of aluminium alloy with provision for mounting air filter and the exhaust manifold is made of cast iron and provision is made for mounting a temperature sensor of ¼” BSP.

Engine Moving parts

CRANK SHAFT

The crank shaft is made of forged steel, is located in the crank case directly below the cylinder. The crank shaft is supported in the crankcase by bearings known as main bearings. Each main bearing fits on a mass-bearing journal. The purpose of the crank shaft is to change the reciprocating motion of the flywheel.

FLYWHEEL

The flywheel is a heavy, carefully machined, perfectly balanced wheel, bolted to the crank shaft of the engine. The flywheel wheel is marked with graduation lines on the circumference from 0 to 360 degree. A mirror for reflection of graduation lines to the camera is located at the flywheel.

CONNECTING ROD

Connecting rod joins the piston to the crankshaft. The connecting rod is fastened to the piston by hollow steel pins called piston pins.

PISTON

The piston moves up and down in the cylinder. They are the first moving part to receive the push of the burning and expanding fuel in the cylinder. The top of the piston is called the piston head, the piston is an extended crosshead type piston with a flat bottomed bowl. The bowl bottom is made of transparent synthetic quartz window. One mirror is arranged under the bowl and another is set to view the fly wheel timing marks.

PITONS RINGS

Piston rings are located in the ring grooves around the head of the piston. Three purpose are served by the piston rings: they seal the space between the cylinder wall and the piston, preventing the escape of burning gases from the combustion chamber: they control the flow of oil over the cylinder walls; and they dissipate heat to the cylinder walls.

FUEL SYSTEM (OPEN LOOP MPFI)

The Open Loop MPFI system is very useful in research activity for varying the injection timing and duration of the injection. The heart of the system being the electronic injection controller (EIC).

Open Loop MPFI System consists of:-

1. Low pressure System.
2. Electronic Control Unit.
3. Crank angle Encoder.
4. Injector.

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ELECTRONIC CONTROL UNIT

The electronic control unit is a pre-programmed micro controller. The ECU is used to signal start of injection and duration of injection. The Electronic Control unit is provided with two variable controls:-

1. Start of injection: Electronic Control unit receives the signal from the crankshaft position sensor/crank angle encoder and detects the engine crank angle. The user can change the start of injection (Advance or retard) by using a graduated potentiometer knob. The potentiometer is connected to the ECU.

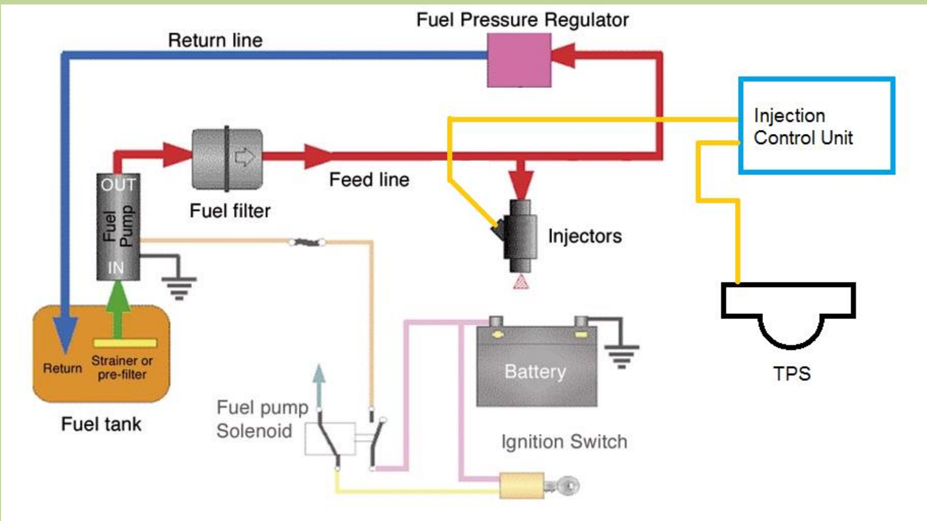
Injection Duration (Throttle): The injection duration can be also be controlled by using a graduated potentiometer knob provided on the ECU. User defined Air/Fuel Ratio is possible by adjusting the fuel flow rate.

INJECTORS

Bosch series of injector like 0280150400 etc with flow rate around 5 litres/hr is used.




Fuel Injection System



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GASOLINE DIRECT INJECTION (OPEN LOOP)

Gasoline direct-injection engines generate the air/fuel mixture in the combustion chamber. During the induction stroke, only the combustion air flows through the open intake valve. The fuel is injected directly into the combustion chamber by special fuel injectors.

Gasoline direct-injection systems are characterized by injecting the fuel directly into the combustion chamber at high pressure. As in a diesel engine, air/fuel-mixture formation takes place inside the combustion chamber (internal mixture formation).

High-pressure generation

The electric fuel pump delivers fuel to the high-pressure pump at a pre-supply pressure of 3...5 bar. The latter pump generates the system pressure depending on the engine operating point (requested torque and engine speed). The highly pressurized fuel flows into and is stored in the fuel rail. The fuel pressure is measured with the high-pressure sensor and adjusted via the pressure-control valve or the fuel-supply control valve integrated, between 70-100 bars. These injectors are actuated by the engine ECU and spray the fuel into the cylinder combustion chambers.

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Common Rail Diesel Injection Fuel System for Diesel Fuel

The variable injection timing kit is an attachment to any Single Cylinder Diesel engine for varying the injection timing, the VIT kit is supplied complete with all components of a CRDI system, the heart of the system being the electronic injection controller (EIC).

Variable Injection Timing Kit consists of:-

1. Low pressure System
2. High Pressure System
3. Electronic Control Unit
4. Crank shaft position sensor
5. Injector

Low pressure system

The low pressure circuit is used to transport the fuel from the fuel tank to the high pressure pump. The low pressure circuit consists of:-

a. Fuel Tank
b. Pre-supply pump: The pre-supply is electric driven pump. The INTERNAL-GEAR is a push/pull design similar to the roller except with limited pressure sustainability and flow volume. In this design an inner gear turns within a stationary outer gear creating the pulling/pushing of fuel. This design is most often used in "in-tank" fuel pumps. The pre-supply pump is used to transport the fuel from the fuel tank to the high pressure pump. a nylon filter is provided at the suction of the pre-supply pump.

c. Fuel Filter: The fuel filter which is installed between the pre-suction pump and high pressure pump, removes dirt and contaminants from fuel before it is delivered to the high pressure pump.

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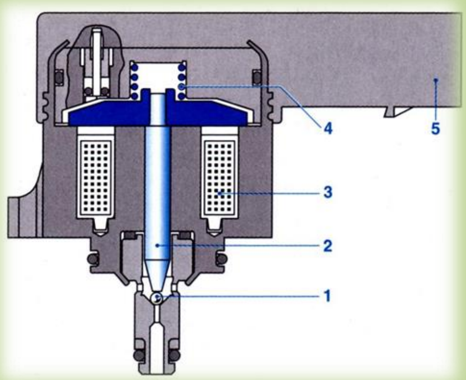
The high Pressure System

High pressure circuit is used generate a constant unvarying high pressure in the high pressure accumulator (the rail) and send the excess fuel back to the fuel tank.

The high pressure pump is coupled to a 5HP 3 Phase motor, because the kit is a standalone system and can be used for any engine for electronic fuel injection purpose. Fuel pressures of up to 500 Bar are generated by the high pressure pump. This pump, which is driven from the motor, normally comprises a radial piston design of the type shown above. The pump is lubricated by the fuel and can absorb up to 3.8kW. So that pump flow can be varied with engine load, individual pistons of the pump are able to be shut down. This is achieved by using a solenoid to hold the intake valve of that piston open. However, when a piston is deactivated, the fuel delivery pressure fluctuates to a greater extent than when all three pistons are in operation.

Pressure Control Valve



The fuel pressure control valve comprises a fuel-cooled solenoid valve. The valve opening is varied by its solenoid coil being pulse width modulated at a frequency of 1 KHz. When the pressure control valve is not activated, its internal spring maintains a fuel pressure of about 100 Bar. When the valve is activated, the force of the electromagnet aids the spring, reducing the opening of the valve and so increasing fuel pressure. The fuel pressure control valve also acts as a mechanical pressure damper; smoothing the high frequency pressure pulses emanating from the radial piston pump when less than three pistons are activated.

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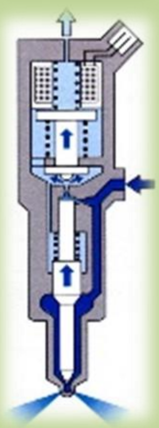
Fuel Rail

The fuel rail feeds each injector. It is made sufficiently large that the internal pressure is relatively unaffected by fuel being released from the injectors. The rail is fitted with a fuel pressure sensor. To guard against dangerously high fuel pressure, a fuel pressure relief valve is also fitted.

Injector



The fuel injectors superficially look like the injectors used in conventional petrol injection systems but in fact differ significantly. This diagram shows a common rail injector. Because of the very high fuel rail pressure, the injectors use a hydraulic servo/electromagnetic system to operate. In this design, the solenoid armature controls not the pintle but instead the movement of a small ball which regulates the flow of fuel from a valve control chamber within the injector.

Crank Shaft Position Sensor

The crank shaft position sensor provided is either a Hall Effect sensor with missing gear teeth or a laser sensor with graduation marking printed on the fly wheel. The crankshaft position sensor is designed to monitor the location of the camshaft within the engine. This information is used to fine-tune the timing of a fuel-injected engine. To detect the position of the shaft, electric induction is used. A crankshaft position sensor typically sends data to the Electronic Control unit.

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Electronic Control Unit

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2. Start of injection: Electronic Control unit receives the signal from the crankshaft position sensor and detects the engine crank angle... The user can change the start of injection (Advance or retard) by using a graduated potentiometer knob. The potentiometer is connected to the ECU.
3. Injection Duration (Throttle): The injection duration can be also be controlled by using a graduated potentiometer knob provided on the ECU.

Engine Combustion Pressure Sensor

Technical Specification

Pressure range		bar	0...100
Make	Cityzen		
Type	Piezoelectric		
Cooling	Air Cooled		
Calibration at 200 °C		bar	0...100
Sensitivity (±0.5 %)		mV/bar	25
Frequency range (-3 dB)		Hz	0,016...20‘000
Linearity		%FSO	≤± 1
Shock		g	2000
Operating temperature range	mounting location Viton cable connection max. short overload <1 h electronics	°C °C °C °C	-50...300 200 240 -10...110
Sensitivity shift	200±150 °C 200±50 °C	% %	≤± 2,5 ≤± 1

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Crank Angle Encoder

General specifications	
Pulse count (PPR)	360
Electrical specifications	
Operating voltage	5 V DC ± 5 %
No-load supply current I_0	Max. 70 mA
Output	
Output type	Pulse
Operating current	Max. per channel 20 mA , conditionally short-circuit
Output frequency	Max. 200 kHz
Rise time	100 ns
Standard conformity	
Shock resistance	DIN EN 60068-2-27, 100 g, 3 ms
Vibration resistance	DIN EN 60068-2-6, 10 g, 10 ... 2000 Hz
Ambient conditions	
Operating temperature	-20 ... 60 °C (253 ... 333 K), fixed cable
Storage temperature	lens -40 ... 70 °C (233 ... 343 K)

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Open ECU Specification

Open ECU with EGR	
ECU processor	Infineon
Crankshaft position	Crank trigger wheel
Camshaft position	Cam trigger wheel
Crank position sensor	Variable reluctance sensor
Cam position sensor	Hall effect sensor
T-map	NTC
Mass air flow	Hot wire type
Software	Engine control system
High pump	Bosch CP-1
CRDI Open ECU Capabilities	• Set idle Speed - (The user can set the required idle speed of the engine) • Closed loop control for idling - (ECU controls the injection until engine idle) • Start angle of Pilot injection - (The user can set the start of injection angle as desired) • Start angle of main injection- (The user can set the start of injection angle as desired) • Injection Duration - (The user can set the Injection duration in terms of crank angle as desired) • Open loop rail pressure - (This is an special feature in which an user can set the Injection Pressure in terms Bar, variable from 200 to 1100 bar) • EGR - (The user can set the EGR flow as desired) • Calibration charts are provided for Injection Quantity at various pressure
GDI Open ECU Capabilities	• Set idle Speed - (The user can set the required idle speed of the engine) • Closed loop control for idling - (ECU controls the injection until engine idle) • Start injection angle for homogeneous operation-(The user can set the start of injection angle as desired) • End injection angle for stratified operation-(The user can set the end of injection angle) • Start angle for spark ignition-(The user can set the spark timing) • Injection Duration - (The user can set the Injection duration in terms of crank angle as desired) • Open loop rail pressure - (This is an special feature in which an user can set the Injection Pressure in terms Bar, variable from 10 to 180 bar) • EGR - (The user can set the EGR flow as desired) • Calibration charts are provided for Injection Quantity at various pressure
PFI Open ECU Capabilities	• Set idle Speed - (The user can set the required idle speed of the engine) • Closed loop control for idling - (ECU controls the injection until engine idle) • End angle of injection - (The user can set the end of injection angle as desired) • Start angle for spark ignition-(The user can set the spark timing) • Injection Duration - (The user can set the Injection duration in terms of crank angle as desired) • Injection pressure - (3bar) • EGR - (The user can set the EGR flow as desired) • Calibration charts are provided for Injection Quantity at various pressure

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AIR FLOW RATE MEASUREMENT METHOD

Air Flow	
Type/Description	Differential Pressure Sensor
Range	0-100kgs/hr
Signal Conditioning	Standalone for each sensors

FUEL MEASUREMENT

Fuel flow rate Measurement method	
Type/Description	Liquid Level Sensor
Range	0-99 Kgs/hr.
Signal Conditioning	Standalone for each sensor

TORQUE OR LOAD MEASUREMENT METHOD

Torque at Dynamometer	
Type/Description	Torque is measured using a load cell transducer. The transducer is a strain gauge base. The output of the load cell is connected to the load cell transmitter. The output of the load cell transmitter is connected to the USB port through interface card.
Range	0-50 Kgs
Signal Conditioning/transmitter	Standalone

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Measurement of Temperatures at different points

Type Range Signal conditioning/transmitter Location	"K" 0-1500ºC Standalone Engine Exhaust Temperature
Type Range Signal conditioning/transmitter Location	"K" 0-300ºC Standalone Ambient

All the measured parameters from the sensor are connected to the computer

Data Acquisition Card

Analog Input	
Differential Channels	12
Resolution	12 bits
Sample Rate	200 Ks/s
Max Voltage	5 V
Number of Ranges	4
Simultaneous Sampling	Yes
On-Board Memory	5120 samples
Analog Output	
Channels	2
Digital I/O	
Input-Only Channels	30
Output-Only Channels	12
Timing	Software
Logic Levels	TTL
Maximum Input Range	0 V - 5V
Maximum Output Range	0 V - 3.3 V
Counter/Timers	
Counters	2
Max Source Frequency	84 MHz
Resolution	12 bits
Logic Levels	TTL
Total DC output Current on all I/O lines	130mA

High Speed Camera &Computer: Clients Scope

CPU	3rd generation Intel® Core™ i3-3220 processor
Operating System	Windows 8 32/64bit
Memory	4GB
Graphics	Intel® HD Graphics 2000 (integrated)
Dimensions	499 x 196 x 397 mm (19.6 x 7.7 x 15.6")
Camera	Integrated 720p HD webcam
Display	20" LCD with LED backlight panel (1600x900) (250 NIT)
ODD	Tray-in DVD reader/writer
I/O Ports	• 6 USB ports (2 USB 3.0, 4 USB 2.0) • 6-in-1 card reader (SD/SDHC/SDXC/MMC/MS/MS-Pro) • Combo jack • 10/100/1000 LAN • HDMI
Storage	Up to 1TB HDD (7,200 rpm)

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SYSTEM CAPABILITIES

Legion Brothers provide the state of the art Automatic DAQ assisted Data acquisition of the following parameters on an innovative engineered software platform “Engine Test Express”

1. Combustion Optical Diagnostics
2. Actual volume of Air.
3. Volumetric Efficiency.
4. Specific fuel consumption (SFC).
5. Brake Thermal Efficiency.
6. Brake power.
7. Heat Balance chart.
8. Mechanical efficiency.
9. Frictional Power.
10. Indicated Power.
11. PV and P-θ diagrams
12. 5% Mass Fraction Burnt Angle
13. 10% Mass Fraction Burnt Angle
14. 50% Mass Fraction Burnt Angle
15. 90% Mass Fraction Burnt Angle
16. 95% Mass Fraction Burnt Angle
17. 99% Mass Fraction Burnt Angle
18. Estimated End of Combustion Angle (EEOC)
19. Gross IMEP
20. Maximum Heat Release Rate
21. Maximum Heat Release rate crank angle
22. Maximum pressure rise rate
23. Maximum pressure rise rate crank angle
24. Maximum pressure
25. Maximum pressure crank angle
26. Start of Combustion
27. Total heat release

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