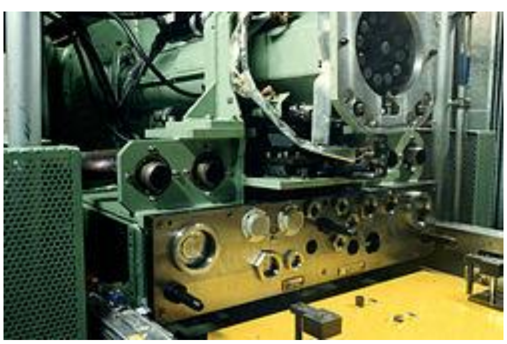
FIRING ENGINE TEST

An **engine test stand** is a facility used to develop, characterize and test engines. The facility, often offered as a product to automotive OEMs, allows engine operation in different operating regimes and offers measurement of several physical variables associated with the engine operation.

A sophisticated engine test stand houses several sensors (or transducers), data acquisition features and actuators to control the engine state. The sensors would measure several physical variables of interest which typically include:

- crankshaft torque and angular velocity
- intake air and fuel consumption rates, often detected using volumetric and/or gravimetric measurement methods
- air-fuel ratio for the intake mixture, often detected using an exhaust gas oxygen sensor
- environment pollutant concentrations in the exhaust gas such as carbon monoxide, different configurations of hydrocarbons and nitrogen oxides, sulfur dioxide, and particulate matter
- temperatures and gas pressures at several locations on the engine body such as engine oil temperature, spark plug temperature, exhaust gas temperature, intake manifold pressure
- atmospheric conditions such as temperature, pressure, and humidity

Engine test stand applications



Engine Test Stand with WALTHER-PRAEZISION Multicoupling System

- Research and Development of engines, typically at an OEM laboratory
- Tuning of in-use engines, typically at service centers or for racing applications
- End of production line at an OEM factory. The changing of the engines to be tested takes place automatically, and fluid, electrical and exhaust gas lines are connected to the test stand and engine and disconnected from them by means of docking systems. When the engine docks in the test stand the mechanical drive shaft is automatically connected to it.

Engine testing for research and development

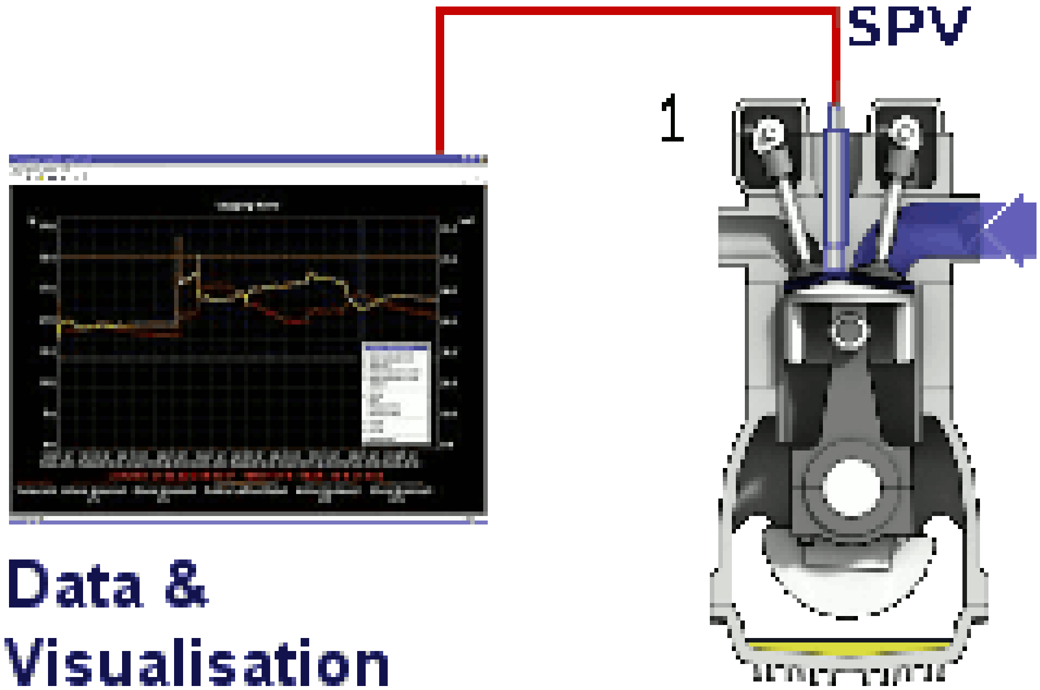
Research and Development (R&D) activities on engines at automobile OEMs have necessitated sophisticated engine test stands. Automobile OEMs are usually interested in developing engines that meet the following threefold objectives:

- to provide high fuel efficiency
- to improve drivability and durability
- to be in compliance to relevant emission legislation

Consequently, an R&D engine test stands allow for a full-fledged engine development exercise through measurement, control and record of several relevant engine variables.

Typical tests include ones that:

- determine fuel efficiency and drivability: torque-speed performance test under steady-state and transient conditions
- determine durability: ageing tests, oil and lubrication tests
- determine compliance to relevant emission legislations: volumetric and mass emission tests over stated emission test cycles
- gain further knowledge about the engine itself: engine mapping exercise or development of multidimensional input-output maps among different engine variables. e.g. a map from intake manifold pressure and engine speed to intake air flow rate.



Scavenging Methods

Since one engine cycle in a two-stroke engine is completed in one crankshaft rotation, gas exchange has to occur while the piston is near BDC. There are two important consequences of this:

Since gas exchange commences before and ends after BDC, a portion of the expansion and compression stroke is unusable.

Piston velocity is low during the entire gas exchange phase and is unable to provide a significant pumping effect on the cylinder charge. Hence, gas exchange can only occur when the intake pressure is sufficiently higher than the exhaust pressure to allow the incoming fresh charge to displace the burned gas in the time available. This process of simultaneously purging exhaust gas from the previous cycle and filling the cylinder with fresh charge for a new cycle is referred to as scavenging. To ensure adequate scavenging, two-stroke engines must be equipped with some form of intake air compression and the intake and exhaust ports and/or valves must be open simultaneously for a sufficient period of time.

Both valves in the cylinder head and ports in the cylinder liner are applied as gas exchange control elements. In the case of ports, the piston also assumes the function of a control slide.

Scavenging in two-stroke engines is performed mainly by one of three methods:

Cross-scavenging

Loop-scavenging

Uniflow-scavenging

Gasoline direct injection

The gasoline is highly pressurized, and injected via a common rail fuel line directly into the combustion chamber of each cylinder, as opposed to conventional multipoint fuel injection that injects fuel into the intake tract or cylinder port. Directly injecting fuel into the combustion chamber requires high-pressure injection, whereas low pressure is used injecting into the intake tract or cylinder port.

In some applications, gasoline direct injection enables a stratified fuel charge (ultra lean burn) combustion for improved fuel efficiency, and reduced emission levels at low load.`

Ultra lean burn or **stratified charge** mode is used for light-load running conditions, at constant or reducing road speeds, where no acceleration is required. The fuel is not injected at the intake stroke but rather at the latter stages of the compression stroke. The combustion takes place in a cavity on the piston's surface which has a toroidal or an ovoidal shape, and is placed either in the center (for central injector), or displaced to one side of the piston that is closer to the injector. The cavity creates the swirl effect so that the small amount of air-fuel mixture is optimally placed near the spark plug. This stratified charge is surrounded mostly by air and residual gases, which keeps the fuel and the flame away from the cylinder walls. Decreased combustion temperature allows for lowest emissions and heat losses and increases air quantity by reducing dilation, which delivers additional power. This technique enables the use of ultra-lean mixtures that would be impossible with carburetors or conventional fuel injection

Stoichiometric mode is used for moderate load conditions. Fuel is injected during the intake stroke, creating a homogeneous fuel-air mixture in the cylinder. From the stoichiometric ratio, an optimum burn results in a clean exhaust emission, further cleaned by the catalytic converter.

Full power mode is used for rapid acceleration and heavy loads (as when climbing a hill). The air-fuel mixture is homogeneous and the ratio is slightly richer than stoichiometric, which helps prevent pinging. The fuel is injected during the intake stroke.

Drawbacks of gasoline direct injection

Although direct injection provides more power and efficiency, a carbon build-up occurs in the intake valves that over time reduces the airflow to the cylinders, and therefore reduces power. Fuel contains various detergents and can keep the intakes clean. When fuel is no longer being sprayed in the intake valves, small amounts of dirt from intake air and blowback carbon from the crankcase ventilation system cakes on the intake walls, even with air filters that prevent most of the dirt from entering the cylinder. This build-up can become severe enough that a piece can break off and has been known to burn holes in catalytic converters. It can also cause sporadic ignition failures. These problems have been known for some time and technologies have been improved to reduce the carbon build-up.

Theory of operation

The major advantages of a GDI engine are increased fuel efficiency and high power output. Emissions levels can also be more accurately controlled with the GDI system.

GDI engine operates into two modes

1) overall lean equivalence ratio composition during low load and low speed operation. 2) Homogeneous stoichiometric mode at higher loads and at all loads and higher speed. At medium load region charge is lean or stoichiometric. The combustion system are classified into air guided, wall guided and spray guided system.

The engine management system continually chooses among three combustion modes: **ultra lean burn**, **stoichiometric**, and full power output. Each mode is characterized by the air-fuel ratio. The stoichiometric air-fuel ratio for gasoline is 14.7:1 by weight (mass), but ultra lean mode can involve ratios as high as 65:1 (or even higher in some engines, for very limited periods). These mixtures are much leaner than in a conventional engine and reduce fuel consumption considerably.