TVET CERTIFICATE III IN AUTO ENGINE TECHNOLOGY

AUTOMOTIVE ENGINE OVERHAULING

AUTEO301

Overhaul automotive engine

Competence

RTQF LEVEL: 3

Learning hours: 40

Credits: 4

Sector: Transport and Logistics

Sub-sector: Automobile

Module Note Issue date: October, 2020

Purpose statement

This particular module describes the performance outcomes, skills and knowledge required to repair the motor vehicle engine. It is very core to every mechanic to demonstrate the understanding of the working principle of the engine, to disassemble, inspect and assemble the engine components.

Table of Contents

Total Number of Pages: 108

Learning unit 1 –Demonstrate the understanding of the working principle of the engine

Introduction

An overhaul engine is one that has been removed, disassembled, cleaned, inspected, repaired as necessary and tested using factory service manual approved procedures. The procedure generally involves honing, new piston rings. Bearings, gaskets and oil seals. Engine overhaul is basically giving engine new life.

Overhaul means to make necessary repairs on, restore to serviceable condition. To investigateur or examine thoroughly for repair or révision

Evolution of the motor vehicle

I860 The Frenchman **Lenoir** constructs the first fully operational internal-combustion engine; this power plant relies on city gas as its fuel source. Thermal efficiency is in the 3% range.

1867 Otto and Langen display an improved internal combustion engine at the Paris International Exhibition. Its thermal efficiency is approximately 9%. (R.Gscheidle, 2006)

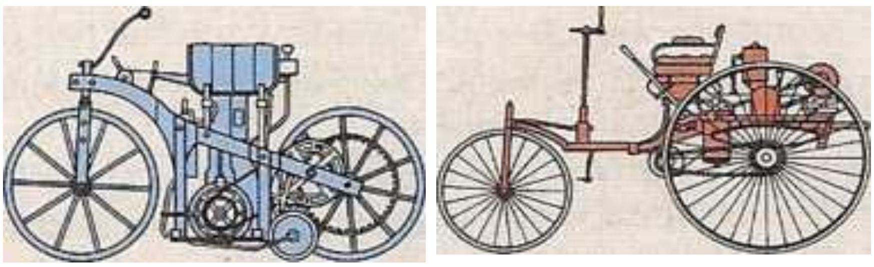


Fig. 1: Daimler motorcycle and Benz motor carriage

1876 Otto builds the first gas-powered engine to utilise the **four-stroke compression cycle.** At virtually the same time **Clerk** constructs the first gas-powered **two-stroke engine** in England.

1883 Daimler and **Maybach** develop the first high speed **four-cycle petrol engine** using a **hot-tube ignition system.**

1885 The first **self-propelled motorcycle** from **Daimler.** First **self-propelled three-wheeler** from **Benz** (patented in 1886) **(Fig. 1).**

1886 First **four-wheeled motor carriage** with **petrol engine** from **Daimler (Fig. 2).**

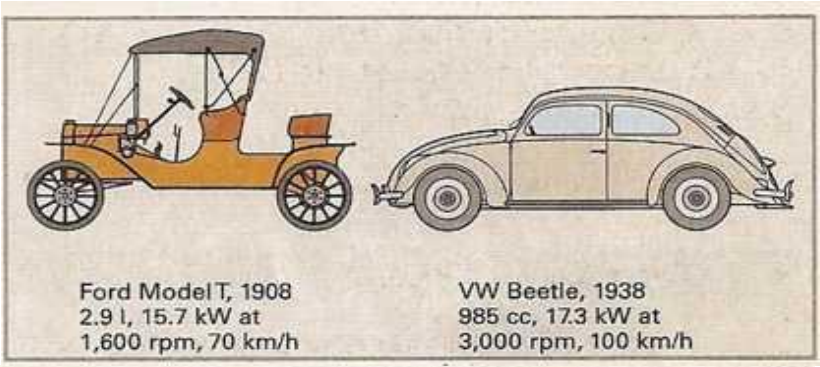
1887 Bosch invents the **magneto ignition.**

1889 Dunlop in England produces the first **pneumatic tyres.**

1893 Maybach invents the **spray-nozzle carburettor.**

1893 Diesel patents his design for a heavy oil-burning powerplant employing the self-ignition concept.

1897 MAN presents the first workable diesel engine.



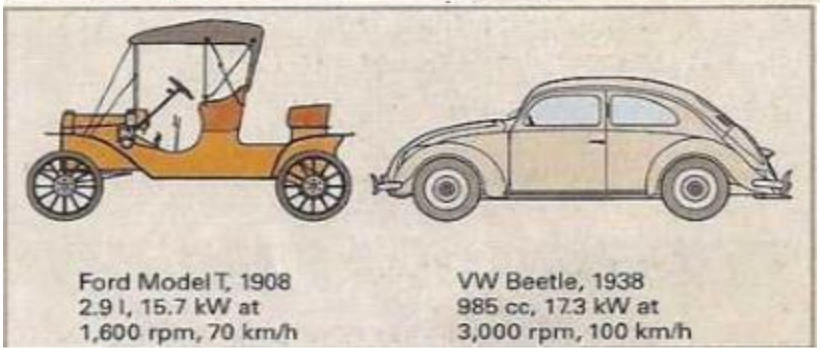


Figure2: Ford model T and VW beetle

1897 First **Electro mobile** from **Lohner-Porsche (Fig. 2).**

1899 Fiat Automobile Factory founded in Turin.

1913 Ford introduces the **production line** to automotive manufacturing. Production of the **Tin Lizzy** (Model T, **Fig. 3).** By 1925, 9,109 were leaving the production line each day.

1916 The **Bavarian Motor Works** are founded.

1923 First **motor lorry** powered by a **diesel engine** produced by **Benz-MAN (Fig. 4).**

1936 Daimler-Benz inaugurates series-production of passenger cars propelled by **diesel engines.**

1938 The **VW Works** are founded in Wolfsburg.

1949 First **low-profile tyre** and first **steel-belted radial tyre** produced by **Michelin.**

1950 First **gas-turbine** propulsion unit for automotive application makes its debut at **Rover** in England.

1954 NSU-Wankel constructs the rotary engine

1966 Electronic fuel injection (D-Jetronic) for standard production vehicles produced by **Bosch.**

1970 Seatbelts for driver and front passengers.

1978 Initial application of the **ABS Antilock Braking System** in passenger cars.

1984 Debut of the **airbag** and **seatbelt tensioning system.**

1985 Advent of a **catalytic converter** designed for operation in conjunction with closed-loop mixture control, intended for use with unleaded fuel.

1997 Electronic **suspension control systems.**

DESIGN OF MOTORVEHICLE

The motor vehicle consists of component assemblies and their individual components. The layout of the individual assemblies and their relative positions is not governed by invariable standards. Thus, for. Example, the engine may be designed as an independent assembly, or it may be integrated as a sub- assembly within a larger powertrain unit.

One of the options described in this book is to divide the vehicle into 5 main assembly groups:

Engine, drivetrain, chassis, vehicle body and electrical system.

The relationships between the assemblies and their constituent components are illustrated in

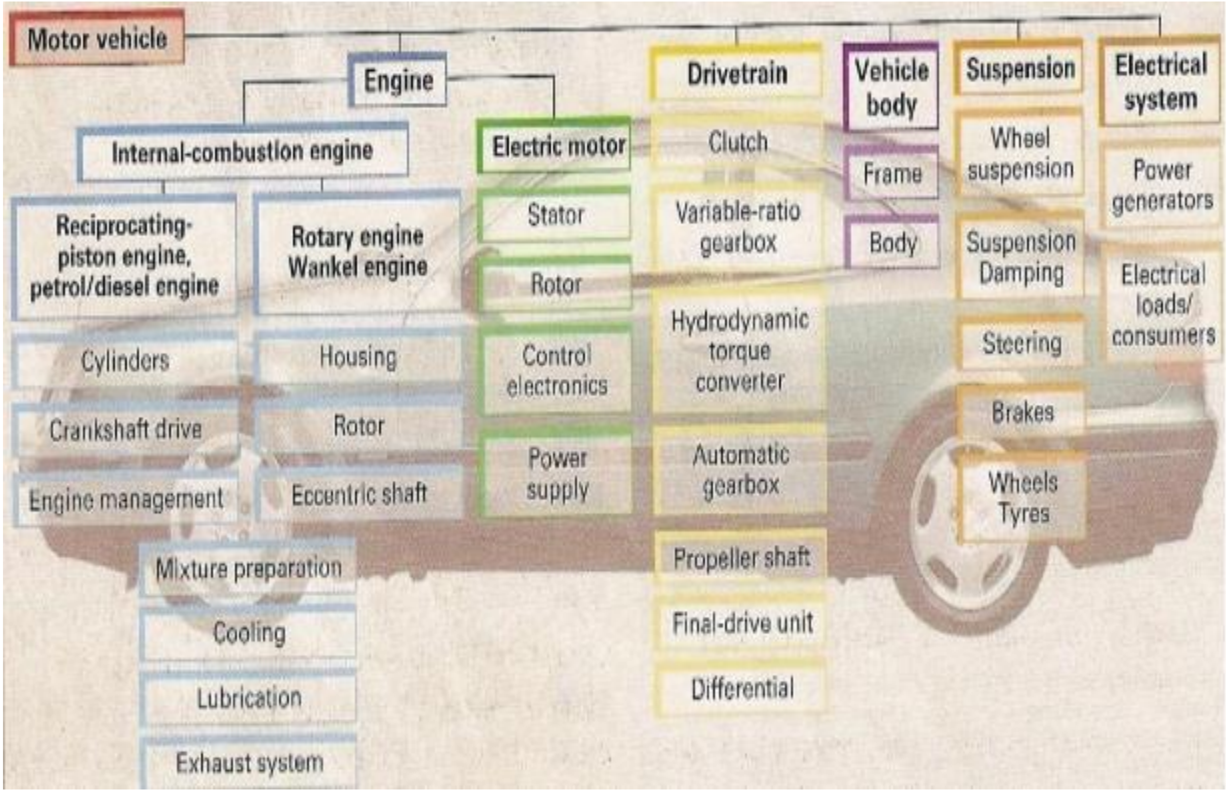


Figure3 : Design of motor vehicle

ENGINE CLASSIFICATIONS

Today's automotive engines can be classified in several ways depending on the following design Features:

- **Operational cycles**. Most technicians will generally come in contact with only four-stroke engines. However, a few older cars have used and some cars in the future will use a two-stroke engine.
- **Number of cylinders**. Current engine designs include 3-, 4-, 5-, 6-, 8-, 10-, and 12-cylinder engines.
- **Cylinder arrangement**. An engine can be flat (opposed), inline, or V-type. Other more complicated designs have also been used.
- **Valve train type**. Engine valve trains can be either the **overhead camshaft (OHC)** type or the camshaft in-block **overhead valve (OHV)** type. Some engines separate camshafts for the intake and exhaust valves. These are based on the OHC design and are called **double**

overhead camshaft (DOHC) engines. V-type DOHC engines have four camshafts—two on each side.

- **Ignition type**. There are two types of ignition systems: spark and compression. Gasoline engines use a spark ignition system. In a spark ignition system, the air-fuel mixture is ignited by an electrical spark. Diesel engines, or compression ignition engines, have no spark plugs. A diesel engine relies on the heat generated as air is compressed to ignite the air-fuel mixture for the power stroke.
- **Cooling systems**. There are both air-cooled and liquid-cooled engines in use. Nearly all of today's engines have liquid-cooling systems.
- **Fuel type**. Several types of fuel currently used in automobile engines include gasoline, natural gas, methanol, diesel, and propane. The most commonly used is gasoline although new fuels are being tested.

(R.Gscheidle, 2006)

LO 1.1 – Demonstrate the understanding of the design and operating principle of a four stroke engine

- **Content/Topic 1 Demonstration of design and operating principle of spark ignition engine**

CATEGORISATION OF COMBUTION ENGINES

By mixture formation and ignition:

Spark-ignition engines. These are run preferably on petrol and with external or even internal mixture formation. Combustion is initiated by externally supplied ignition (spark plug).

Diesel engines. These have internal mixture formation and are run on diesel fuel. Combustion in the cylinder is initiated by auto-ignition.

By operating principle:

Four-stroke engines. These have a closed (separate) gas exchange and require four piston strokes or two crankshaft revolutions for one power cycle.

Two-stroke engines. These have an open gas exchange and require two piston strokes or one crankshaft revolution for one power cycle.

By cylinder arrangement (Fig. 1):

- In-line engines
- Opposed-cylinder engines
- V-engines
- VR-engines

By piston stroke:

- Reciprocating engines
- Rotary engines

By cooling

- Liquid-cooled engine
- Air-cooled engines

2.1SPARK-IGNITION ENGINE

The spark-ignition engine is an internal-combustion engine which converts chemical energy into thermal energy by burning fuel and then converts the thermal energy into mechanical energy via a piston.

The spark-ignition engine **(Fig. 2)** consists primarily of four assemblies and additional auxiliary installations:

- **Engine case:** Cylinder-head cover, cylinder head, cylinder, crankcase, oil pan
- **Crankshaft drive:** Piston, connecting rod, crankshaft
- **Engine timing**: Valves, valve springs, rocker arms, rocker-arm shaft, camshaft, timing gears, timing *chain* or toothed belt
- **Mixture-formation:** Injection system or carburetor, intake pipe
- **Auxiliary installation:** Ignition system, engine lubrication, engine cooling, exhaust system, if necessary supercharging system.

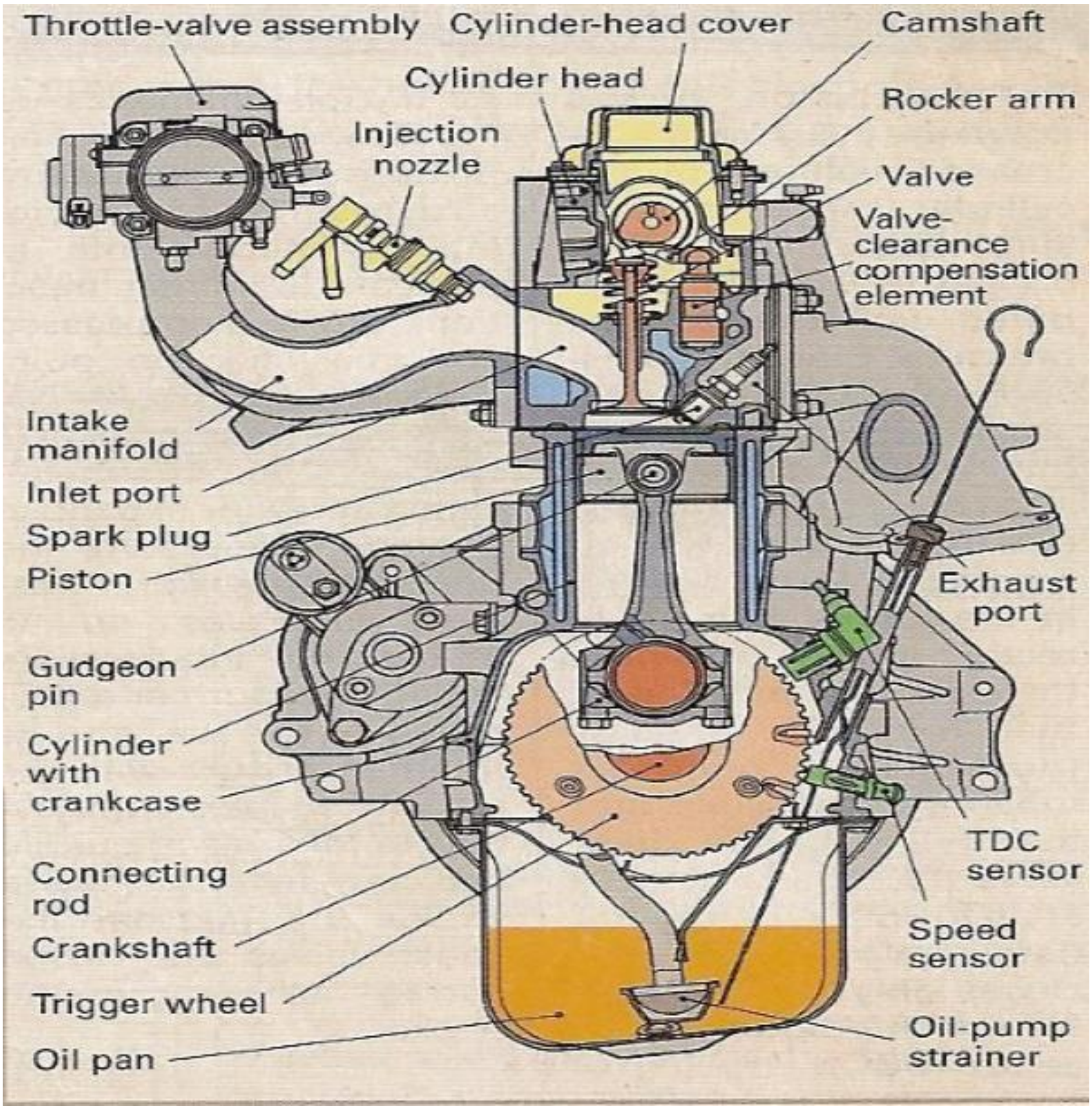


Figure4 : structure of a four stroke-spark ignition engine

Operating principle of spark-ignition engine

The four stroke of the power cycle are induction, compression, combustion and exhaust. One power cycle takes a place in two crankshaft revolutions (720^0 crank angle).

(R.Gscheidle, 2006)

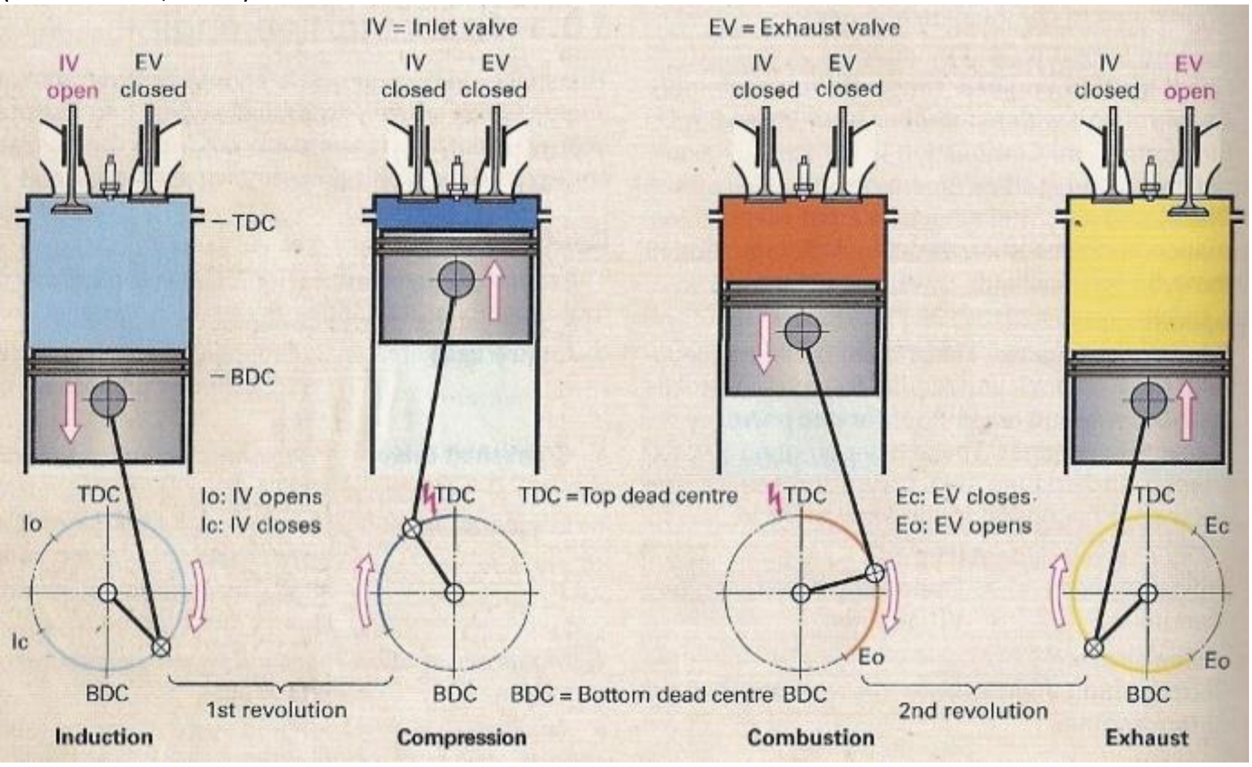


Figure 5: The four stroke of the power cycle

1. INDUCTION STROKE

The **intake valve** is open and the piston inside the cylinder travels downward, drawing a mixture of air and fuel into the cylinder. The crankshaft rotates 180 degrees from **top dead center (TDC)** to bottom dead center **(BDC)** and the camshaft rotates 90 degrees.

2. COMPRESSION STROKE

As the engine continues to rotate, the intake valve closes and the piston moves upward in the cylinder, compressing the air-fuel mixture. The crankshaft rotates 180 degrees from bottom dead center (BDC) to top dead center (TDC) and the camshaft rotates90 degrees.

3. COMBUSTION STROKE

When the piston gets near the top of the cylinder, the spark at the spark plug ignites the air-fuel mixture, which forces the piston downward. The crankshaft rotates 180 degrees from top dead center (TDC) to bottom dead center (BDC) and the camshaft rotates 90 degrees.

4. EXHAUST STROKE

The engine continues to rotate, and the piston again moves upward in the cylinder. The exhaust valve opens, and the piston forces the residual burned gases out of the **exhaust valve** and into the exhaust manifold and exhaust system. The crankshaft rotates 180 degrees from bottom dead center (BDC) to top dead center (TDC) and the camshaft rotates 90 degrees.

FEATURES OF SPARK IGNITION ENGINE

Running on petrol or gas

Mixture formation

External mixture formation, the fuel –air mixture is formed in the carburetor or in the intake manifold outside the cylinder.

Internal mixture formation, initially only air is admitted into the cylinder during the induction stroke. The fuel –air mixture is formed during the induction or compression stroke by the injection of fuel into the cylinder

Externally supplied ignition

Constant volume combustion

Combustion takes place in a virtually constant volume thanks to the sudden combustion of the fuel-air mixture.

Quantity regulation

The quantity of fuel-air mixture is altered according to the position of the throttle valve (load state)

Charge

Charge refers to the mass of the gases (fuel-air mixture or air) flowing into the cylinder during the induction stroke.

Charge improvement

In order to improve charge and with it power, it is possible to extend the opening times of the inlet valve from 180^0crank angle (corresponding to the piston stroke) to up to315^0crank angle (CA). During the exhaust stroke, the burned gases expelled at high speed generate a suction effect. If the inlet valve is opened before the piston has reached top dead center, the mixture or the intake air can flow against the movement of the piston into the cylinder as result of the vacuum pressure.

Valve overlap

Both the inlet valve and the exhaust valve are opened in transition phase from the exhaust stroke to the induction stroke.

Volumetric efficiency

The volumetric efficiency is the ratio of fuel-air mixture actually drawn in in kg to the theoretically possible (complete) cylinder charge with fuel-air mixture.

In the case of internal mixture formation, the volumetric efficiency is the ratio of air mass drawn in to theoretically possible air charge in kg.

$$\lambda_L = \frac{m_z}{m_{th}}$$

λ_L	Volumetric efficiency
m_z	Drawn-in mass of fresh-air or fuel-air mixture in kg
m_{th}	Theoretically possible mass of fresh-air or fuel-air mixture in kg

In naturally aspirated engines, the volumetric efficiency ranges between 0.6 and 0.9 (charge 60% to 90%) while, in supercharged engines, a volumetric efficiency of 1.2 to 1.6 (charge120% to 160%) is possible.

(R.Gscheidle, 2006)

The char

ge can additionally be improved by a lower flow resistance of the fresh gases and by lower internal cylinder temperatures. This is achieved by:

- Optimally structured induction pipes
- Favourable combustion-chamber shapes
- Large inlet passages
- Several inlet valves per cylinder
- Good cooling

The charge deteriorates as a result of:

- The flow resistance of the throttle valve
- Decreasing valve opening times at high speeds
- Lower air pressure, with an increase in altitude to 100 m engine power drops by roughly10%.

Compression ratio

- **Combustion chamber,** this is the space enclosed by the cylinder, cylinder head and the piston crown. Its size changes continually during a stroke. The combustion chamber is at its largest stroke when the piston is at BDC and at its smallest when the piston is at TDC. The largest combustion chamber is composed of swept volume and compression chamber.
- **Compression space VC.** This is the smallest combustion chamber.
- **Swept volume Vh**. This is the space between the two piston dead centres TDC and BDC. **Total swept volume VH.** This is derived from the sum total of the swept volumes of the individual cylinders of an engine.

$$\textbf{Compression ratio} = \frac{\text{Swept volume + compression space}}{\text{Compression space}}$$

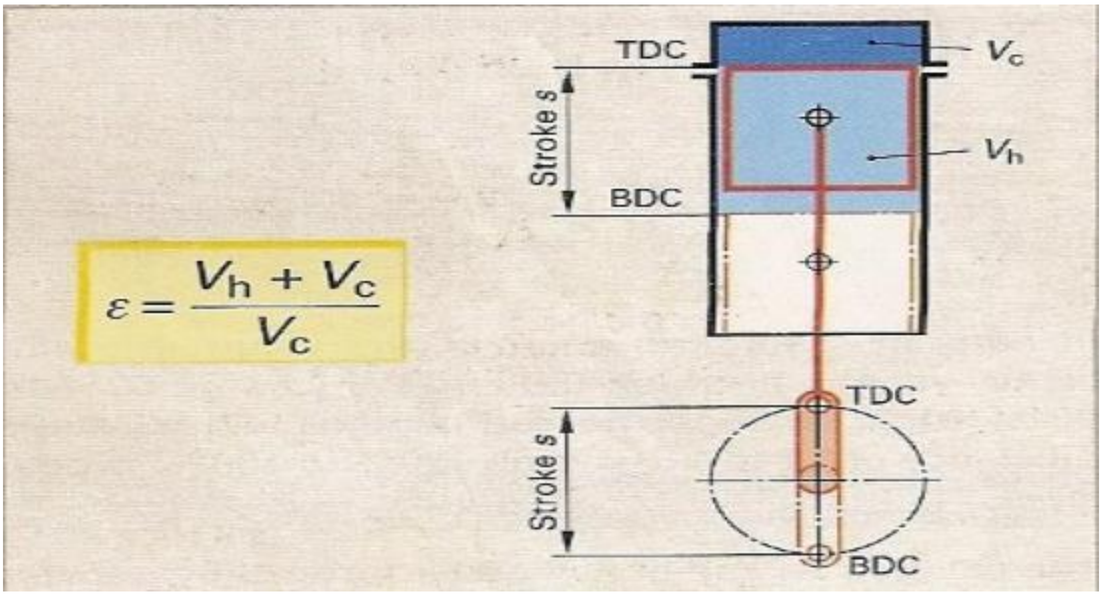


Figure 6 : Compression ratio

(R.Gscheidle, 2006)

Table 1 Compression of compression ratios		
Compression ratio	~10 bar	~16bar
Final Compression pressure	~30 bar	~42 bar
Maximum compression pressure	~ 4 bar	~ 3 bar
Pressure during operning of exhaust valve	400 °C	500 °C
Final compression temperature	~10 bar	~16bar

The higher the compression ratio of a spark-ignition engine, the better the utilisation of fuel energy and thus the engine's efficiency.

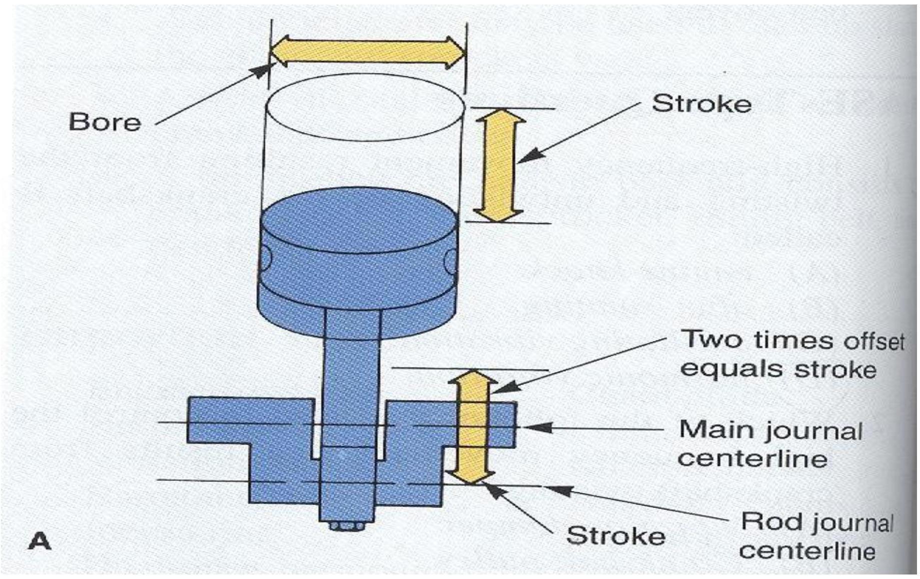


Figure 7 : Cylinder measurement

The higher the compression ratio of spark-ignition engine, the better utilization of fuel energy and thus the engine’s efficiency.

Reasons for power increase:

- Better removal of burned gases from the smaller compression space.
- Higher temperature during compression, better and more complete carburetion.
- On account of the higher compression. The burned gases can expand to a larger volume, the exhaust gas temperature decreases and less thermal energy is lost through the exhaust.

Boyle mariotte

(ERJAVEC, 2010)

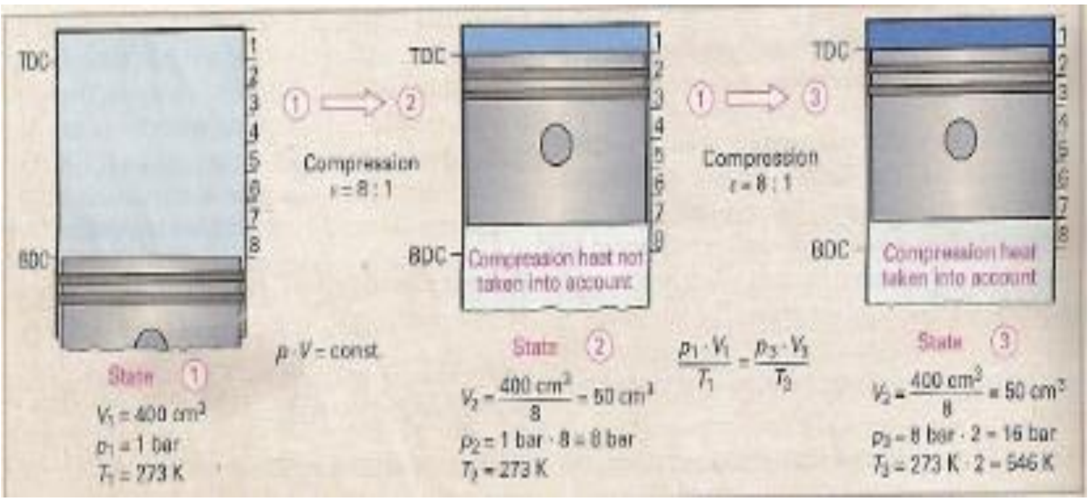


Figure8: Boyle mariotte law

Knocking combustion

A spark ignition engine will knock if the fuel-air mixture, instead of the combustion initiated by the ignition spark, ignites by itself.

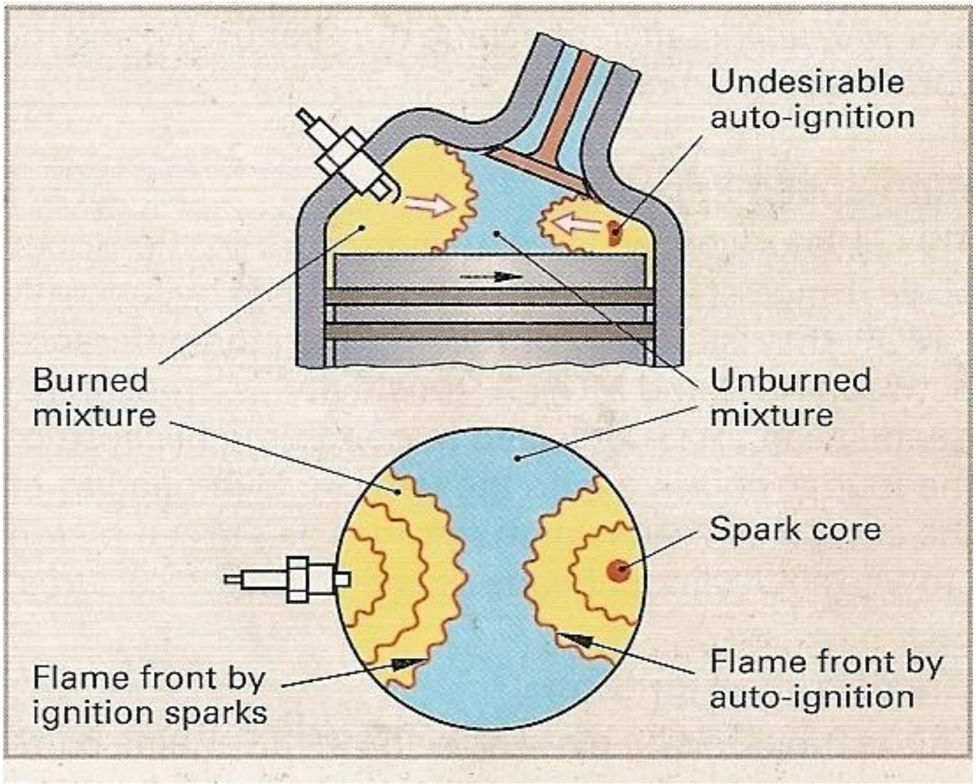


Figure9 : Knocking combustion

Causes of knocking combustion

A part from the use of unsuitable fuels, knocking can also be caused by:

- Excessive Advanced ignition.
- Uneven mixture distribution in the cylinder.
- Poorer heat dissipation due to carbon-residue deposits or faults in the cooling systems.
- An excessively high compression ratio.

Pressure-volume diagram (P-V iagram)

Spark ignition engine

The relationship between pressure, volume and temperature of gases can be carried over for the power cycle of a four-stroke spark-ignition engine into pressure volume diagram (p-v diagram).According to Boyle-Mariotte and Gay-Lussac, this produces an ideal diagram in which the volume does not change, i.e, remains constant, at the respective piston reversal points at BDC and TDC during the combustion process and the exhaust process.

Ideal constant-volume combustion calls for the following preconditions:

- The cylinder contains only fresh gases and no residual exhaust gases
- Complete combustion of the fuel-air mixture
- Loss-free charge cycle
- No heat transfer at the cylinder
- Constant volume during combustion and cooling
- The combustion chamber must be gastight (piston rings)

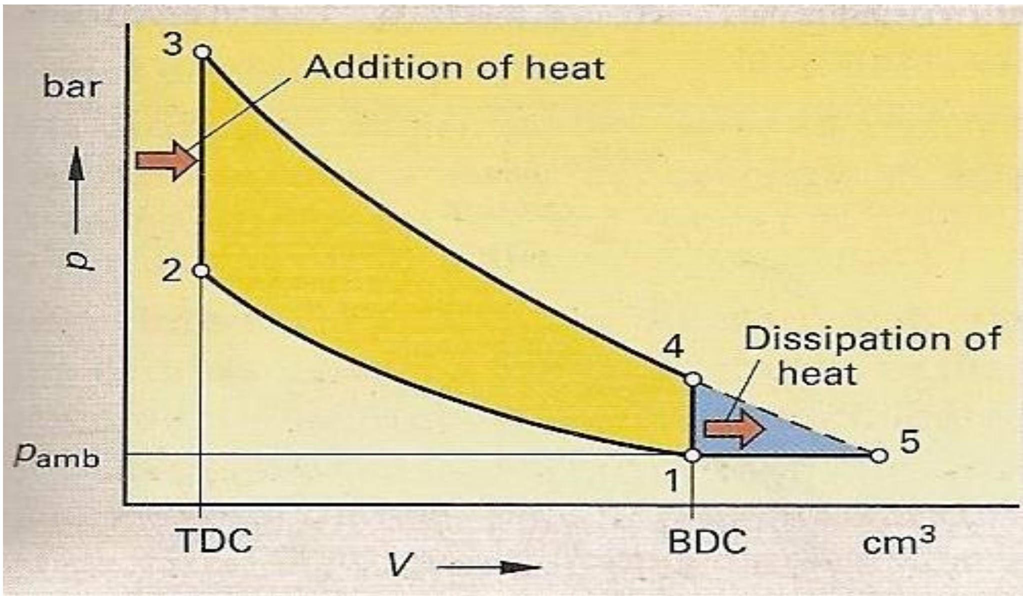


Figure 10: Ideal constant-volume process (p-v diagram)

Process sequence

1-2 Compression of the fuel-air mixture, pressure increase, no addition of heat.

2-3 Combustion of the fuel-air mixture, pressure increase with a constant volume, I.e., the piston remains for the brief period of combustion at TDC, addition of heat

3-4 Expansion. The gas under high pressure expends and moves the piston to BDC, the starting volume is reached. No addition of heat.

4-1 Cooling. The process takes places with a constant volume. The pressure drops as a result of heat dissipation until the starting pressure at point 1 is reached again.

Energy gain, energy loss

The area created in the diagram **(Fig. 10)** with the corners 1-2-3-4 reflects the work gained during a power cycle (surface +).

The work gained could be greater if the exhaust valve were not to open already at point 4 but only after the gases have expanded down to the starting pressure at point 5.

However, this is not possible in practice because extending the expansion is associated with increasing the stroke (long-stroke engine). Thus the area 1-4-5 reflects the work lost.

The work gained can be increased by increasing the compression ratio.

Diesel engine

In contrast to a spark-ignition engine, the pressure theoretically does not change during the combustion process; this phenomenon is referred to therefore as constant-pressure combustion. In reality, neither the constant-volume nor the constant-pressure process takes place in ideal circumstances because the conditions cannot be maintained.

Actual P-V diagram

The pressure characteristics during the four strokes of power cycle can be recorded with piezoelectric indicator on the running engine and displayed as a curve on the screen. Here the differences from the ideal P-V diagram can be clearly seen. In practice, the curve shapes of a spark-ignition engine and a diesel engine still differ only in the extent of the pressures

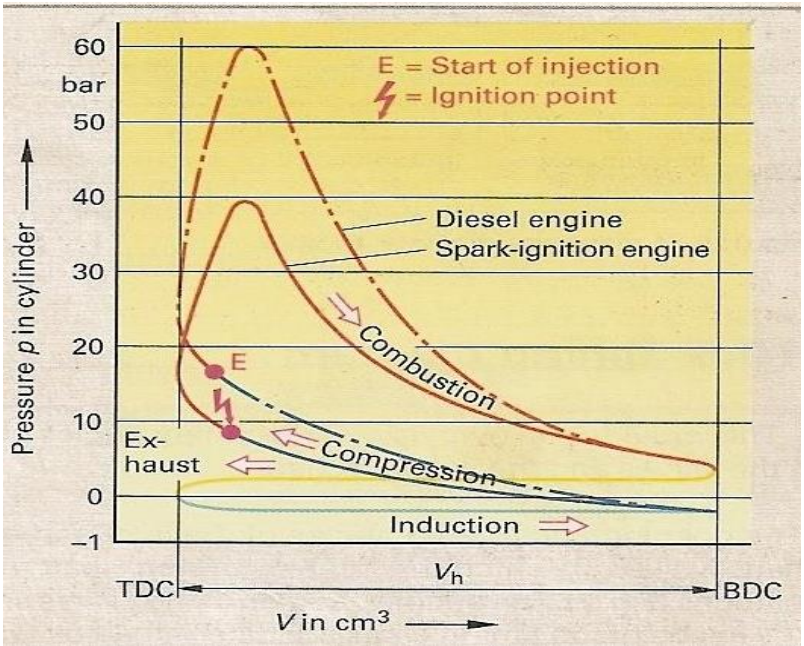


Figure 11 : Actual p-v diagram

ERROR DETECTION IN THE P-V DIAGRAM

Larger deviations from the normal pressure characteristic enable errors in the engine settings (mixture formation, spark adjustment, compression) and above all errors arising from knocking phenomena to be detected.

Ignition point too advanced:

The highest possible pressure is already reached before the piston has arrived at top dead center. The high pressures and temperatures created result in knocking combustion, poorer exhaust gas values and loss of power, which can be identified from the smaller area in the diagram.

Ignition point too retarded:

Normal rise of the compression line up to top dead center. After a short drop in the pressure after TDC, it rises again but can no longer reach the maximum combustion pressures because due to the retarded ignition point the piston has moved too far in the direction of BDC before the fuel-air mixture has burned fully. The consequences are loss power, higher fuel consumption and risk of overheating.

Leaking valves or piston rings:

Normal pressure build-up not possible, the rise of the compression line is flatter. The maximum combustion pressure cannot be reached even when the ignition point is correct. The consequences are loss of power and poorer exhaust-gas values.

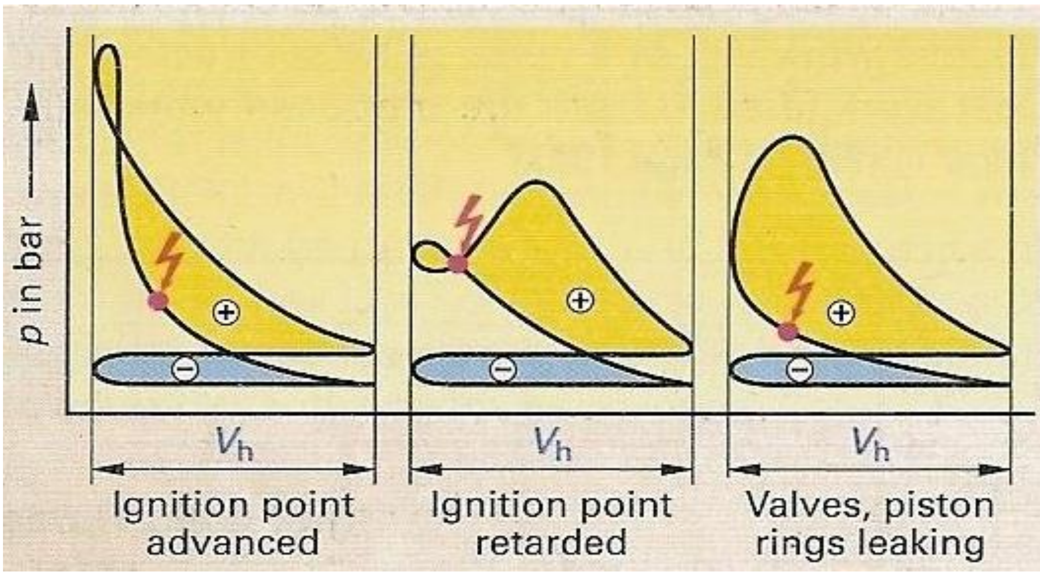


Figure 12 : P-V diagrams of faulty engines

TIMING DIAGRAM

This provides an overview of the timing angles of the valves and the valve overlap.
The opening and closing angles of the inlet and exhaust valves are entered in degrees of crankshaft revolutions**.** The opening angles of the valves and the shape of the timing cams are determined by way of tests for each type in such a way that the engine delivers the best power possible. Because this is not possible over the entire speed range, engines are equipped with adjustable inlet camshafts.The opening and closing angles of the inlet valves can be changed by a specific adjustment angle (variable timing).

The timing angles of the individual engines deviate from each other to the extent that each engine has its own timing diagram, As a rule, the angles from the opening through to the closing of the valves are greater the higher the normal running speed of the engine is.

Symmetrical timing diagram, the angles IO before TDC and EC after TDC are identical in size, as are the angles EO before BDC and IC after BDC.

(R.Gscheidle, 2006)

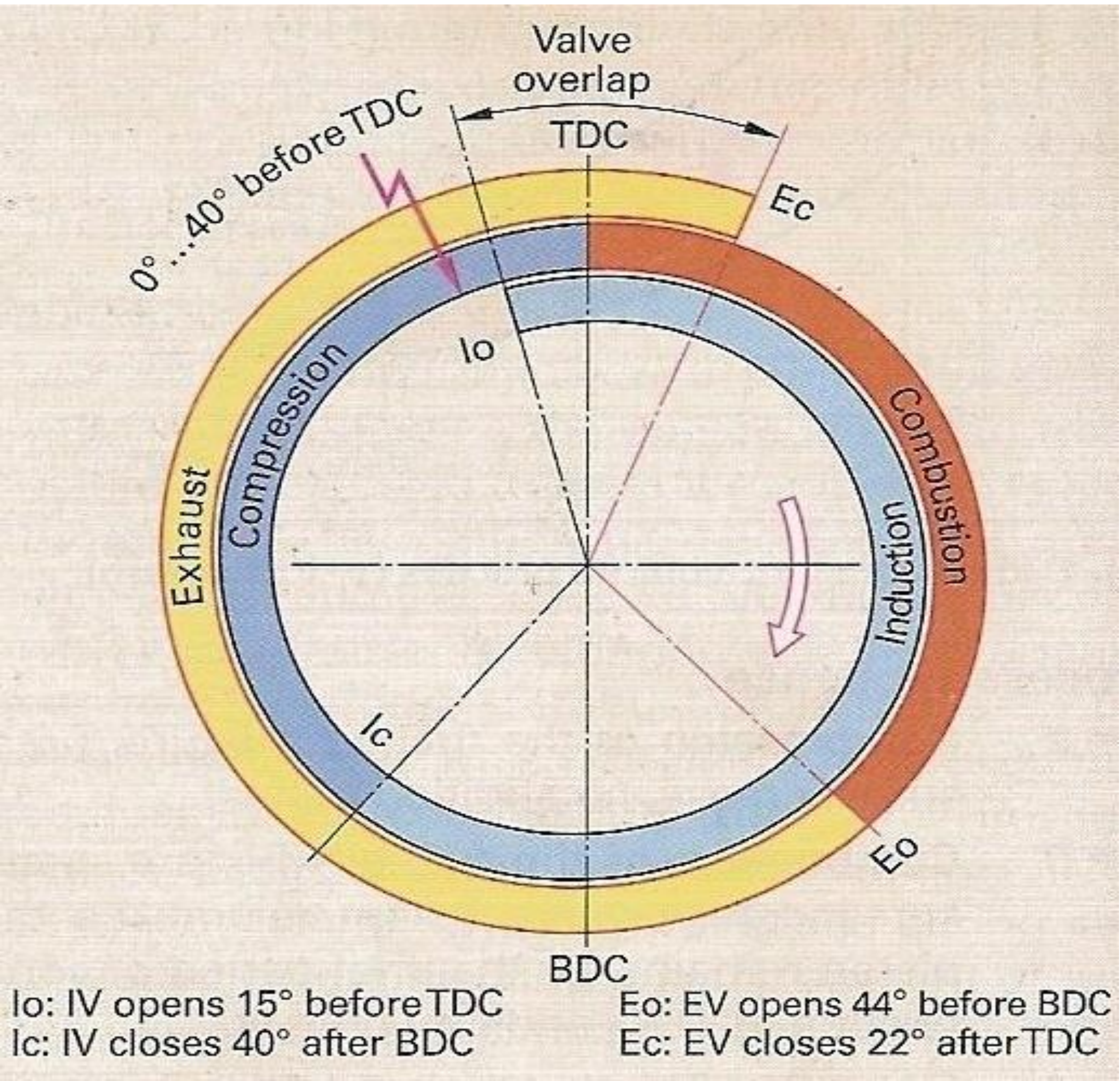


Figure 13 : Timing diagram of a four stroke spark ignition engine

CYLINDER NUMBERING, FIRING ORDERS

Cylinder numbering. The designation of the individual cylinders of an engine is standardized. The counting of the cylinders starts from the end opposite the output end. In the case of V-, VR-and opposed-cylinder engines, the counting starts on the left cylinder bank and then each bank is counted through.

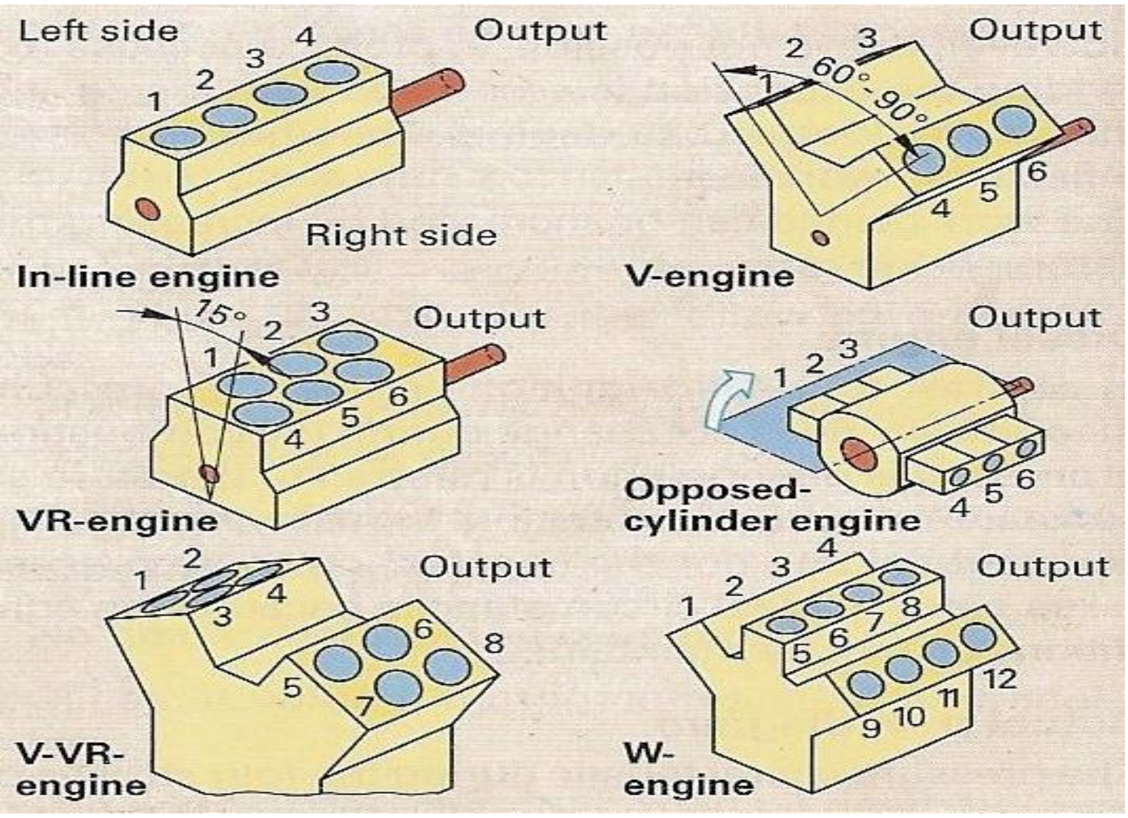


Figure 14: Cylinder numbering

COMMON CYLINDER NUMBERING AND FIRING ORDER

IN-LINE

4-Cylinder	6-Cylinder
① ② ③ ④	① ② ③ ④ ⑤ ⑥
Firing Order 1–3–4–2 / 1–2–4–3	Firing Order 1–5–3–6–2–4

V CONFIGURATION

V6		V8	
⑤ ③ ①	Right Bank	① ② ③ ④	Right Bank
⑥ ④ ②	Left Bank	⑤ ⑥ ⑦ ⑧	Left Bank
Firing Order	1–4–5–2–3–6	Firing Order	1–5–4–8–6–3–7–2
② ④ ⑥	Right Bank	① ② ③ ④	Right Bank
① ③ ⑤	Left Bank	⑤ ⑥ ⑦ ⑧	Left Bank
Firing Order	1–6–5–4–3–2	Firing Order	1–5–4–2–6–3–7–8
① ② ③	Right Bank	② ④ ⑥ ⑧	Right Bank
④ ⑤ ⑥	Left Bank	① ③ ⑤ ⑦	Left Bank
Firing Order	1–2–3–4–5–6	Firing Order	1–8–4–3–6–5–7–2
① ② ③	Right Bank	② ④ ⑥ ⑧	Right Bank
④ ⑤ ⑥	Left Bank	① ③ ⑤ ⑦	Left Bank
Firing Order	1–4–2–3–5–6	Firing Order	1–8–7–2–6–5–4–3

Figure15 : Cylinder numbering and firing order

FIRING ORDER AND IGNITION INTERVAL IN MULTIPLE CYLINDER ENGINES

Firing order This indicates the order in which the power strokes of the individual cylinders of an engine follow each other.

Ignition interval

This indicates the interval in crank angles degrees in which the power strokes or the firing operations of the individual cylinders follow each other. The greater the number of cylinders, the smaller the ignition interval. Engine operation becomes smoother and the torque output is more regular.

$$\text{Ignition interval} = \frac{720^\circ\ \text{CA}}{\text{Cylinder number}}$$

Example: In the case of a 5-cylinder engine, the ignition interval is calculated from 720^{0}CA: 5=144^{0}CA.

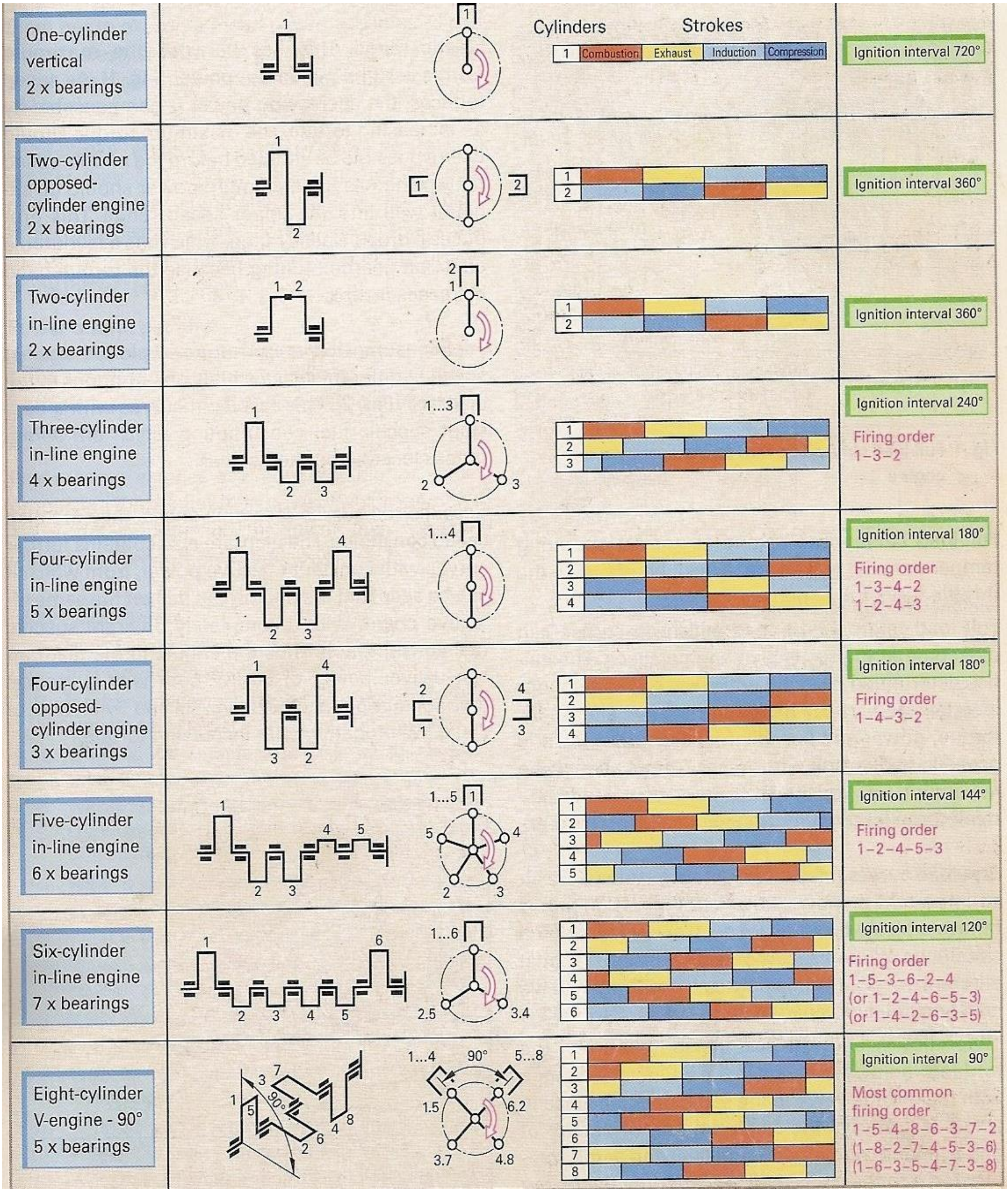


Figure 16 : Crankshaft designs, firing and power stroke order

Engine performance curves

The characteristic of an engine is derived from the measured values for power, torque and specific fuel consumption determined on the test bench at different speeds.

When these measured values are plotted in a chart against the speeds, the curves located by the corresponding measuring points produce the engine performance curves.
There are full-load and part-load curves.

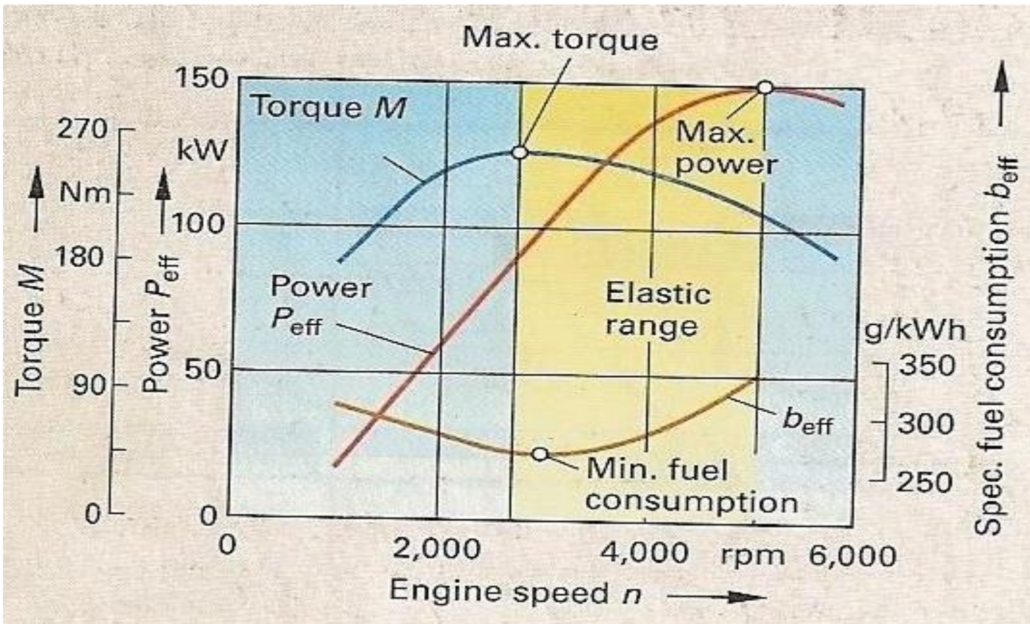


Figure 17 : Full-load curves of a four-stroke spark-ignition

Full-load curves. Full-load refers to the load which an engine can overcome at the respective engine speed; the throttle valve is full open. It is possible to determine from these curves shapes the maximum torque, the maximum power and the minimum fuel consumption for an allocated speed.
Part-load curves. Measurements at part load are also important in view of the fact that an engine is rarely subjected to full load in everyday driving conditions. The throttle valve is only partially opened in these tests.
Elastic range. This lies between the maximum torque and the minimum power. As speed reduces, the decreasing power is compensated by an increasing torque.

- Content/Topic 2 Demonstration of design and operating principle of diesel engine

Like the spark-ignition engine, the diesel engine is an internal-combustion engine.
A **diesel engine** (also known as a **compression-ignition engine**) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel that has been injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to gasoline), which uses a spark plug to ignite an air-fuel mixture. The engine was developed by German inventor Rudolf Diesel in 1892. The diesel engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) can have a thermal efficiency that exceeds 50%.

1. DESIGN

The diesel engine, like the spark-ignition ensile, consists primarily of four assemblies and additional auxiliary installations: Engine case Crankshaft drive, Engine timing
Fuel system with fuel-injection equipment, fuel-supply pump, fuel filter, high-pressure injection system, e.g.: common-rail system - unit-injector system.

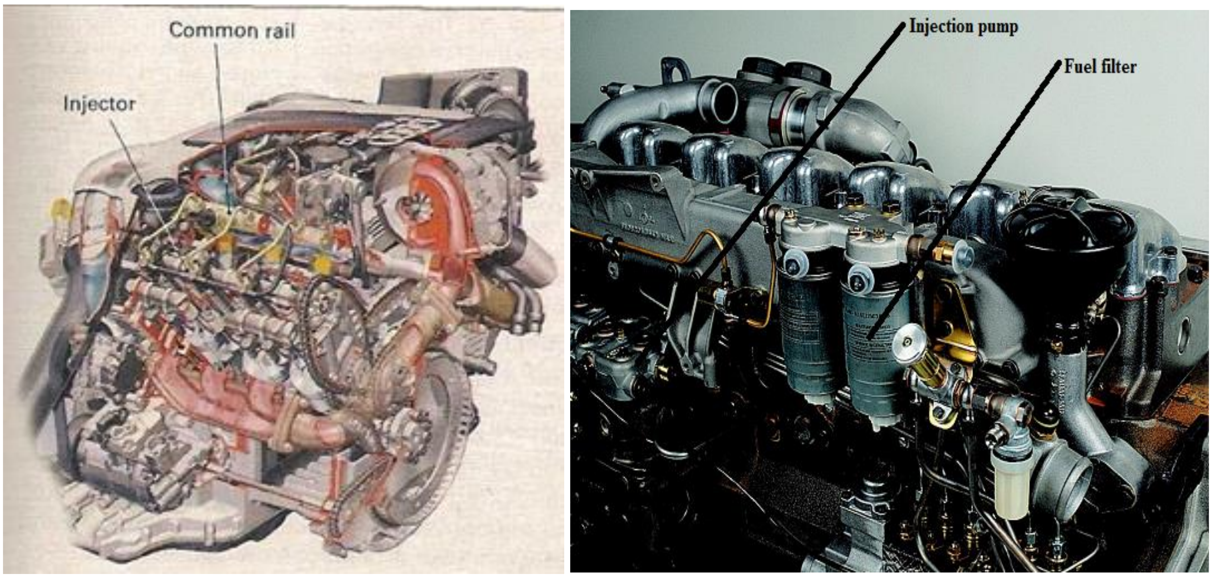


Figure18:diesel engine

FEATURE OF DIESEL ENGINE

Running on diesel or biodiesel fuel

Internal mixture formation

Only air is admitted into the cylinder during the induction stroke. The fuel-air mixture is formed during the compression stroke by the injection of fuel under high pressure into the cylinder.

Auto-ignition

Immediately after being *injected,* the fuel is automatically ignited on the air, which has been rendered extremely hot by compression. The final compression temperature exceeds the ignition temperature.

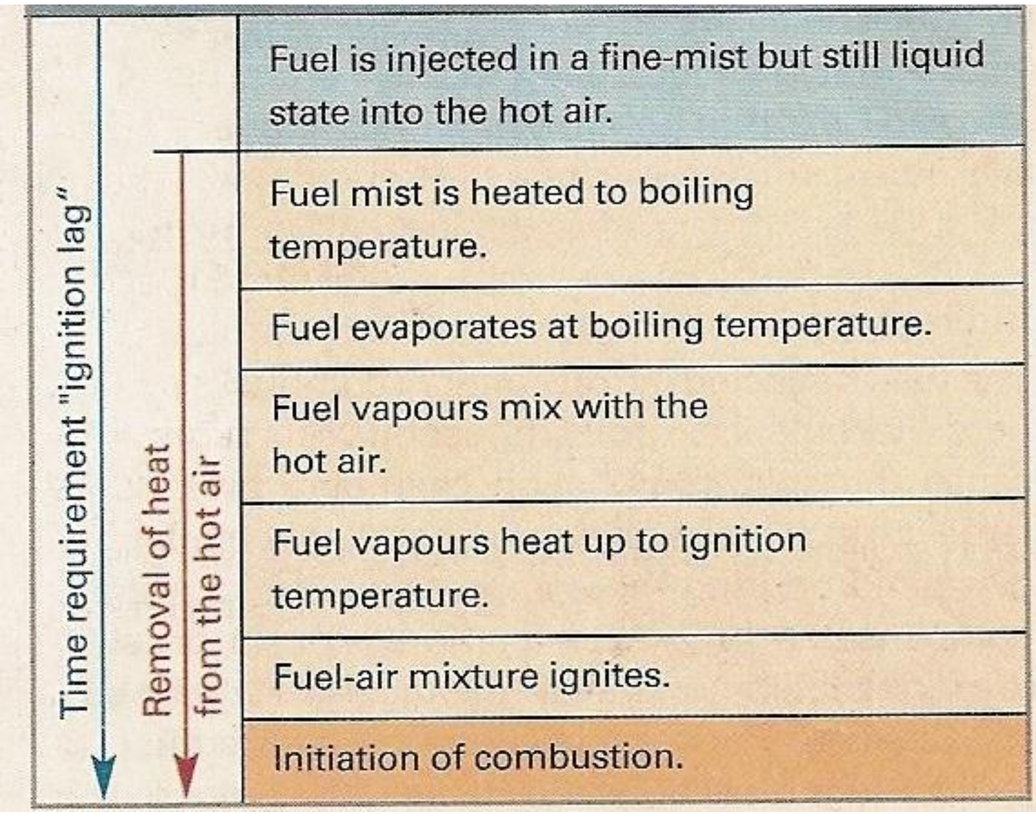
Quality regulation

The naturally aspirated engine is unthrottled, i.e. there is no throttle valve before the intake ports. In this way, the engine is supplied over the entire speed range with an extensively constant air flow as the charge. Load control is effected by altering the quantity of fuel to be injected, which in turn alters the fuel-air mixture depending on the operating state.

Internal mixture formation

After the start of injection, the still liquid fuel must be converted into an ignitable mixture. Table 1 sets out the time that elapses from the start of injection until auto-ignition. For internal mixture formation heat is' removed from the hot air so that this air cools. But the air temperature must always be above the auto-ignition temperature of the fuel. The time between the start of injection and the start of combustion is known as the ignition lag.

Table of Internal mixture formation and initiation of combustion



Advantages and disadvantages

Advantages of diesel
When compared to gasoline engines, diesel engines offer many advantages. They are more efficient and use less fuel than a gasoline engine of the same size. Diesel engines are very durable. This is due to stronger construction and the fact that diesel fuel is a better lubricant than gasoline. This means that the fuel is less likely to remove the desired film of oil on the cylinder walls and piston rings of the engine. Diesel engines are also better suited for moving heavy loads at low speeds.

Fuel economy
Diesel cars can easily approach the fuel economy of hybrid without resorting to mileage-boosting devices such as auto shut off systems and low rolling resistance tires.

Torque: Diesels produce large amounts of torque (pulling power) at low engine speeds; a small four-cylinder diesel can easily produce as much torque as a larger six-cylinder gasoline engine.

Longevity: Diesels are less prone to wear than gasoline engines.

Alternative fuels: Unlike gasoline engines, diesels can run on non-petroleum-based fuel (biodiesel) with no major modifications.

Safety: Diesel fuel is less volatile than gasoline, and will only ignite under severe pressure and/or very high temperatures.

Disadvantages of diesel engines

Noise: Unlike gasoline engines, which produce most of their noise from the easily-muffled exhaust system, most diesel noise comes from the engine itself.

Expense and weight: Diesel engines employ much higher compression ratios than gasoline engines; they compress combustion air to about 1/25th of its original volume (as opposed to gasoline engines, which compress their fuel-air mixtures to around 1/8th to 1/10th of its original volume).

Emissions: Though the diesel engine was invented well over a century ago, diesel emissions technology is still in its infancy.

Messy fuel: Diesel fuel is greasy, smelly, and can be difficult to wash off of hands or clothes. (Some diesel owners carry gloves to wear while refueling.)

Smoke: Diesel vehicles have a reputation of being smoky, smelly, and slow, a throwback to the low-tech diesels found in many trucks.

Difficult cold weather starting

OPERATING PRINCIPLE OF DIESEL ENGINE

Compression-ignition (C.I) engines burn fuel oil which is injected into the combustion chamber when the air charge is fully compressed. Burning occurs when the compression temperature of the air is high enough to spontaneously ignite the finely atomized liquid fuel. In other words, burning is initiated by the self-generated heat of compression. Compression-ignition (C.I) engines are also referred to as 'oil engines', due to the class of fuel burnt, or as 'diesel engines' after Rudolf Diesel, one of the many inventors and pioneers of the early C.I. engine. Just like the four-stroke-cycle petrol engine, the Compression-ignition (C.I.) engine completes one cycle of events in two crankshaft revolutions or four piston strokes. The four phases of these strokes are (i) induction of fresh air, (ii) compression and heating of this air, (iii) injection of fuel and its burning and expansion, and (iv) expulsion of the products of combustion.

INDUCTION STROKE

With the inlet valve open and the exhaust valve closed, the piston moves away from the cylinder head. The outward movement of the piston will establish a depression in the cylinder, its magnitude depending on the ratio of the cross-sectional areas of the cylinder and the inlet port and on the speed at which the piston is moving. The pressure difference established between the inside and outside of the cylinder will induce air at atmospheric pressure to enter and fill up the cylinder. Unlike the petrol engine, which requires a charge of air-and-petrol mixture to be drawn past a throttle valve, in the diesel-engine inlet system no restriction is necessary and only pure air is induced into the cylinder. A maximum depression of maybe 0.15 bar below atmospheric pressure will occur at about one-third of the distance along the piston's outward stroke.

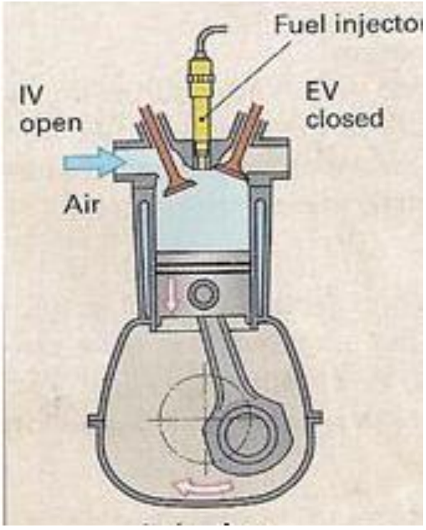


Figure19: Induction stroke

Compression stroke
With both the inlet and the exhaust valves closed, the piston moves towards the cylinder head. The air enclosed in the cylinder will be compressed into a much smaller space of anything from 1/12 to 1/24 of its original volume. A typical ratio of maximum to minimum air-charge volume in the cylinder would be 16:1, but this largely depends on engine size and designed speed range. During the compression stroke, the air charge initially at atmospheric pressure and temperature is reduced in volume until the cylinder pressure is raised to between 30 and 50 bar. This compression of the air generates heat which will increase the charge temperature to at least 600°C under normal running conditions.
(BOSCH, 2005)

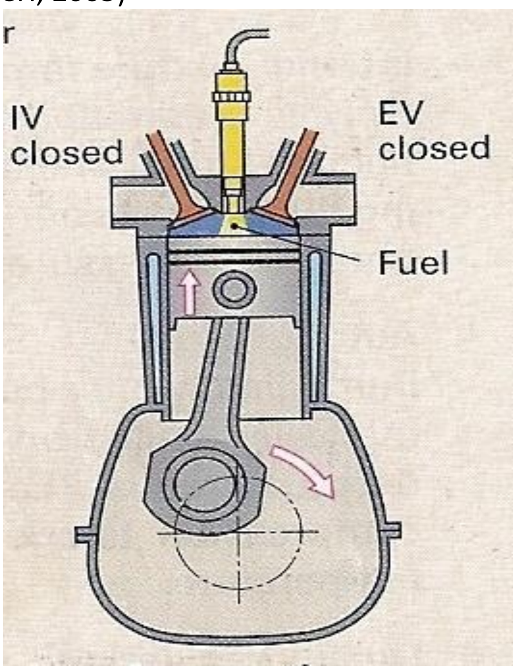


Figure20:Compression stroke

Power stroke:
With both the inlet and the exhaust valves closed and the piston almost at the end of the compression stroke, diesel fuel oil is injected into the dense and heated air as a high-pressure spray of fine particles. Provided that they are properly atomized and distributed throughout the air charge, the heat of compression will then quickly vaporize and ignite the tiny droplets of liquid fuel. Within a

very short time, the piston will have reached its innermost position and extensive burning then releases heat energy which is rapidly converted into pressure energy. Expansion then follows, pushing the piston away from the cylinder head, and the linear thrust acting on the piston end of the connecting-rod will then be changed to rotary movement of the crankshaft

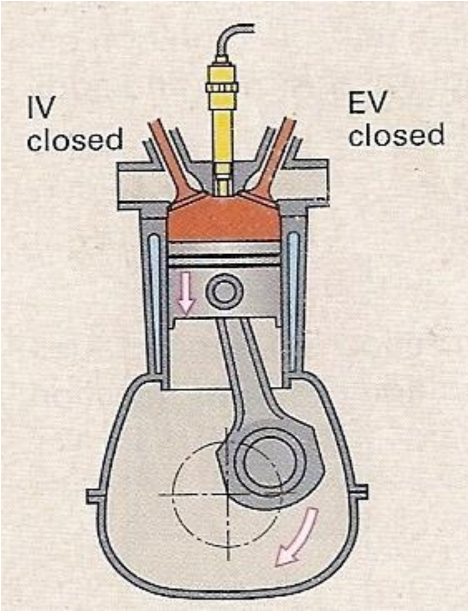


Figure 21: Power stroke
Exhaust stroke

When the burning of the charge is near completion and the piston has reached the outermost position, the exhaust valve is opened. The piston then reverses its direction of motion and moves towards the cylinder head. The sudden opening of the exhaust valve towards the end of the power stroke will release the still burning products of combustion to the atmosphere. The pressure energy of the gases at this point will accelerate their expulsion from the cylinder, and only towards the end of the piston's return stroke will the piston actually catch up with the tail-end of the outgoing gases. The figure below illustrates the sequence of the four operating strokes as applied to a four-cylinder engine, and the combined operating events expressed in terms of cylinder pressure and piston displacement are shown in

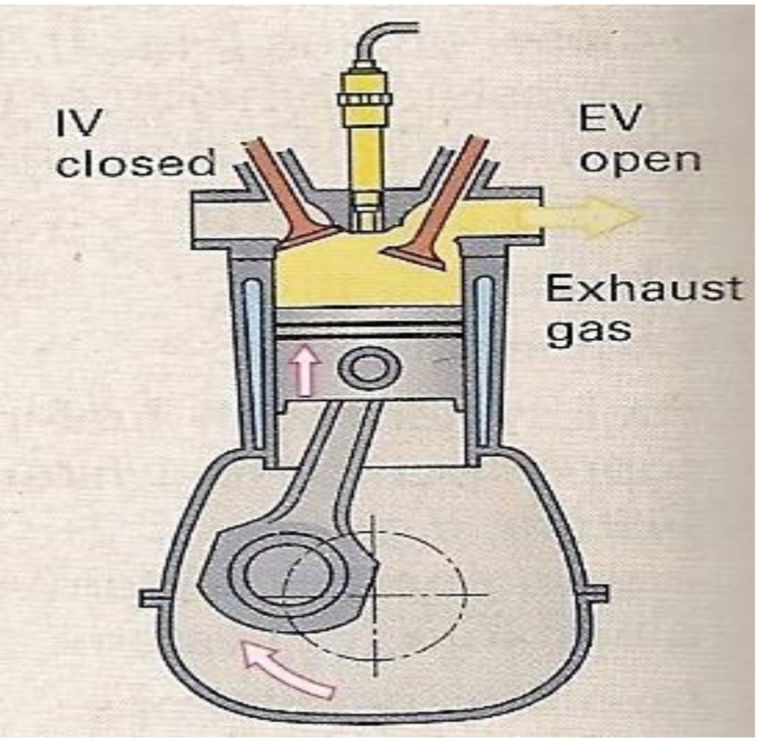


Figure22: Exhaust stroke

- **Content/Topic 3. Demonstration of General physics and chemical principles for engines**

  Features of diesel engine

- **Running** on diesel or biodiesel fuel.
- **Internal mixture formation**

Only air is admitted into the cylinder during the induction stroke. The fuel-air mixture is formed during the compression stroke by the injection of fuel under high pressure into the cylinder.

- **Auto-ignition**

Immediately after being injected, the fuel is automatically ignited on the air, which has been rendered extremely hot by compression. The final compression temperature exceeds the ignition temperature.

- **Quality regulation**

The naturally aspirated engine is unthrottled, i.e. there is no throttle valve before the intake ports. In this way, the engine is supplied over the entire speed range with an extensively constant air flow as the charge. Load control is effected by altering the quantity of fuel to be injected, which in turn alters the fuel-air mixture depending on the operating state.

Internal mixture formation

After the start of injection, the still liquid fuel must be converted into an ignitable mixture. **Table 1** sets out the time that elapses from the start of injection until auto-ignition. For internal mixture formation heat is- removed from the hot air so that this air cools. But the air temperature must always be above the auto-ignition temperature of the fuel.

The time between the start of injection and the start of combustion is known as the ignition lag.

LO 1.2 –Identify engine mechanical components

- **Content/Topic 1 Identification of engine case**

Figure23 : Engine case

An **engine** casing is the outside cover of an **engine**, and is usually made of metal. An **engine** casing can also be called an **engine case** or a **case** cover.

(www.wikipedia.org, 2015)

A **crankcase** is the housing for the crankshaft in a reciprocating internal combustion engine. In most modern engines, the crankcase is integrated into the engine block.

CRANKCASE

The crankcase houses the crankshaft and sometimes also the camshaft. The cylinders are bolted to the crankcase.

Design

The crankcase is usually divided at the height of the crankshaft bearings. The crankcase upper half contains the bearing seats for the crankshaft. The bearing caps are secured from below with bolts. The advantage of this arrangement is that the crankshaft can be easily removed. The crankcase lower half is designed as the oil pan and is bolted oil- tight to the crankcase upper half.

The crankcase is manufactured from cast iron or from Al alloys and is used in air-cooled engines.

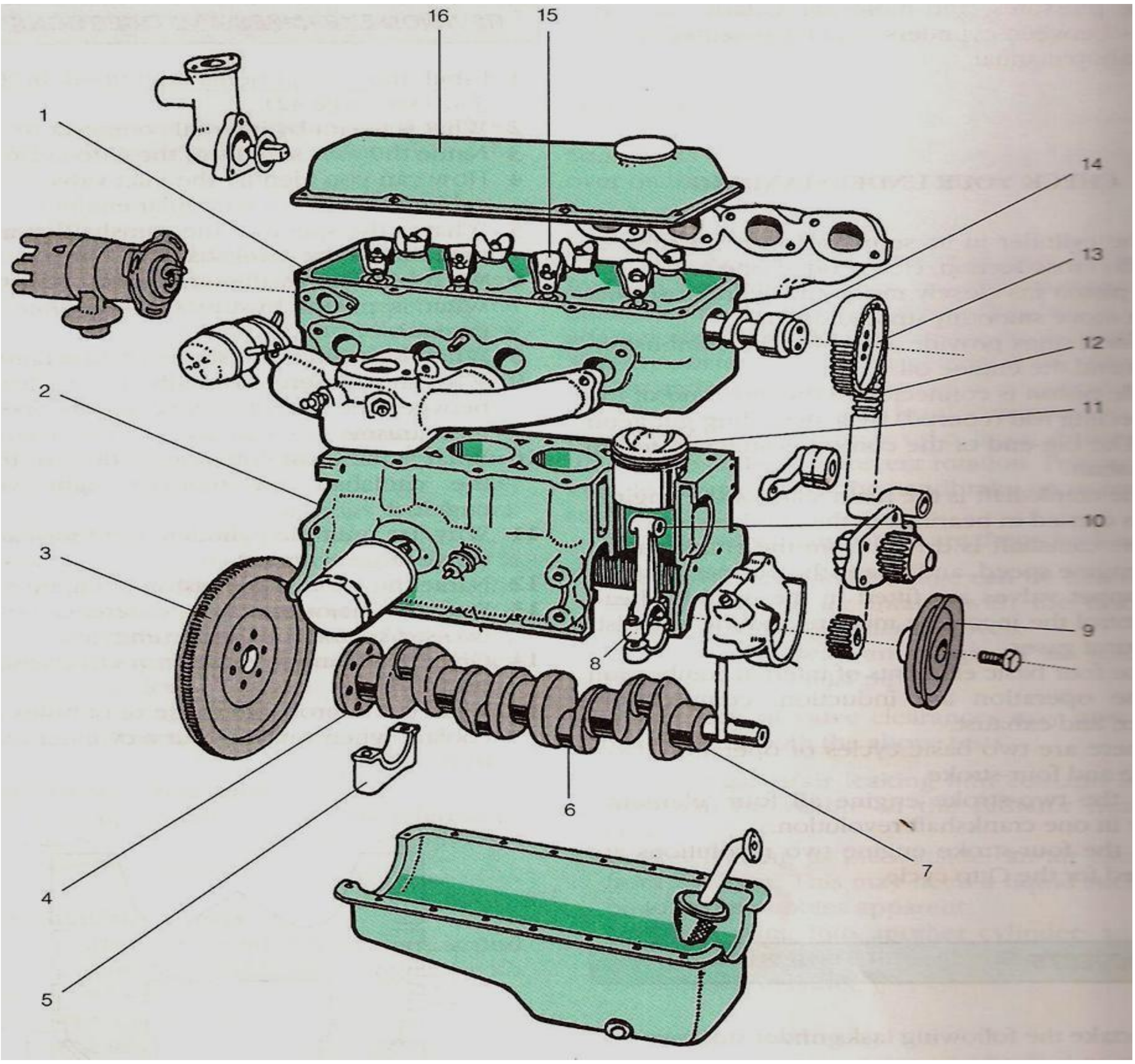


Figure 24 : Engine components

- Cylinder head (in Cast iron or aluminum)
- Cylinder block
- Fly wheel

- Flange
- Main bearing cap (in Cast iron)
- Rod journal
- Main journal
- Connecting rod big end, or Lower end
- Crankshaft pulley
- Connecting rod small end, or top end
- Piston
- Timing belt or drive belt / drive chain
- Camshaft sprocket
- Camshaft
- Rocker arm
- Rocker arm cover (in Chrome -plated steel)

Engine block= cylinder+ crankcase

Two-stroke engines typically use a crankcase-compression design, resulting in the fuel/air mixture passing through the crankcase before entering the cylinder(s). This design of the engine does not include an oil sump in the crankcase.

Four-stroke engines typically have an oil sump at the bottom of the crankcase and the majority of the engine's oil is held within the crankcase. The fuel/air mixture does not pass through the crankcase in a four-stroke engine, however a small amount of exhaust gasses often enter as "blow-by" from the combustion chamber.

The crankcase often forms the lower half of the main bearing journals (with the bearing caps forming the other half), although in some engines the crankcase completely surrounds the main bearing journals

Figure25 : **CYLINDER BLOCK WITH PISTONS**

Figure 26 : Cylinder block

This presentation will explore: Cylinder Block Construction
Cylinder Block Sleeves Cylinder Head Construction
Cylinder Head Components

The cylinder block is usually made of cast iron for strength or aluminium for light weight (fuel economy) and good heat dissipation.

The underside of the cylinder

The cylinder bores pass through the block, where the water jacket surrounds them.

Figure 27 : Under of cylinder bore

There are mountings for the starter motor, alternator, distributor, cam Underside drives and other components.

Cylinder Block Top View

Core plugs seal the coolant jacket holes left by the manufacturing process.

The deck surface is ground flat for a good contact to mount the Cylinder head.

A gasket and high tensile bolts complete the seal between the cylinder block and cylinder head.

Figure 28 : Cylinder block

Cylinder Sleeves

Cylinder sleeves (or liners) are precision, steel tubular inserts fitted or pressed into the cylinder block, as walls for the pistons to move in.

They are usually made of cast iron or steel, and may also be used to repair badly damaged cylinder walls in cast iron blocks. lack of structural support from the block

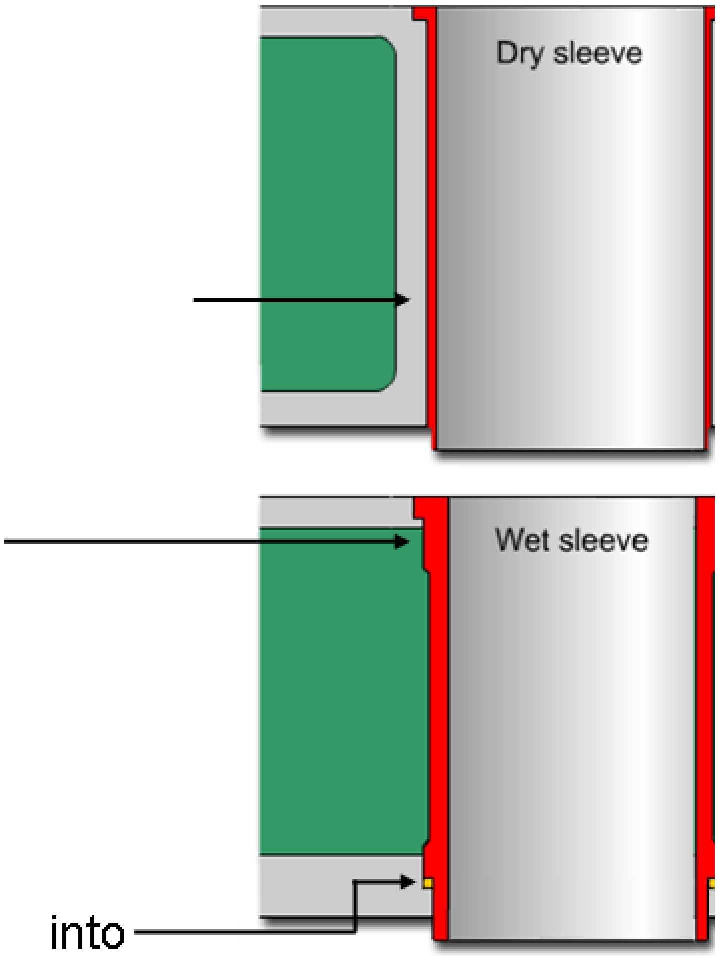


Figure29 : Wet and Dry Sleeves

Dry Sleeves

Dry sleeves are pressed into cylinder bores in the block.
They do not make contact with the coolant, but are supported by the cylinder block walls.

Wet Sleeves

The coolant is in direct contact with a wet sleeve, improving cooling efficiency.

The wet sleeve must therefore be thicker than a dry sleeve to account for the lack of structural support generated by the block as in the case of the dry sleeve.

A seal is fitted at the top and bottom of a wet sleeve to prevent coolant leakage the crankcase.

Cylinder Head (2 Valve and Cylinder Head (4 Valve)

Cylinder head construction varies with engine design, and combustion chamber design will

Cylinder head construction varies with engine design, and combustion chamber design will vary from engine to engine. This is dependent on the valve arrangement, performance required and intended efficiency.

The cylinder head shown is an aluminum, four-valve with pent?

Figure30: **Cylinder Head (4 Valve)**

CYLINDER, CYLINDER HEAD Functions:

- Form the combustion chamber together with the piston
- Guidance of the piston by the cylinder

Stresses

- High combustion pressures and temperatures
- Larger thermal stresses due to rapid temperature changes
- Cylinder barrel subjected to wear due to piston friction and combustion residues.
- Increased friction during cold starting, carburetted fuel washes lubricant layer off the cylinder.

Properties of materials

- High strength and inherent stability
- Good heat conduction
- Low thermal expansion
- High resistance to wear
- Good sliding properties for the cylinder face

Components of cylinder head

The cylinder head contains many component Valve mounts consist of springs, guides, seats, seals, retainers and keepers.

In the case of the OHV layout shown, the valves are opened by pivoted rocker arms moved by pushrods from a camshaft mounted in the block.

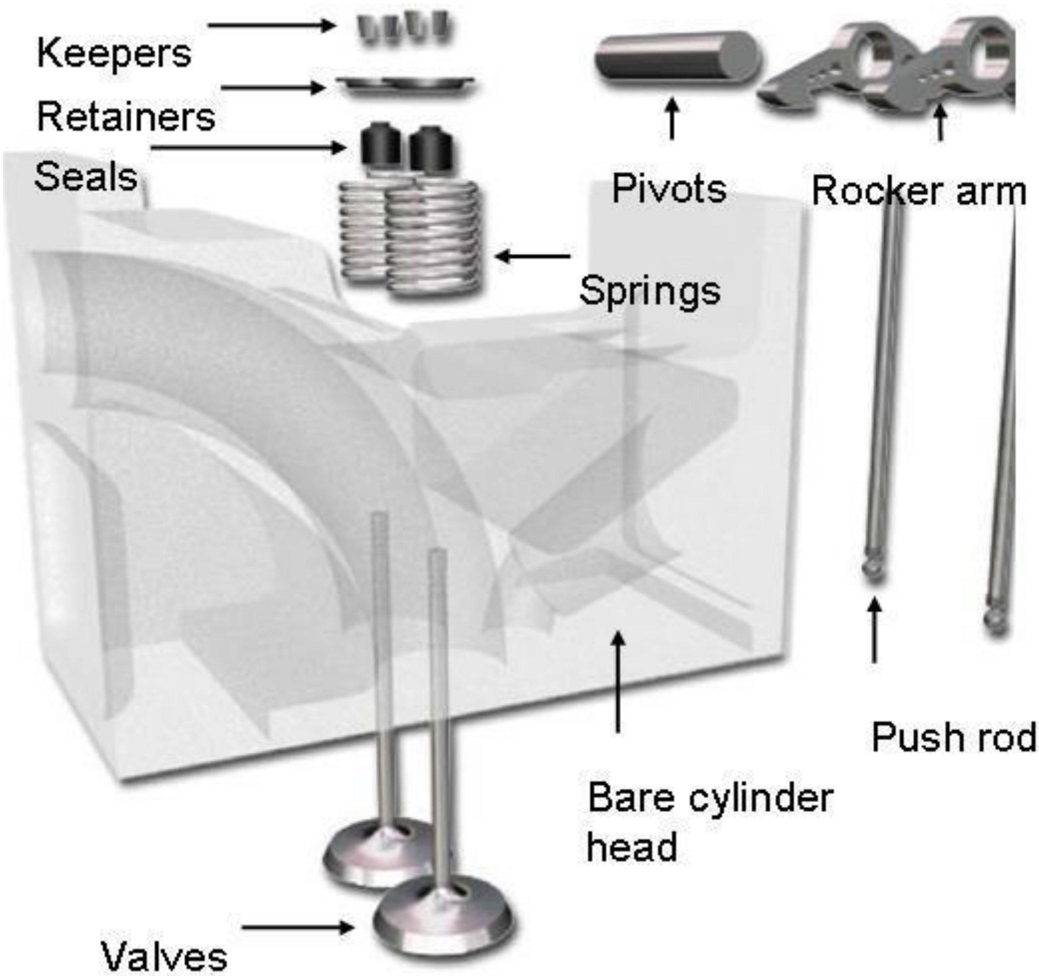


Figure31 : Components of cylinder head

Cylinder head gasket

The cylinder-head gasket is intended to seal the combustion chamber gas-tight and prevent coolant or engine oil from escaping from the flow ducts.

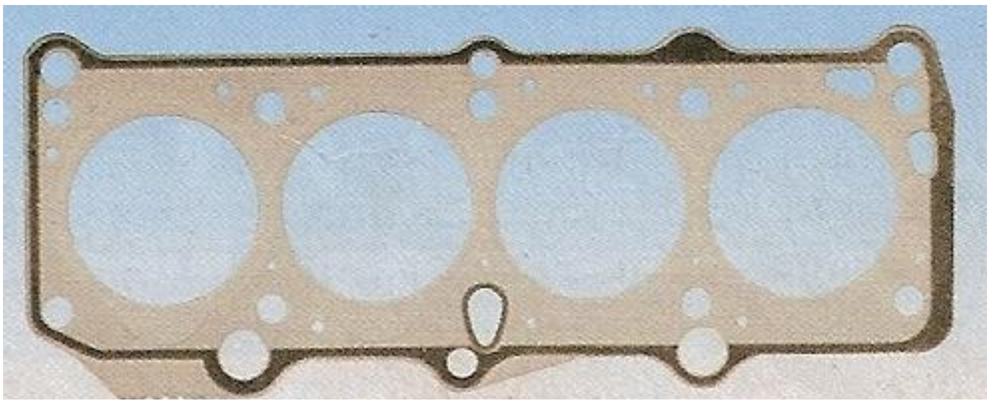


Figure 32 : Cylinder head gasket

To obtain a good seal, it is necessary for the cylinder block and cylinder head to have a level surface.

Stresses

Fuel, exhaust gas, engine oil and coolant come into contact with the cylinder-head gasket in liquid and gaseous form, in cold and superheated states and partly mixed under high pressure and vacuum pressure with chemically active agents.

The gasket must therefore satisfy the following requirements:

- Elastic adaptation of the sealing surfaces in all operating states
- Low tendency to settle so as to facilitate cylinder head tensioning without retightening.
- No sticking to sealing surfaces in order to simplify removal.

- **Content/Topic 2 Identification of crankshaft drives for an engine**

The **crankshaft drive** is the complete mechanism which converts the up and down movement of the piston in the engine into the rotary motion of the **crankshaft**.

The **crankshaft** is essentially the backbone of the internal combustion engine. The **crankshaft** is responsible for the proper operation of the engine and converting a linear motion to a rotational motion

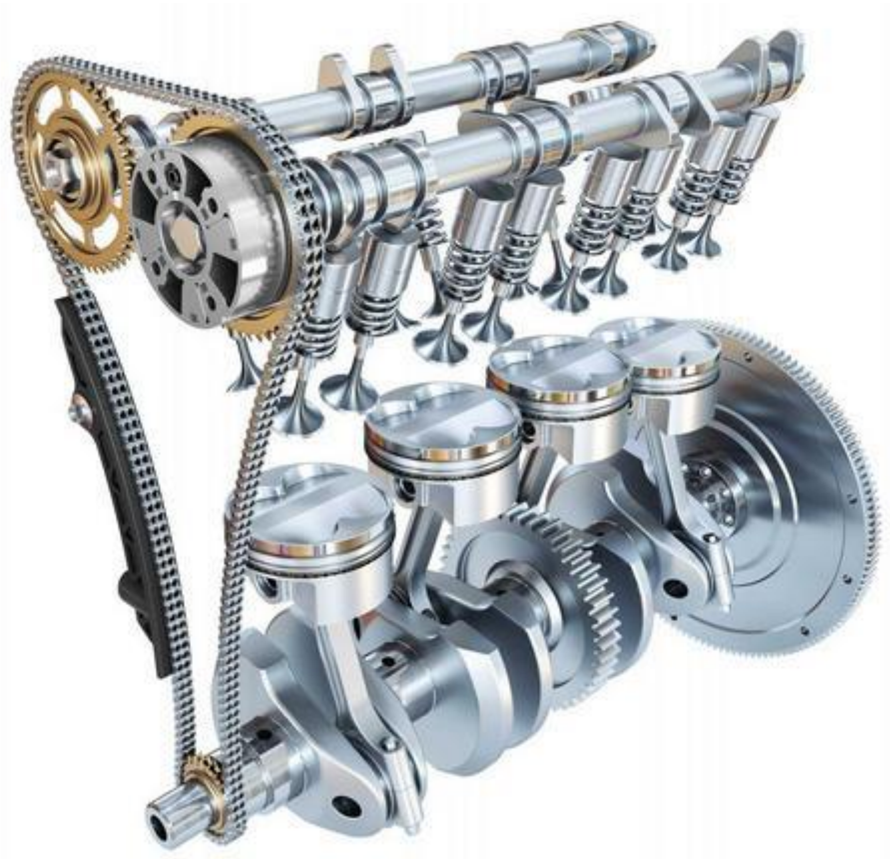


Figure 33 : Crankshaft drive

Piston

Functions

- Provides a moving seal for the combustion chamber against the crankcase
- Absorbs the gas pressure generated during combustion and transmit it via the connecting rod as the torsion force to the crankshaft.

- Transmit the heat given off by the combustion gases to the piston crown for the most part to the cylinder wall.
- Gas exchange control in two stroke engine

Stresses Piston
force Lateral force
Axial offset
Friction force
Heat

Piston material

The material must demonstrate the following properties on account of the different types of stress and strain to which the piston is subjected:

- Low density (smaller acceleration forces)
- High strength (even at high temperatures)
- Good thermal conductivity
- Low thermal expansion
- Low frictional resistance
- High resistance to wear

DESIGN AND DIMENSIONS

Piston is made up of the following different sections:

- Piston crown
- Piston-ring belt with fire land
- Piston skirt
- Pin bosses

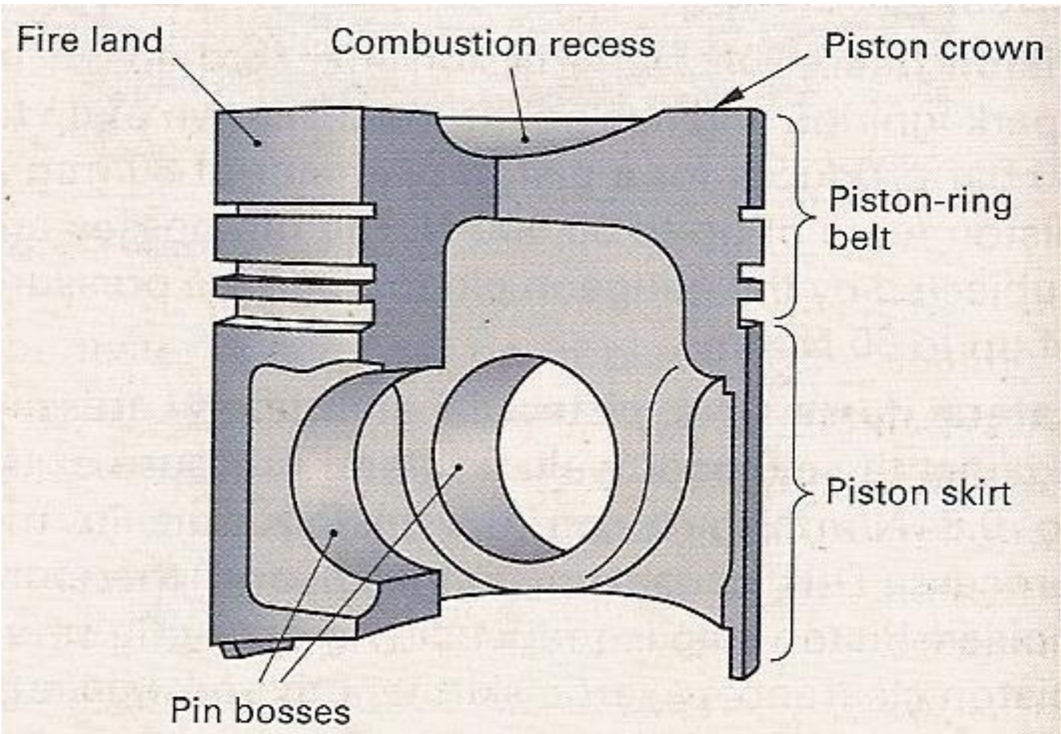


Figure 34 : piston design

Piston crown: This is either flat or slightly curved inward (dished) or outwards (domed). The

compression space can be partly transposed into the piston by the integration of a combustion recess in the piston crown. The shape of the piston crown is also influenced by the shape of the compression space and the arrangement of the valves.
Fire land: This is intended to protect the uppermost piston ring against excessive heating. The piston skirt serves to guide the piston in the cylinder. It transmits the side forces to the cylinder walls. The pin bosses transmit the piston force to the gudgeon pin. The compression height influences the compression ratio; an adequate skirt length helps to keep piston slap in the cylinder to a minimum during side changing.

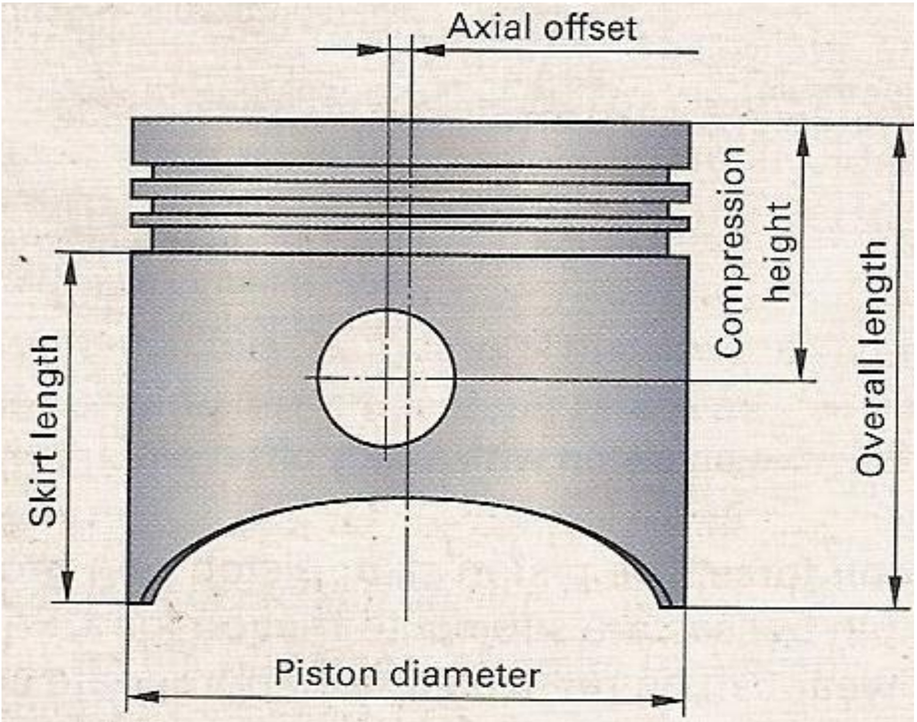


Figure 35 : Main piston dimensions

Piston rings

Two different types are used:

- Compression ring
- Oil control ring

Compression rings:

- These seal the piston in the cylinder against the crankcase.
- These remove the heat from the piston to the cooled cylinder.

Oil control rings:

- **T**hese escape excess lubricating oil off the cylinder wall
- Return this lubricating oil to the oil pan

PROPERTIES

Piston rings must be elastic and must not change their shape permanently when slipped over the piston and when compressed to their nominal dimension. The contact pressure against the cylinder wall is additionally intensified during operation by the gas forces behind the rings.

Piston-ring shape		Abbre-viation	Installation instruction	Purpose of shape
Cross-section	Designation			
	Plain ring (compression ring)	P	Possible in both directions	Easy to manufacture
	Taper-face ring	TF	Ring flank designated with "Top" in direction of piston crown	Acceleration of running-in process (usually in uppermost groove)
	Keystone ring (half)	K	Tapered ring flank in direction of piston crown	Prevention of sticking in groove
	L-ring	LR	Large internal ring dia. in direction of piston crown or top ring edge = piston-crown edge	Intensified contact pressure due to combustion gases
	Stepped ring	S	Turned-out angle in direction of skirt end	Additional oil-scraping effect
	Slotted oil-control ring (normal)	SI	Possible in both directions	Scraping effect with oil passage to piston interior
	Slotted oil-control ring with spiral-type expander (bevel-edged ring)	SP	Possible in both directions	Higher contact pressure, better scraping effect

Properties of piston ring

Piston damage:

Piston damage can be incurred if the pistons are incorrectly handled during assembly and installation in the engine, e.g. cylinder deformation due to unevenly tightened cylinder-head bolts, excessively tight fitting of the gudgeon pin in the connecting rod eye, irregularities on the cylinder liners.

Piston damages may also be caused by the following:

- **A**uto-ignition
- Knocking combustion
- Combustion malfunctions in diesel engine
- Inadequate or no lubrication
- Overheating due to inadequate engine cooling, retarded ignition and excessive fuel supply.

Checking piston diameter and installation clearance

Piston manufacturers supply ready-to-install pistons with the largest skirt diameter (piston diameter) marked in mm, e.g. 84.00, on the piston crown **.**The diameter is measured at the end of the skirt, vertically to the pin axis.

Figure36 : Installation of piston

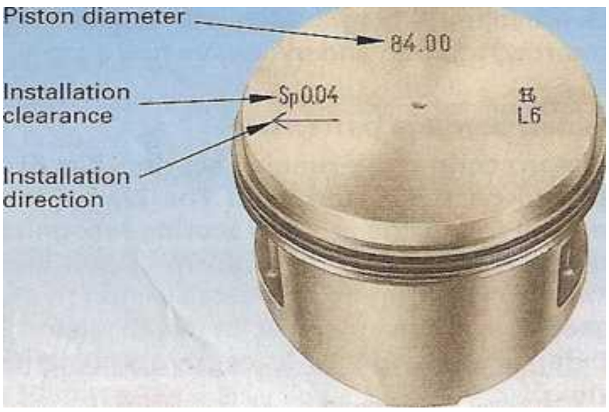


Figure37: Hole in piston crown

The installation clearance which is also stamped on the piston crown, eg 0.04, denotes the difference between the cylinder and piston diameters in mm at 20^0C.

Cylinder diameter = Piston diameter + Installation clearance

Installing the piston rings

Piston rings are supplied already installed in the piston. If individual piston rings are to be inserted, it is important to use the correct ring type and ensure that the ring flank marked "Top" points towards the piston crown. Always use a pair of piston-ring pliers

Axial clearance in the ring grooves greater than 0.025 mm to 0.04 mm depending on the piston type may cause jamming and "pumping" of the piston rings, i.e. if the ring groove is heavily worn the rings act like pumps supplying oil to the combustion chamber. Even when the piston is installed, piston rings should still have a gap clearance of 0.2 mm to 0.3 mm -otherwise their spring effect could be impaired and the rings themselves could break. Gas losses occur if the clearance is too large. It is possible to check the the clearance with a gauge by inserting the ring without the piston on atrial basis in a cylinder bore.

Figure38: installation of piston ring

CONNECTING ROD

Functions

- Connects the piston to the crankshaft
- Converts the linear motion of the piston into rotary motion of the crankshaft
- Transmits piston force to the crankshaft, where it generates torque

Stresses

- Pressure forces in the longitudinal direction as a result of the gas pressure on the piston crown
- Acceleration forces in the form of tensile and pressure forces in the longitudinal direction as a result of constantly changing piston speed
- Bending forces in the connecting-rod shank as a result of oscillating motion about the gud-geon-pin axis
- Buckling stress on account of the large pressure forces

In the interest of minimising the inertia forces, the mass of the connecting rod should be as small as possible.

Connecting-rod materials

Connecting rods (Fig. 1) are mainly manufactured from alloyed tempering steel which is drop-forged or from alloyed steel powder as a sinter forging**.** Sinter-forged connecting rods have better mechanical properties than their drop-forged counterparts. Their cross-sections can therefore be smaller and with it their weight lower. Weight tolerances practically never arise.The big end acquires its ultimate shape already during the manufacturing process. It is not sawn through, rather it is first slit with a laser and then cracked with a wedge.The connecting rod and the big-end bearing cap have the same granu lar fracture surface and ensure that the big-end bearing cap is precisely seated on the big end during assembly

(R.Gscheidle, 2006)

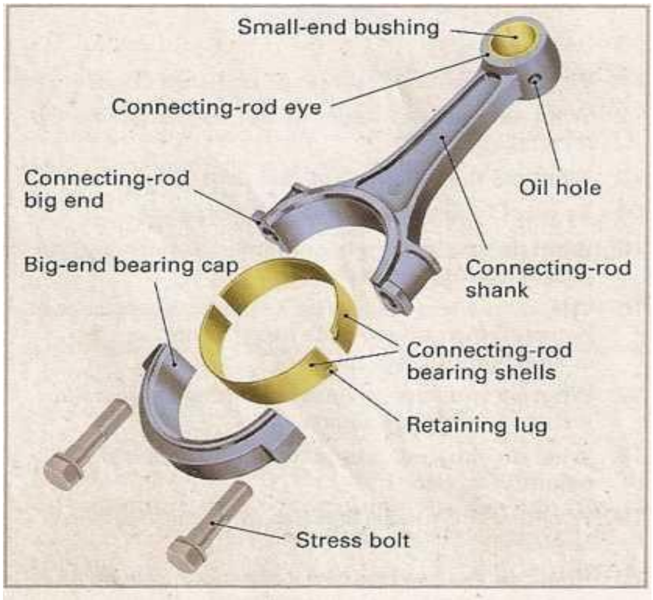


Figure39 : Connecting rod with the bearing shells

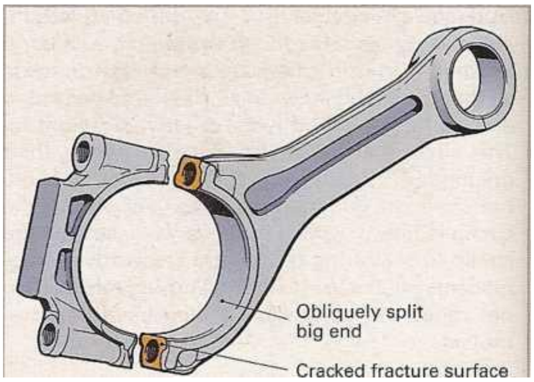


Figure 40 : Cracked connecting rod. Obliquely split

Design

Connecting-rod eye. This accommodates the gudgeon pin. If the gudgeon pin is float-mounted, a bushing, usually made from a copper alloy (CuPb- Sn), is pressed into the connecting-rod eye. If the gudgeon pin is to be fixed in the connecting-rod eye with a shrink fit, it is shrunk directly into the eye. **Connecting-rod shank.** This connects the connecting-rod eye to the big end. In order to increase its resistance to buckling, its cross-section is usually a double-T-profile section.

Connecting-rod big end. Together with the big-end bearing cap, this encloses the connecting-rod bearing, which is designed as a split plain bearing.The big-end bearing cap is usually secured to the big end with stress bolts.

Mounting of connecting rod on crankshaft.
In the same way that the crankshaft is mounted in the crankcase, this mounting is achieved in multilayer bearing shells **(Fig. 1, Page 224).** These shells are secured against sliding and turning by retaining lugs. **Bearing clearance.** This is specified by the manufacturer and can be determined by measuring the connecting-rod bearing and the crankpin. When Plastigage is used**,** each bearing must be measured individually.

Special connecting-rod design
Trapezoidal connecting rods. The bottom half of the connecting-rod eye, which must absorb the combustion pressure, is wider while the top half remains narrower due to the lower levels of stress to which it is exposed. This arrangement creates the connecting-rod eye's trapezoidal shape.

Obliquely split connecting rods. Because of the higher pressures in diesel engines, the connecting- rod big end must be designed more sturdily with he result that its size outstrips the cylinder diameter. Withdrawal through the cylinder is only made possible by an obliquely split big end.

Single-piece connecting rods. In two-stroke singlecylinder engines the connecting-rod big end is often not split and the crankshaft must therefore be assembled from individual pieces. Antifriction bearings can be used instead of plain bearing.

Lubrication. The connecting-rod bearing is lubricated by engine oil which is supplied through a hole to the crankpin from the crankshaft journal.The small- end bushing with gudgeon pin is usually adequately lubricated by splash oil (oil hole in the connecting-rod eye.

CRANKSHAFT
Functions

- Generates rotary force and thus a torque from the connecting-rod force.
- Transmits one part of the torque via the flywheel to the clutch.
- Drives engine accessories with the other part of the torque.

Stresses
The connecting rods and pistons must be accelerated and decelerated again by the crankshaft during each stroke.This gives rise to high acceleration forces. High centrifugal forces also act on the crankshaft. The forces that are created cause the crankshaft to be subjected to torsional and bending stress and to torsional vibrations, and the bearings are also subjected to wear.

Crankshaft materials
The crankshaft is manufactured from

- alloyed tempering steel
- nitriding steel
- nodular graphite cast iron

Crankshafts manufactured from steel are drop- forged.The interconnected fibre orientation and the tight structure thereby achieved result in great strength.
Crankshafts manufactured from nodular cast iron have good vibration-damping properties.

Design
Crankpins, crankshaft journals. Each crankshaft features crankshaft journals lying along a single axis for mounting in the crankcase and crankpins for mounting the connecting-rod bearings. The boundary layers of these journals are hardened and ground.

Crank webs. The crankshaft journals and crankpins are connected to each other by crank webs. The crankpins and crank webs produce an unequal mass distribution.This is compensated by counterweights at the opposite ends to the crankpins. Oil holes (also known as oilways) lead from the crankshaft journals through the crank webs to the crankpins.

Crankshafts must be dynamically balanced. An accumulation of material at specific points can be eliminated by balance holes.

Thrust bearing. One of the crankshaft journals is provided with side thrust faces. A thrust bearing (locating bearing) is mounted on this crankshaft journal for the purpose of axially locating the crankshaft. This locating bearing prevents, for example, displacement of the crankshaft when the clutch is actuated.

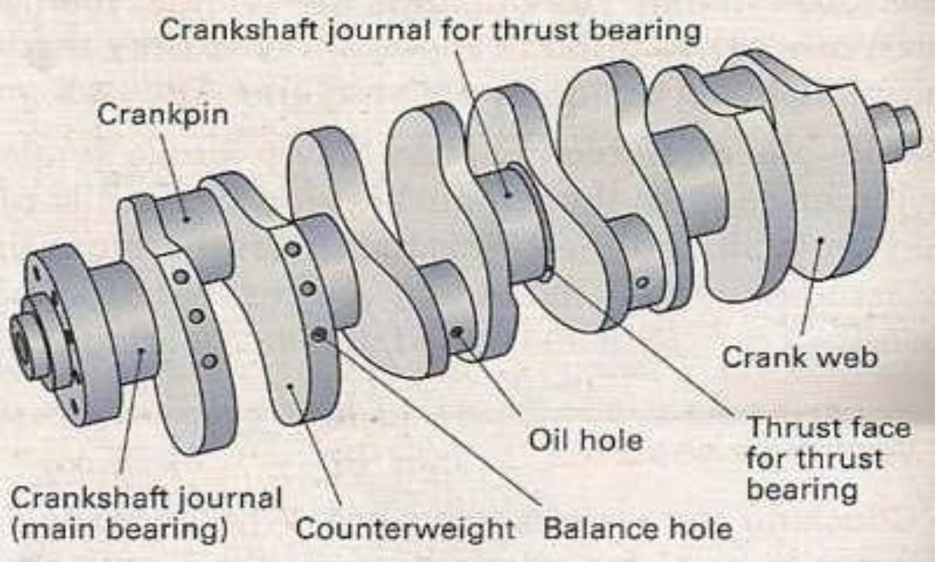


Figure 41 : Crankshaft designations

The flywheel, on which the clutch is usually mounted, is attached to the output end of the crankshaft. The opposite end of the crankshaft accommodates a gearwheel, a sprocket or a toothed-belt wheel (drive for camshaft, oil pump, etc.), a belt pulley and if necessary a vibration damper.

The shape of the crankshaft is determined by the

- number of cylinders number of crankshaft bearings
- size of the stroke
- firing order
- arrangement of the cylinders

Throw. This consists of a crankshaft journal and its two adjacent crank webs. Thus, for example, in straight-four engines, all the crankshaft throws lie in a single plane, while, in straight-six engines, the throws are offset by 120° to each other.Throws for parallel cylinders are always parallel. Those cylinders whose pistons are offset by a crankshaft angle of 360° to each other during a power cycle are called parallel cylinders.

Flywheel

A flywheel can store energy (available power) during the power stroke and release it again at a later stage.This flywheel energy is used to overcome the "idle strokes" and dead centres in the power cycle and compensate speed fluctuations. The ring gear with which the pinion for starting the engine meshes is usually shrunk onto or bolted to the circumference of the flywheel.The clutch transmits the engine torque from the flywheel to the gearbox.

The flywheel is manufactured from steel or special cast iron. The flywheel and crankshaft are usually dynamically balanced together so as to eliminate the risk of excessive imbalance at high rotational speeds. Excessive imbalance would cause the crankshaft to rotate irregularly and subject the bearings to excessive load.

- **Content /Topic 3 Identification of engine timing of vehicle**

Figure42 : Engine timing side

Timing often **means** the selection of the exact time or speed at which to do something in order to get the desired or best result. One of the meanings of time as a verb is to choose the moment or occasion to do something, as in She timed that pass perfectly. **Timing** is the noun form of this.

In a spark **ignition** internal combustion **engine**, **Ignition timing** refers to the **timing**, relative to the current piston position and crankshaft angle, of the release of a spark in the combustion chamber near the end of the compression stroke. Setting the correct **ignition timing** is crucial in the performance of an **engine**.

The engine timing gear controls the moment and the duration of the intake of fresh gases and the moment and the duration of the discharge of exhaust gases.

The moments are given as opening and closing points of the valves in crankshaft-angle degrees, e.g. Io 15° beforeTDC, Ic 42° after BDC (see timing diagram,

Design of engi n e timing gear

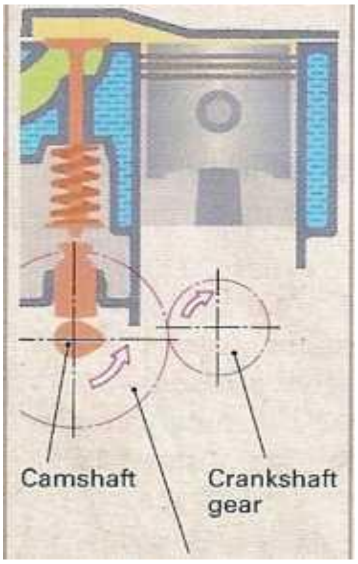
The engine timing gear is driven from the crankshaft via toothed belt, roller chain or gears to the camshaft. The camshaft cams open the inlet and exhaust valves against the spring force of the valve springs via transfer elements, e.g. tappets.The valves are closed again by the spring force of the valve springs.

Because one power cycle stretches over four strokes, i.e. two crankshaft revolutions, and the valves are only actuated once in the process, the camshaft must rotate at half the speed of the crankshaft. The crankshaft gear therefore has half as many teeth as the camshaft gear.

Arrangement of valves. The following different arrangements may be used:

- **Side-valve engine (Fig. 1), SV** engine.The valves are closed in the direction of BDC.The valves are side-mounted in this type of engine. Engines of this type are not used in motor vehicles because of the unfavourable shape of their combustion chambers.

Overhead-valve engine (Figs. 2 to 5). The valves are closed in the direction of TDC. Engines of this type



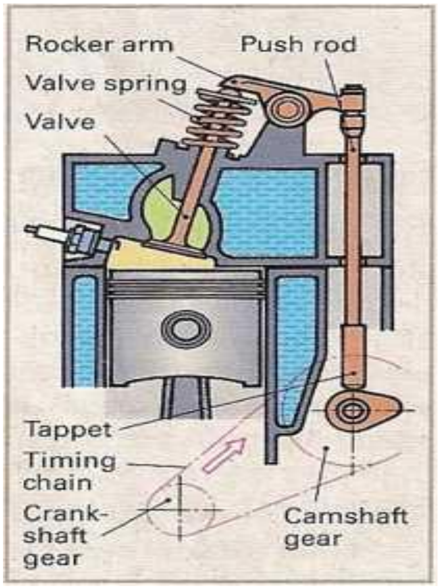


Figure 43: side valve and overhead valve

Arrangement of camshaft. The following different arrangements are possible in overhead-valve engines: OHV engine (OverHead Valves). Inverted valves in the cylinder head; the camshaft is located in the cylinder block or in the crankcase **.**

- OHC Engine (OverHead Camshaft).The camshaft is located above the cylinder head**.**

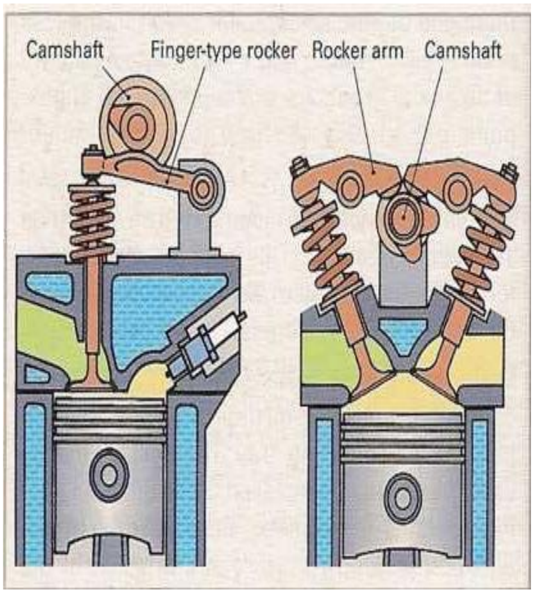


Figure 44: Over Head engine

DOHC engine (Double OverHead Camshaft).Two camshafts are located above the cylinder head.

CIH engine (Camshaft In Head).The camshaft is located in the cylinder head

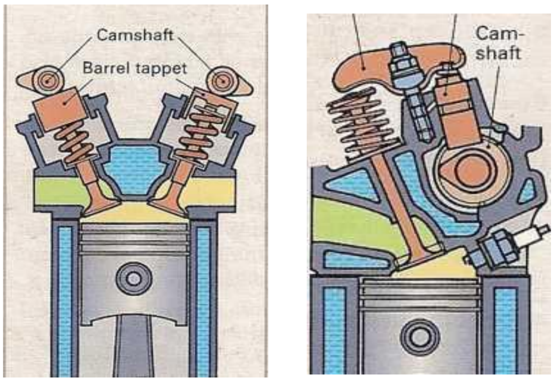


Figure45 : DOHC engine and CIH engine

Multiple-valve tech nology
In the interests of further improving the gas exchange in the cylinder, engines are also equipped with two or three inlet valves together with one or two exhaust valves.

Three-valve version. Two inlet valves are arranged opposite one larger exhaust valve. If it is not possible to position the spark plug centrally, dual ignition with two off-centre spark plugs is used. This brings about improved burning of the mixture in the vicinity of the piston edge and at the fire land. A common camshaft controls the valves.

Four-valve version (Fig. 3). This is the most common used

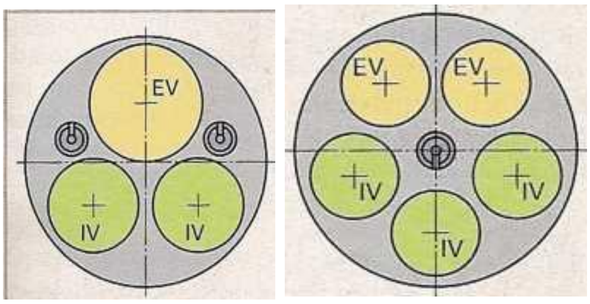


Figure46 : Three and four valve version

Multiple-valve-technology engine. Two frequently larger inlet valves are arranged opposite two exhaust valves. The spark plug can be positioned almost centrally.The inlet valves and the ex-haust valves each require a separate camshaft.

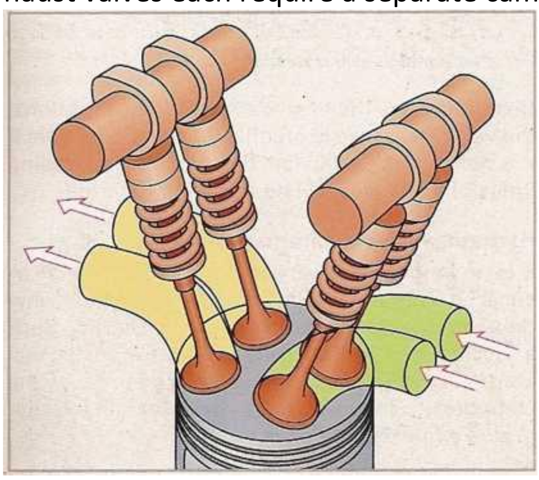


Figure 47 : Four valve version

Five-valve version. Three inlet valves and two exhaust valves offer the maximum through- flow cross-section. The spark plug can usually be positioned centrally.The inlet camshaft actuates the three inlet valves and the exhaust camshaft actuates the two exhaust valves.

Timing-gear components

Valves

Two different types are used: **inlet** and **exhaust valves.** The diameters of the valve heads and the valve lift must be sufficiently large as to facilitate as much as possible an unhindered gas exchange.The exhaust valve often has a smaller diameter than the inlet valve because the still high pressure of the exhaust gases when the exhaust valve opens ensures that the combustion chamber is quickly emptied.

Design . A valve consists of a valve head and a valve stem. The valve head must in conjunction with the valve seat in the cylinder head seal the combustion chamber gas-tight. At the end of the valve stem is a recess or one or more grooves, with which the valve cones engage.The valve cones are pressed by the valve spring retainer into the recess or into the grooves of the valve stem.

Stresses. The valves are exposed to extremely high stress. They are raised roughly 4,000 times per minute and driven by the valve springs back onto the valve seats. The valve stem and the end of the stem are subject to friction wear.

Inlet valves (Fig. 4) may be permanently cooled by the fresh gases, but can still reach temperatures of up to approx. *500 °C.*

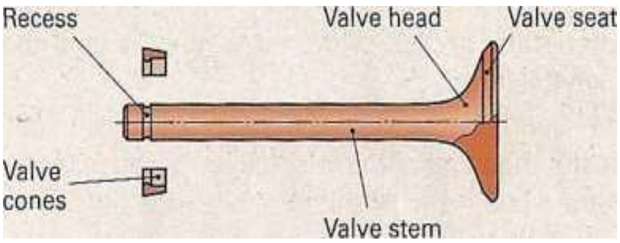


Figure. 48: Inlet valve

Inlet valves are usually single-metal valves. The valve seat, valve stem, recess for the valve cones and end face at the end of the stem can be hardened in order to reduce wear.

Exhaust valves (Fig. 1, Page 234). These are subjected to thermal load by the hot combustion gases (on the valve head up to approx. 900 °C) and to chemical corrosion. Exhaust valves are therefore usually manufactured as bimetal valves. Creep-, corrosion- and scale-resistant steel is used for the valve head and the lower part of the valve stem, which above all are exposed to the combustion gases. Such steels are not heat-treatable, have poor sliding properties, tend to seize in the valve guide and are poor conductors of heat.

(R.Gscheidle, 2006)

The upper part of the stem is made from heat-treatable steel with good thermal conductivity. Both parts are connected to each other, for example by friction welding.

Hollow-stem valves These are exhaust valves which in order to improve heat dissipation have a cavity which is filled by up to 60 % with sodium. Sodium melts at roughly 97 °C and has good thermal conductivity. The sloshing movement of the liquid sodium causes the heat to be dissipated more quickly from the valve head to the valve stem, thereby reducing the temperature of the valve head by roughly 100 °C. The valves are frequently armour-plated at the valve seat **,** e.g. with hard metal, in order to reduce wear and to prevent the seat from breaking on the valve head.

Valve clearance.

Inlet and exhaust valves expand during operation, depending on the temperature increase and material used. Linear deformations caused by wear also occur in the transfer elements of the timing gear. Clearance between the transfer elements is provided for so that the inlet and exhaust valves can close perfectly in all operating states.The valve clearance is generally greater when the engine is cold than when it is hot.

The clearance of the exhaust valves is usually greater than that of the inlet valves because the former are subject to hotter temperatures.

Valve clearance too small. The valve opens earlier and closes later.

The exhaust valve can become too hot because not enough heat can be dissipated from the valve head to the valve seat due to the shortened closing time. When the valve clearance is to small, there is also the danger that the exhaust valve or the inlet valve will no longer open when the engine is hot. In this situation, exhaust gas is drawn in through the gap in the exhaust valve and flames flash back through the gap in the inlet valve.This results in gas losses and power losses.The valves are overheated by the hot exhaust gases constantly flowing past, and this burns the valve head and valve.seats.

Valve clearance too large. The valve opens too late and closes too early.This results in shorter opening times and smaller opening cross-sections, which in turn diminish charge and power. The mechanical stress on the valve and valve noises increase.

Adjustment of valve clearance. There are different ways of adjusting the valve clearance, depending on the engine type and make. It can be carried out when the engine is cold or even when it is hot, or when the engine is stopped or even when it is running at low speed.

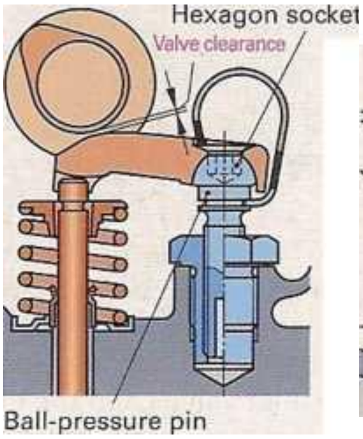
In the case of an overhead camshaft and rocker arms, the valve clearance can be adjusted with an adjusting screw and a lock nut or, as shown in the following figure**,** by adjusting the ball-pressure pin in the self-locking thread on the bearing of the finger-type rocker.The valve clearance is checked at the gap between the cam base circle and the finger-type rocker.

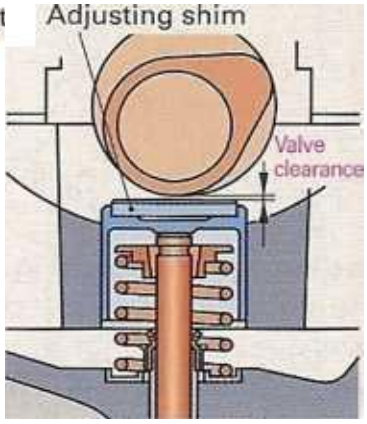
In the case of an overhead camshaft and barrel tappets **(Fig. 2),** hardened adjusting shims of varying thicknesses are placed in the tappet in order to adjust the correct valve clearance, which can be checked directly at the gap between the cam base circle and the adjusting shim.

Depending on manufacturers specifications, the valve clearance is roughly 0.1 mm to 0.3 mm. If it is not correctly adjusted, the opening and closing times of the valves will be shifted or deferred.

Hydraulic valve clearance compensation

Figure 49 : Adjustment with **Adjustment with adjusting shim**





Ball pressure pin

It is no longer necessary to adjust the valve clearance on engines which are equipped with a hydraulic valve-clearance compensation facijity. Such a facility uses hydraulically actuated transfer elements to compensate linear deformations of the components. In this way, the valve clearance is kept at zero while the engine is running.

Design

The clearance-compensation element is located in the barrel tappet. The valves are actuated directly by the overhead camshaft via barrel tappets

The hydraulic barrel tappet is connected to the engine's oil circuit. Oil is supplied through a side bore in the tappet into the valve-tappet chamber and from there via the opening in the tappet base into the supply chamber via the pressure pin.

(R.Gscheidle, 2006)

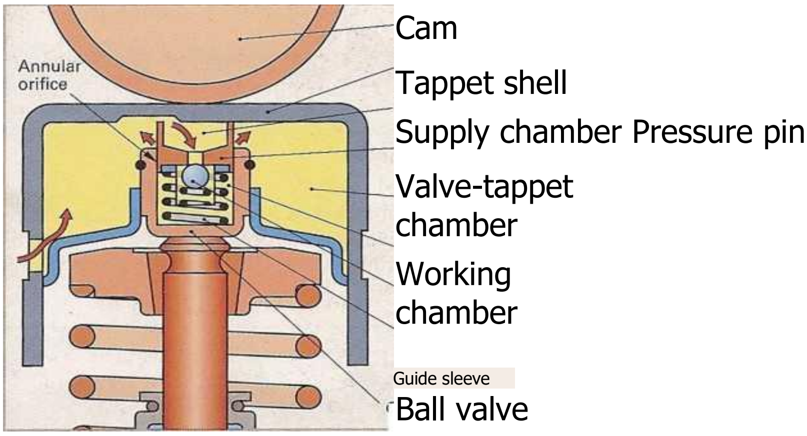


Fig. 50: Barrel tappet with hydraulic valve-clearance

Operating principle

Trailing cam. The pressure pin is not subjected to load.The compensating spring forces the pressure pin upwards until the barrel tappet touches the cam or the cam base circle. As a result of the enlarged space below the pressure pin, oil flows from the supply chamber through the ball valve into the working chamber.

Leading cam. The pressure pin is subjected to load, the ball valve closes and the oil in the working chamber acts like a "rigid connection".The inlet or exhaust valve is opened via the guide sleeve. Excess oil can escape through the annular orifice between the pressure pin and the guide sleeve, e.g. in the event of thermal expansion of

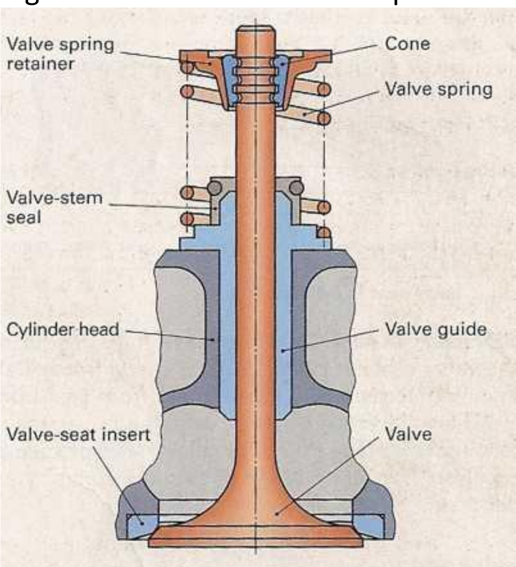


Figure51 : Valve guide

Valve guide

Special valve guides with good sliding properties are pressed into cylinder heads made of Al alloys. These guides are usually made of cast bronze or special cast iron.The valve-stem seal at the top end of the valve guide must guarantee an adequate film of oil in the valve guide; however, it must prevent engine oil from getting through the valve guide into the intake or exhaust port. This would result in high oil consumption and oil-carbon deposits on the valve stem and even the effect of the catalytic converter could be impaired.

Possible fault in hydraulic valve clearance compensation

Chattering noises as a result of excessive valve clearance

- Compensating element runs dry because of excessive wear at the annular orifice.
- Oil restraint valve in the engine lubricating circuit

No valve-clearance compensation

- Faulty valve-clearance compensating element.
- Air in the valve-clearance compensating element caused by foaming oil due to an excessively high oil level.

Valve seat in cylinder head

The valve seats in the cylinder head **(Fig. 1)** usually have the same cone angle as the valve heads.The seat angle is 45°.

Correction angles. These are 15° and 75°. The correction angles improve the flow behaviour and serve to correct the valve-seat width.

Valve-seat width. This provides for a good combustion-chamber seal. It is approximately 1.5 mm for the inlet valve and approximately 2 mm for the exhaust valve in order to improve heat dissipation. Occasionally the seat angles on the valve head and in the cylinder head are slightly different, e.g. 44° on the valve head and 45° in the cylinder head.This creates a narrow sealing edge to the combustion chamber which increases in size during operation to the normal seat width.

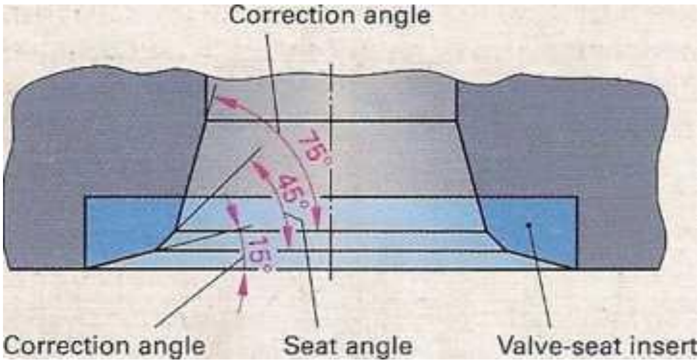


Figure52 : Valve seat in cylinder head

Valve-seat inserts. These increase the strength of the valve seats in cylinder heads made from Al alloys and occasionally those made from cast iron. Valve-seat inserts are creep-, wear- and scale-resistant and are made from high-alloy steels or special cast iron.They are pressed or shrunk into the cylinder head.

Valve spring

This closes the valve at the end of the induction or exhaust stroke. Helical springs are used here. In the interests of avoiding a spring fracture caused by natural oscillation at high engine speeds, valve springs can be wound with a variable uphill gradient, in a tapered shape or with a decreasing wire diameter. Occasionally even two valve springs are arranged inside each other.

Camshaft

This must execute the lifting movement of the valves at the correct time and in the correct se-quence and facilitate closing of the valves by the valve springs.

Cast camshafts These are manufactured from alloyed flake-graphite or nodular-graphite cast iron as clear chill castings.

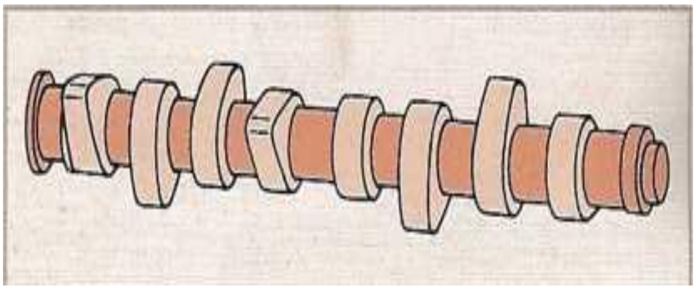


Figure53 : camshaft

Built-up camshafts Here the cams are manufactured individually from case-hardening, tempering or nitriding steel.The cams are then shrunk onto a steel tube.

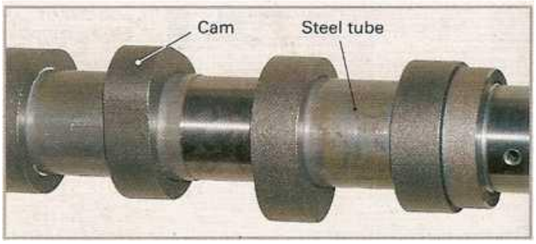


Fig. 54: Built-up camshaft

Cam shapes As the valves are opened and closed, these determine the

- Opening duration
- Height of the valve lift Lifting speed * Sequence of movements

Pointed cam. The valve is slowly raised and closed and remains fully open for a short time only.

Asymmetrical cam. The flatter leading cam face effects a slower opening and the steeper trailing face a longer opening of the valve and a faster closing.

Steep (sharp) cam. The valve is quickly opened and closed and remains fully open for a longer time.

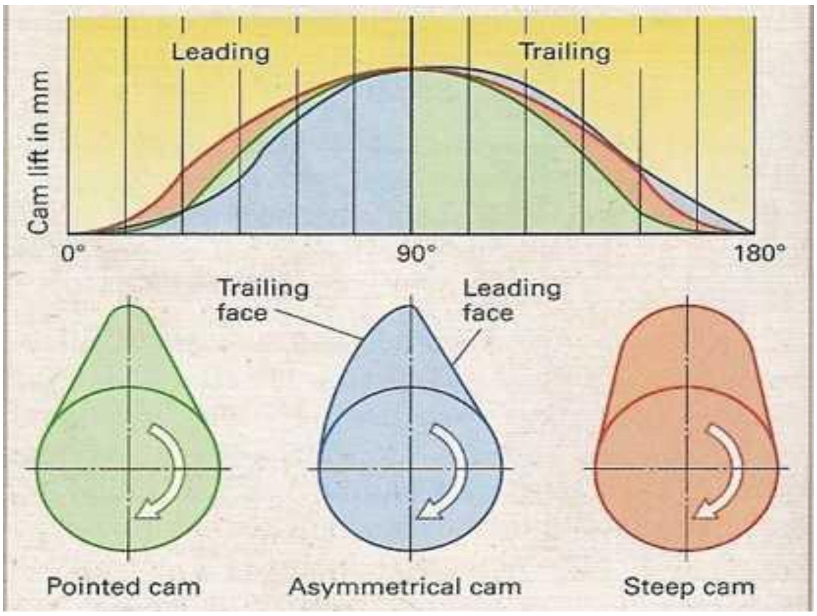
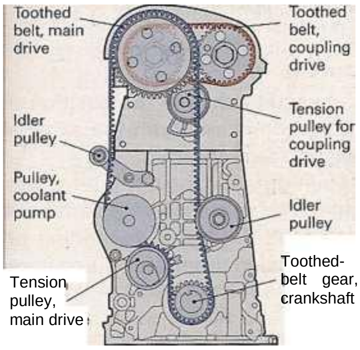


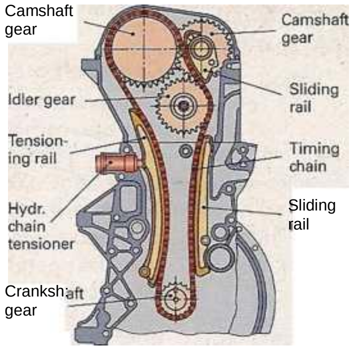
Figure55 : Camshaft shape and cam tilt

CAMSHAFT DRIVES

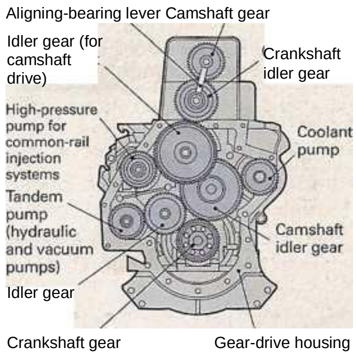
Toothed-belt drive



Chain drive



Spur-gear drive



Plastic belts are used. The tension member in back of the belt usually consists of a Glascord insert, it transmits the tensile forces and limits elongation. The toothed belt is prevented from lateral movement on the toothed-belt pulley by a guide.

This is used when larger forces are to be transmitted and the timing has to be adhered to precisely. A constant chain tension is achieved by a chain tensioner. In the interests of damping chain noises, the chain can be guided in plastic sliding rails and the crankshaft gear can also be rubber-coated.

The rotary motion of the crankshaft is transmitted via a set of gears to the camshaft arranged in the cylinder head. The gears have helical teeth for noise-damping purposes. Advantages: High drive torques can be transmitted with great precision and the overall length can be reduced by narrow gears.

Features of a toothed belt:

- Low mass.
- Silent operation.
- Low production costs.
- Requires only minimal initial tension.
- Requires no lubrication.
- Must be kept free from oil.
- Must not be kinked.

Manufacturer's instructions must be observed when the belt is replaced

Finger-type rockers, rocker arms

If the valves are not actuated directly by the camshaft via barrel tappets, they are opened by the camshaft via finger-type rockers or rocker arms.

Finger type rockers : Are one-arm levers which rest at one end on a ball pin.At the other end they transmit the fitting movement of the cam to the valve. The friction between the cam and rocker can be greatly reduced by using a roller cam follower Can timing cause hard start

Usually, hard starting occurs when the ignition timing is too advanced, not retarded. An overly advanced condition will cause backfire through the carb and overly retarded willcause backfire through the exhaust. If you are not using a timing light, I wouldrecommend that you do

What Causes Timing Chain to Jump, The most common cause oftiming chain stretch is lack of maintenance and regular oil changes. Worn out oil can no longer lubricate the chain and will cause the rollers and links to wear against each other

Symptoms of incorrect ignition timing are poor fuel economy, sluggish acceleration, hard starting, backfiring, or "pinging" or "spark knock". Too little spark advance will cause low power, bad gas mileage, backfiring, and poor performance. Too much advance will cause hard starting and pre-ignition.

What happens when engine timing is off.If the **engine timing** of the cam is **off**, your car will either be running rough or not at all. If the **ignition timing** is the problem, it isn't as easy to notice because it has four cycles: Intake valve sucks in air while fuel is delivered by the injectors. The fuel mixture is reduced

Symptoms of incorrect **ignition timing** are poor fuel economy, sluggish acceleration, hard starting, backfiring, or "pinging" or "spark knock". Too little spark advance will cause low power, bad gas mileage, backfiring, and poor performance. Too much advance will cause hard starting and pre-**ignition**

Why is timing so important.It will serve you well when identifying business trends because it will allow you to catch emerging trends as quickly as possible and maximize your return on them. Whilst **timing**is **important**, it is merely a function of finding the right balance between supply and demand.

LO 1.3 – Demonstrate the understanding of the design and operating principle of a two stroke engine

- Content/Topic 1 Design of two stroke engine

A power cycle in two stroke engine takes place during one crankshaft revolution (360$_0$).
Two stroke spark ignition engine consists of:

1. Engine case: Cylinder head, cylinder, crank case
2. Crankshaft drive: piston, connecting rod, crankshaft.
3. Mixture formation: carburettor or fuel injection system, intake manifold
4. Auxiliary devices: Ignition system, engine cooling, exhaust system and lube oil metering pump with total loss lubrication (separate lubrication)

Because the gas exchange is usually controlled by the piston and via the ports in the cylinder wall, there is no need any of the engine management components which are used in four stroke engine.

Digrram of two stroke spark iginition engine

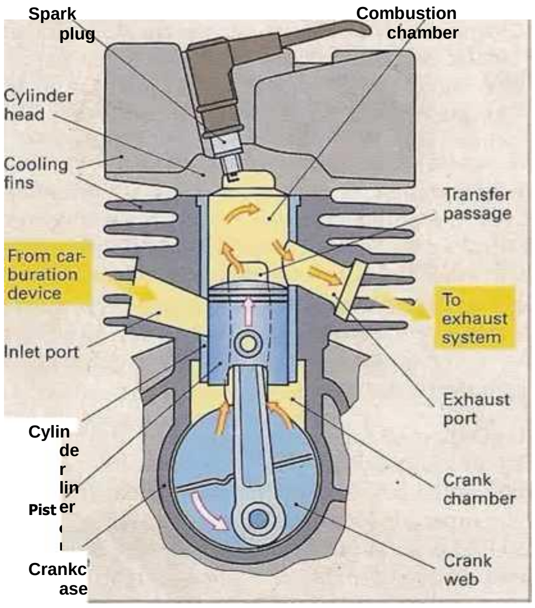


Figure 56 : Design of a two-stroke spark-ignition engine

- Content/Topic 2 Understandingoperating principle of two stroke engine

Operating principle

The power cycle of a two-stroke engine is made up, as in a four-stroke engine, of **induction, compression, combustion, exhaust.** However, the sequence of the individual processes (Table 1) differs in terms of location and duration.
In order in a two-stroke engine to limit the power cycle to two piston strokes or to one crankshaft revolution, the processes of the power cycle must take place both in the cylinder and in the crank chamber. The crank chamber together with the bottom end of the cylinder and the underside of the piston forms a pump. The crank chamber must therefore also be gastight.

Processes in a two stroke engine	
Processes in the cylinder (above the piston)	Transfer(scavenging) Compression Combustion Exhaust
Process in the crank chamber (Below the piston)	Pre-induction Induction Pre-compression Transfer(scavenging)

- **Inlet port:** This connect the carburettor with the crank chamber
- **Transfer passage:** This connects the crank chamber with the combustion chamber
- **Exhaust port:** This connects combustion chamber with the exhaust system

The two stroke engine has one open gas exchange. This means the exhaust ports and transfer passages are simultaneously open over a larger part of the exchange. It is therefore inevitable that on the one hand mixing between fresh gases and exhaust gases takes place and on the other hand fresh gas losses occur in two stroke engine.

Operating principle (Three-port two stroke engine)

1st Stroke, crankshaft angle 00……..1800 Piston moves from BDC to TDC

Processes in the crank chamber

- **Pre-induction.** Once the piston has closed the transfer passage, the increase in volume creates the vacuum pressure of **0.2bar…..0.4bar** in the crank chamber. This process is known as pre-induction.
- **Induction stroke:** When the piston finally uncovers the inlet port, the actual process of inducting the fuel air mixture into the crank chamber begins.

Processes in the combustion chamber

- **Compression stroke.** Once the piston has closed the exhaust port, the process of compressing the fuel air mixture in the cylinder begins. Ignition takes place shortly before TDC.
- **Induction stroke.** When the piston finally uncovers the inlet port, the actual process of inducting the fuel-air mixture into the crank chamber begins.
- **Processes in the combustion chamber Compression stroke.** Once the piston has closed the exhaust port, the process of compressing the fuel-air mixture in the cylinder begins. Ignition takes place shortly before TDC.

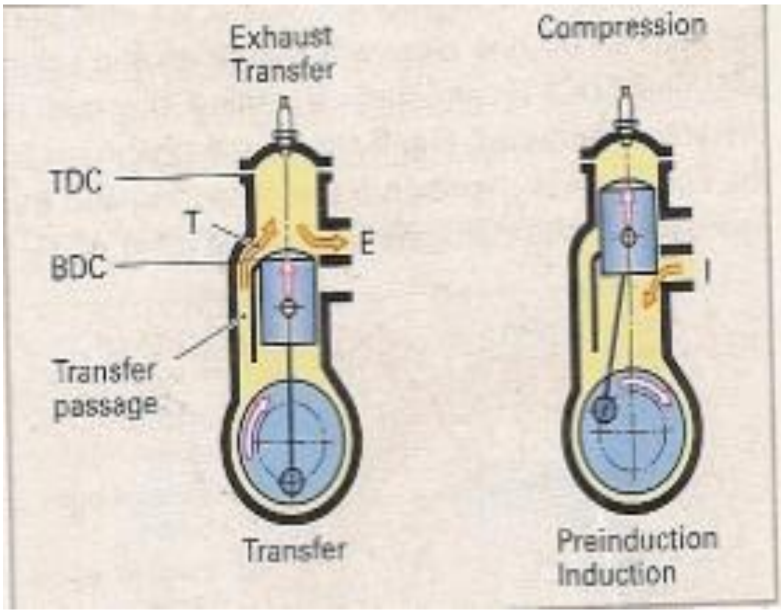


Figure 57 : 1st stroke of two stroke

2nd stroke, crankshaft angle 1800….3600 piston travels from TDC to BDC

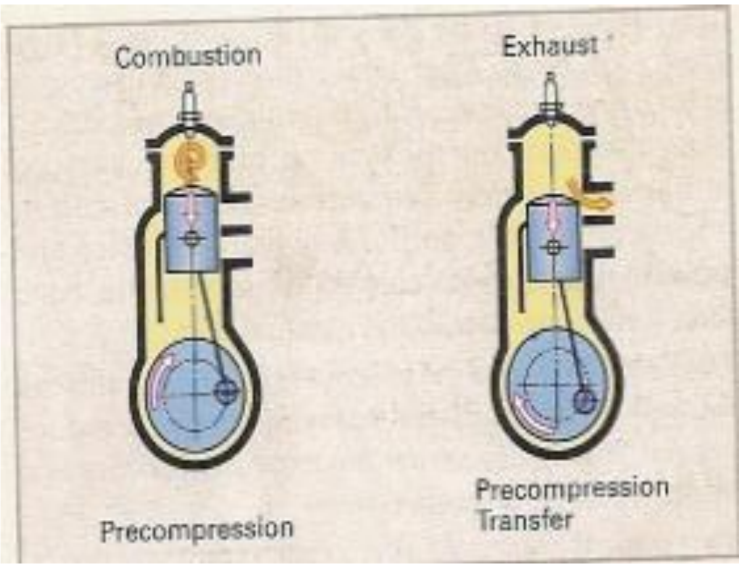


Figure58: 2nd stroke of two stroke

Processes in the combustion chamber power stroke. The pressure of the combustion gases moves the piston from TDC to BDC.
Processes in the crank chamber. Once the piston has closed the inlet port, pre-compression of the fuel air mixture to approximately **0.3 bar….0.8bar** gauge pressure begins.
Gas exchange process. (Processes under and above the piston) the gas exchange takes place during the transition to the next power cycle.
Exhaust stroke. The top edge of the piston uncovers the slightly higher exhaust port and the exhaust gases rush out. It then uncovers the transfer passage and the pre-compressed fuel air mixture as it is passes from the crank chamber assumes the task of scavenging the cylinder and discharging the residual exhaust gases.

The initial dynamic pressure in the exhaust pipes forces the residual exhaust gases initially back into the crank chamber when the transfer passage is uncovered. In this way, the pre-compression pressure of 0.3 bar increases to the scavenging pressure of approximately 0.8 bar. This in return instigate the transfer of the fresh gases, the scavenging process is completed when the piston on its way to TDC has closed the transfer passage and then the exhaust port.

Gas pressure in bar			
Induction	**compression**	**combustion**	**exhaust**
-0.4…..-0.6	**8…12**	**25…40**	**3…..o.1**
Pre-induction	**Pre-compression**		**Transfer**
-0.2…-0.4	**0.3…0.8**		**1.3….1.6**

Scavenging process (reversal scavenging)

In the case of conventional SCHNURLE Reverse scavenging (Adolf Schnurle,German engineer,1896-1951),there is a transfer passage on either side of exhaust port. A piston window controls the inlet port. This form of scavenging is also known as <triple flow scavenging>.

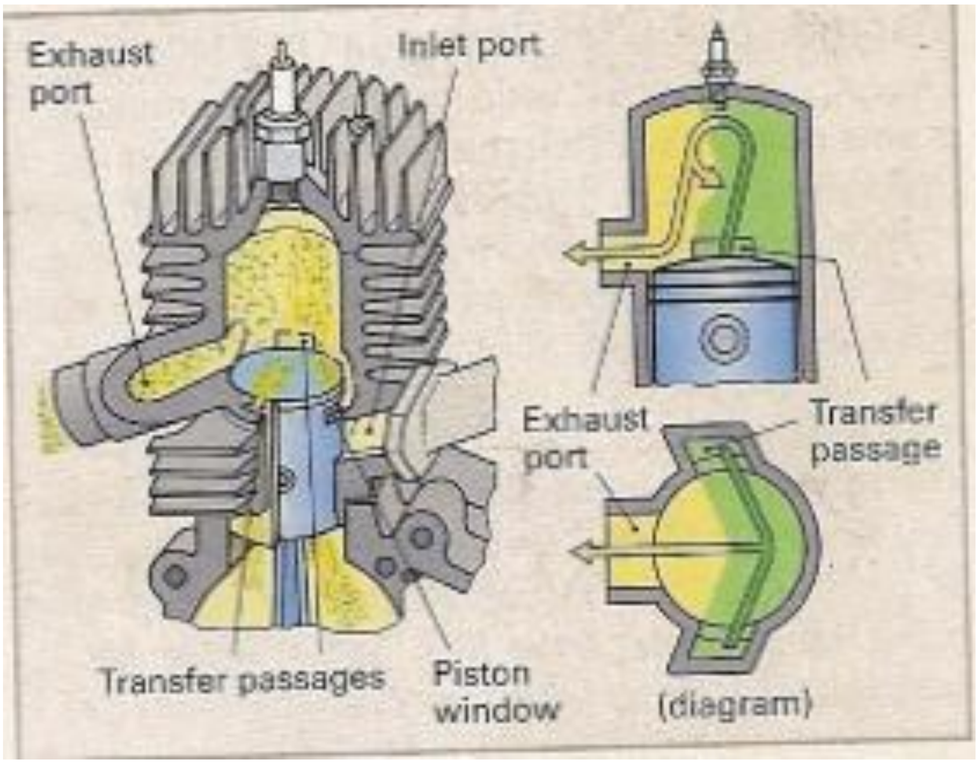


Figure59: Reverse scavenging

The scavenging flows are routed from the scavenging passages situated at an angle to the cylinder axis to the cylinder wall opposite the exhaust. There they mount up and push out the residual exhaust gases. Following the cylinder wall, to the exhaust port. The scavenging flows therefore loop back in the cylinder.There can also be three or more transfer passages situated opposite the exhaust port or ports. In the case of four passage reverse scavenging, the two main scavenging flows meet opposite the exhaust port and are diverted upward. After being diverted, this movement being encouraged by the shape of the cylinder head, they force out the majority of the exhaust gas to exhaust port. The two auxiliary ports scavenging ports are routed in such a way that they force and expel the exhaust gas core still situated in< the dead area> of the cylinder to the exhaust port.

The looping of the main scavenging flows and the routing of the auxiliary scavenging flows reduce scavenging losses, expel exhaust gas core and improve volumetric efficiency

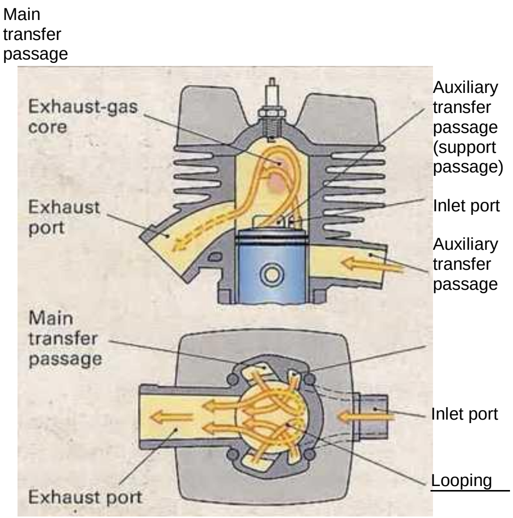


Fig.60: Multiport reverse scavenging (loop scavenging)

Vibration processes during gas exchange

Two-stroke engines with symmetrical timing diagrams operate with a large overlap of the timing or the gas-exchange processes. The abrupt gas-ex- change processes generate vibrations in the gas columns. These vibrations must be tuned to each other in the interests of reducing fresh-gas losses. **Inlet process**

The fresh-gas column vibrates between the induction system, the inlet port and the crank chamber. Under correct tuning conditions the piston must close the inlet port when the fresh-gas column vibrates back to the crank chamber. The fresh gas is no longer able to flow back and the compression pressure increases.

Exhaust and scavenging process

The gas columns vibrate between the exhaust system, the cylinder and the crank chamber. The exhaust gas flowing out under pressure generates a pressure wave which is reflected by a baffle plate in the front silencer. This prevents fresh gas from flowing into the exhaust port. On account of these vibration processes the exhaust pipe with silencer and the intake line with air filter must be precisely matched to each other in orderto avoid charge losses. Inexpert or inappropriate modification or remachining will result in power losses and higher specific fuel consumption.

Symmetrical timing diagram (Fig. 2).

In a two-stroke engine with gas-exchange control by the piston the inlet and exhaust ports and the transfer passage are opened precisely as many degrees before TDC or BDC as they are closed. If, for example, the piston moving to TDC opens the inlet port 55° before TDC, the latter will also be closed again 55° after TDC. A symmetrical timing diagram is therefore produced. **Fig. 2** shows the processes in the combustion chamber in the outer ring and the processes in the crank chamber in the inner ring.

Io Inlet port opens
Ic Inlet port closes
Eo Exhaust port opens
Ec Exhaust port closes
To Transfer passage opens
Tc Transfer passage closes
Ip Ignition point *a* Exhaust-lead angle
/? Exhaust-trail angle

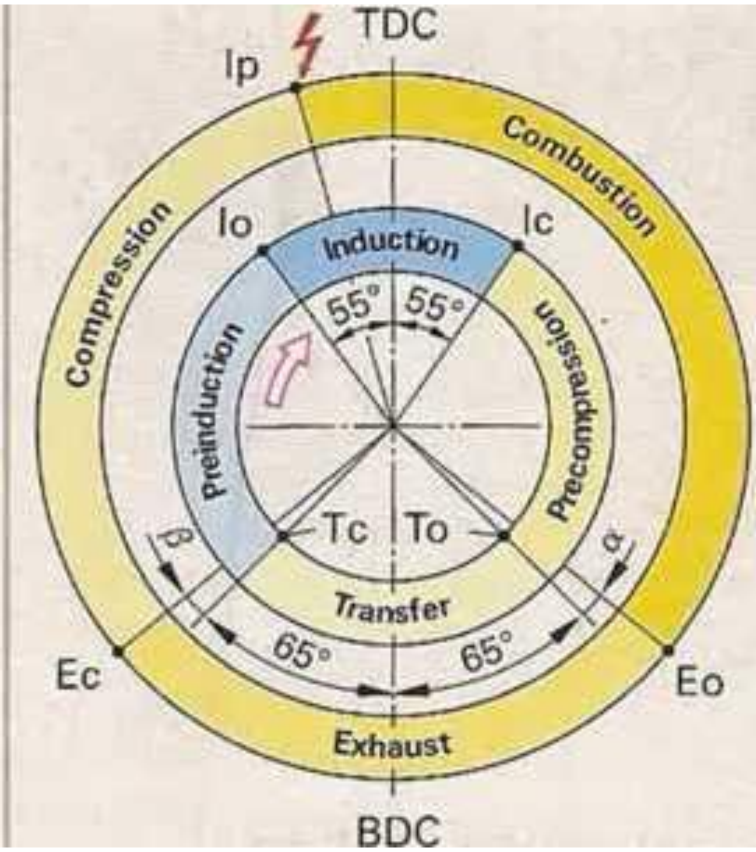


Figure 61 : ssymetrical timing diagram

Favourable exhaust lead. The piston moving to BDC opens first the exhaust port and then the transfer passage. The opening of the exhaust port is accompanied by a marked pressure drop such that the residual exhaust gases do not blow back so severely into the crank chamber and mix there with the precompressed fresh gas.

Harmful exhaust trail. The piston moving to TDC closes first the transfer passage and then the exhaust port. Fresh gases can be forced out to the exhaust port in the process.

Charge loss. A two-stroke engine has only roughly 130° crankshaft angle available for scavenging, corresponding to approximately one third of the gas- exchange time of a four-stroke engine.
Inlet control and/or exhaust control is used on account of these disadvantages.This results in asymmetrical timing diagrams.

Asymmetrical timing diagram
In the case of an asymmetrical timing diagram **(Fig. 61),** the opening and closing angles for the individual ports vary in size and are therefore no longer symmetrical toTDC or BDC.

Asymmetrical timing diagrams for inlet and exhaust control cannot be obtained with piston-dependent port control.

Useful supercharging/boosting. In two-stroke engines with asymmetrical timing diagrams the transfer passage can be closed afterthe exhaust port; the charge is improved by the mass inertia of the fresh gases.
"Useful supercharging/boosting" can only be achieved with highly elaborate design features, e.g. by inlet control using slides and by exhaust control using cam-controlled exhaust valves.

Inlet port opens Inlet port closes
Exhaust port opens
Exhaust port closes

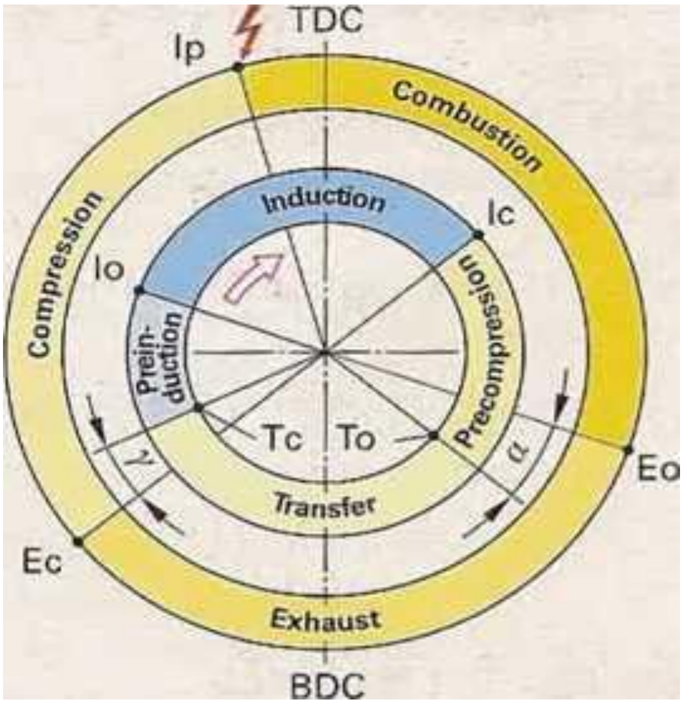


Figure62 : Assymetrical timing diagram

The opening or/and closing angles can be "advanced" or "retarded" for the inlet process by means of diaphragm or rotating-slide control

- <u>Content/Topic 3 Understanding types of control for two stroke engine</u>

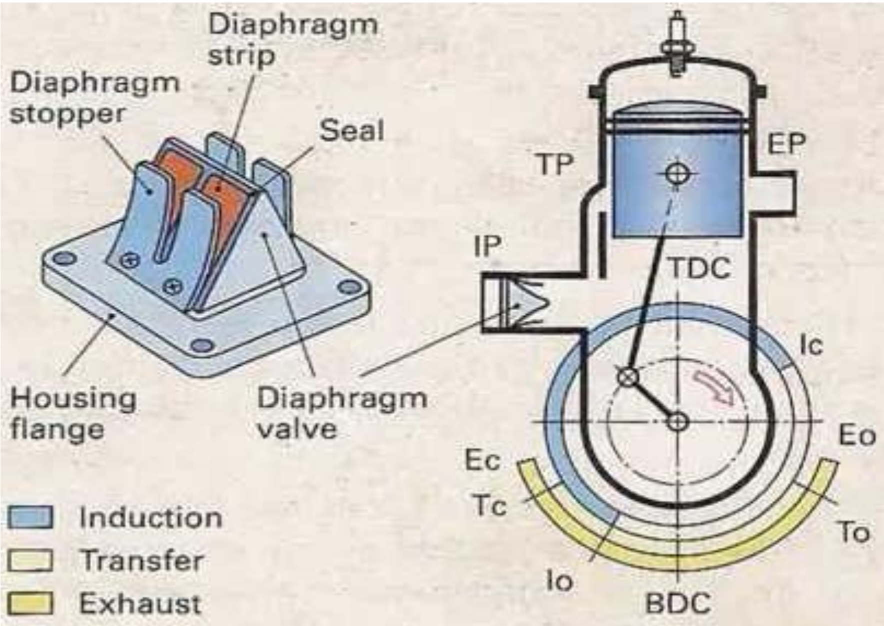
Inlet control

Diaphragm control . The supply of fresh gas is controlled by means of a diaphragm valve in the inlet port. When the piston moves toTDC (preinduction), a vacuum pressure is generated in the crank chamber.The diaphragm valve is opened by the differential pressure of the crank-chamber and atmospheric pressures. The fresh gas can flow during induction into the crank chamber until the precompression pressure generated by the pressure of the downward-moving piston and the pretensioned diaphragm close the inlet port. In this way, the diaphragm valve prevents the inducted fresh gas from flowing back into the induction system. An improved fresh-gas charge is achieved as a result.

Design of diaphragm valve The diaphragm strips are made of highly elastic, thin spring steel

and open already under the slightest differential pressure.The diaphragm stopper restricts the valve movement of the diaphragm strips and prevents them from swinging up.

Figure62: Diaphragm control



Rotating slide control

The inlet port is controlled by rotating slides. Unlike diaphragm control angles can not vary here. The opening of the inlet port into the crank chamber is opened and sealed by a rotating slide. The rotating slide rotates at cranlshaft speed.

It utulises the shapes of it recess and the opposition in the relation to the crankshaft to determine the inlet angle and thus the inlet time.Crank webs with recesses can also be used as rotating slide

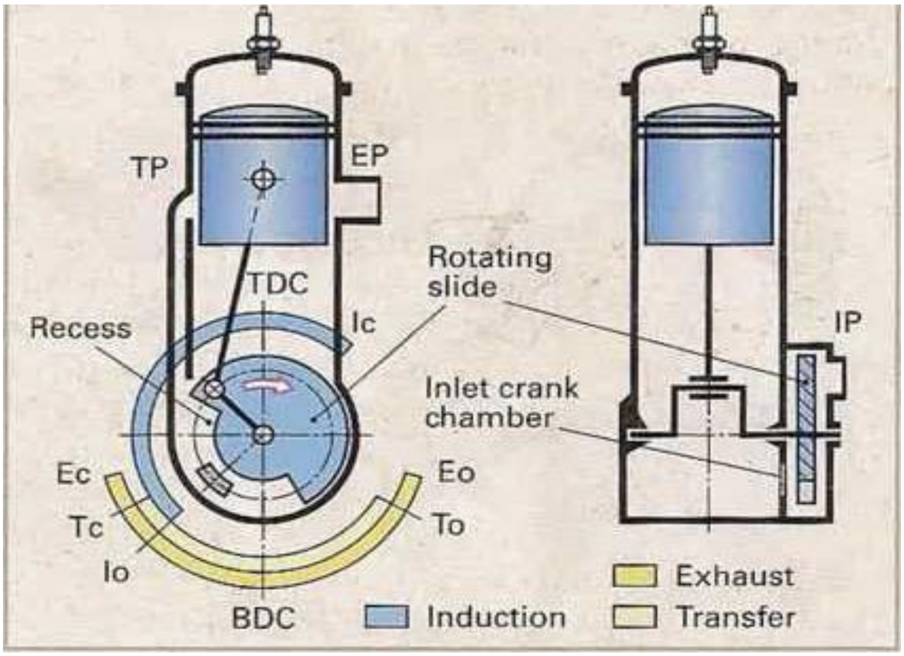


Figure63 : Rotating slide control

Features of inlet control

- Asymmetrical timing diagram.
- Control angles for "Inlet port opens" and "Inlet port closes" differ in size - control angles for transfer and exhaust are symmetrical to BDC.
- Variable inlet angle with diaphragm control is dependent on the crank-chamber vacuum pressure.
- Constant inlet angle with rotating-slide control.
- Improved crank-chamber charge and thus higher torque, high power output per litre.

Exhaust control

Exhaust control is used to reduce or avoid the harmful exhaust trail. It also improves volumetric efficiency.

If the exhaust backpressure is too low, too much fresh gas escapes into the exhaust system; if it is too high, too little fresh gas is admitted into the cylinder.

The exhaust system can be designed in such a way that at high engine speeds a high exhaust backpressure is generated which however is not achieved at low engine speeds. Within a very narrow speed range (resonance speed) the gas vibrations can be tuned in such a way as to reduce the scavenging losses and improve the volumetric efficiency.

Exhaust control with barrel valve (Fig. 1).

Exhaust control is performed with a barrel valve (power valve system). The barrel valve mounted transversally to the exhaust port has a segmentshaped cut-out with a sharp metering edge. The cross-section of the exhaust port is reduced as a function of engine speed by the rotation of the barrel valve

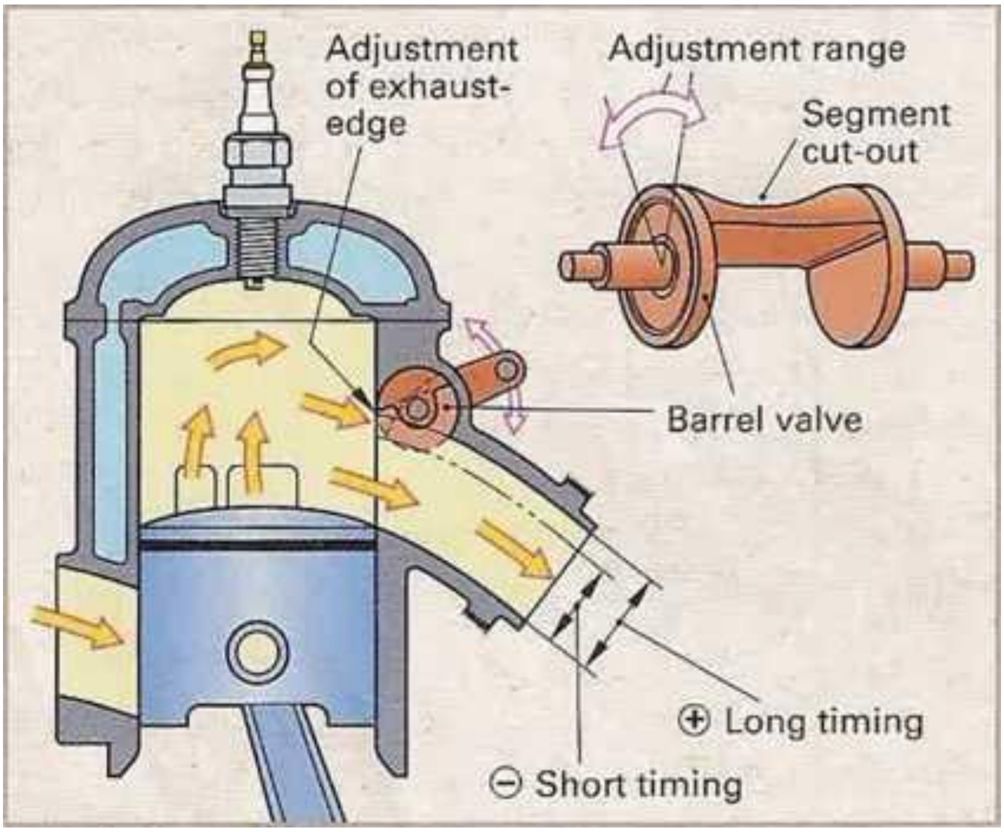


Figure64 : Exhaust control with barrel valve

At low and medium engine speeds the top edge (metering edge) of the exhaust port is displaced downwards by the rotation of the barrel valve and the height of the exhaust-port cross-section is reduced. In this way, the exhaust control angle and the exhaust timing are shortened to prevent fresh gas from flowing into the exhaust port. The effective stroke of the piston and the effective compression ratio are increased in the process. The barrel valve is rotated shortly before the top speed is reached so that the entire exhaust-port cross-section is opened. In this way, a larger exhaust control angle and longer exhaust timing are achieved.

The barrel valve can be positioned as a function of centrifugal force or by means of a servo-motor.The servo-motor records the number of ignition pulses as the reference variable.

Features of exhaust control

Exhaust control by barrel valves has symmetrical timing diagrams.
Reduced fresh-gas losses during scavenging. High torque and high power at low and medium engine speeds.
Barrel valve subjected to high thermal loads, sensitive to carbon deposits.
Poorer cooling ofthe cylinder wall inthe exhaust area.

- Content/Topic 4 Demonstration particular design features of two stroke engine

Particular designJeatures

Crankcase

The crank chamber situated in the crankcase must be sealed to the outside so that it is pressure-proof and must be compact in design so that the necessary precompression pressure can be achieved. Radial shaft seals as used to seal the crankshaft. In multiple-cylinder engines the crankshaft must also be sealed at the intermediate bearings. This prevents gas-exchange processes between the different cylinders and crank chambers.

Lubrication

Because the crank chamber serves to precompress the fuel-air mixture and therefore cannot be equipped with a forced-feed lubrication system, virtually all two-stroke engines have a mixture- or separate-lubrication system.

Mixture lubrication. Lube oil is mixed with the fuel (mixture ratio between 1 : 25 and 1 : WO but usually 1 : 50). When the engine is at normal operating temperature the fuel evaporates and the lube oil precipitates on the bearings and the cylinder wall.

Total-loss lubrication Fuel and oil are stored separately from each other in reservoirs (separate lubrication). From the oil reservoir the oil is supplied by a metering pump eitherto be mixed with the fuel or delivered to the intake port.

Where it is taken up by the fuel-air mixture. The crankshaft bearings can also be supplied directly with oil.

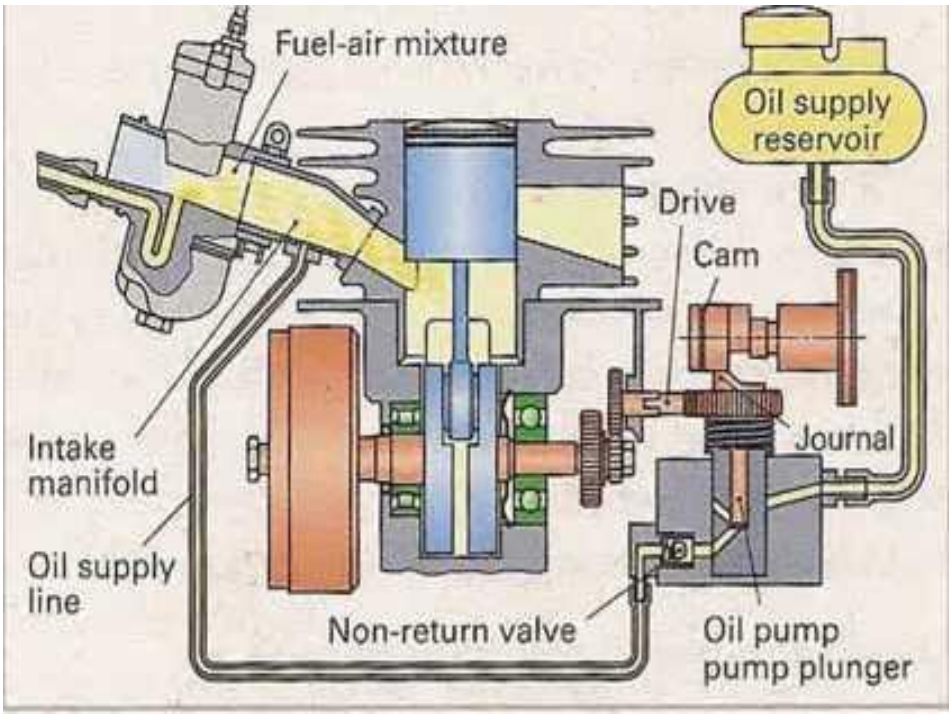


Figure65 : Total loss lubrication with metering pump

The pump element with pump plunger is rotated by the crankshaft and in this way the oil is delivered as a function of engine speed.The coil spring presses the plunger via the journal against the acting cam.

The throttle control alters the cam position and the oil is delivered as a function of load. Speed- and load-dependent metering help to achieve large oil savings (mixture ratio 1 : 100 and leaner).

Crankshaft and connecting rod

Antifriction bearings are used to support the crankshaft and the connecting rod.

If conventional non-split antifriction bearings (needle or roller bearings) are used, the crankshaft must be assembled from individual parts.

Piston with accessories

Because of double the number of working cycles and the control of the exhaust port, the piston in a two-stroke engine can become hotter than that in a four-stroke engine.The greater thermal expansion is compensated by larger installation clearances for the piston, the gudgeon pin and the piston rings. Two-stroke pistons incur greater wear due to the fact that they are exposed to higher levels of stress and strain.

Windows in the piston skirt partially assume the function of controlling the cylinder ports.They do however reduce the inherent stability of the piston.

Extremely light pistons are used in particularly fastrunning two-stroke engines. In this way, the inertia forces that occur during operation can be kept low.

Closed gudgeon pins are used where hollow gudgeon pins would cause a bypass connection of the ports in the cylinder and thus scavenging losses.

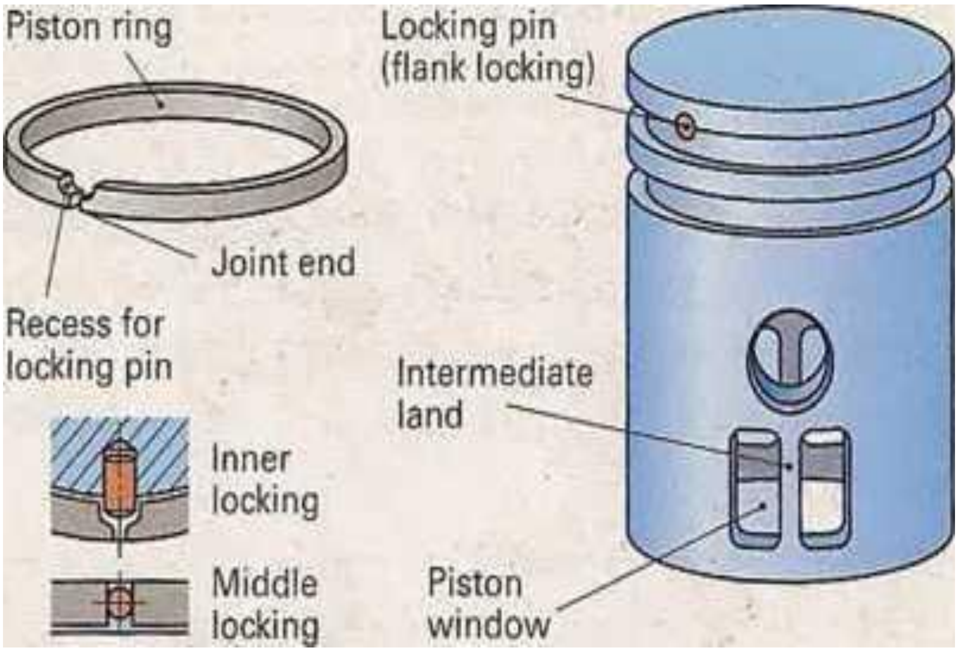


Figure66 : Single metal piston with window

Wire snap rings without hook ends (detachable hooks) are used to lock the gudgeon pins axially. Hooks on account of their mass inertia could cause the snap rings to lift off in fast-running two-stroke engines (up to 16,000 rpm), thus jeopardising their secure seating in the groove.

Piston rings. Plain compression rings are normally used. Small two-stroke engines often have only one piston ring (an L-section ring) to reduce friction loss. This piston ring provides a particularly good seal due to the pressure of the combustion gases. Because of the low oil content in mixture-lubrication systems, two-stroke pistons do not have an oil control ring. Each piston-ring groove features a locking pin as an anti-rotation element.

If these locking pins were not fitted, the joint ends of the piston rings could rotate in such a way as to project and deflect into the cylinder ports and cause damage.

Cylinder

Gas passages, the openings of which are designed as "rectangular" ports, lead through the cylinder walls. The horizontal, curved port edges help the piston rings and piston to slide along without abrupt stresses.

Wide ports are interrupted by intermediate lands so that the closed piston-ring section cannot deflect too far. Carbon deposits can cause above all the exhaust ports to constrict. In this event, poor scavenging means that an ignitable fuel-air mixture is only created after every second scavenging process. The consequences of this are misfiring and therefore power losses.

Exhaust system

The scavenging process is a vibration process.The exhaust pipe with silencer and intake line with air filter must therefore be exactly matched to each other.

Alterations to the exhaust system contravene the statutory requirements and will result in the type approval being invalidated

- Content /Topic5 Demonstrate and understanding the application of two stroke engine

Applicationof two-stroke engines

The use of two-stroke engines is becoming increasingly more infrequent due to the constant tightening of exhaust-emission regulations. Even modern two-stroke engines such as the 50 cc engine with direct injection pictured below **(Fig)** achieve at best Euro 2 ratings on account of their high HC emissions.

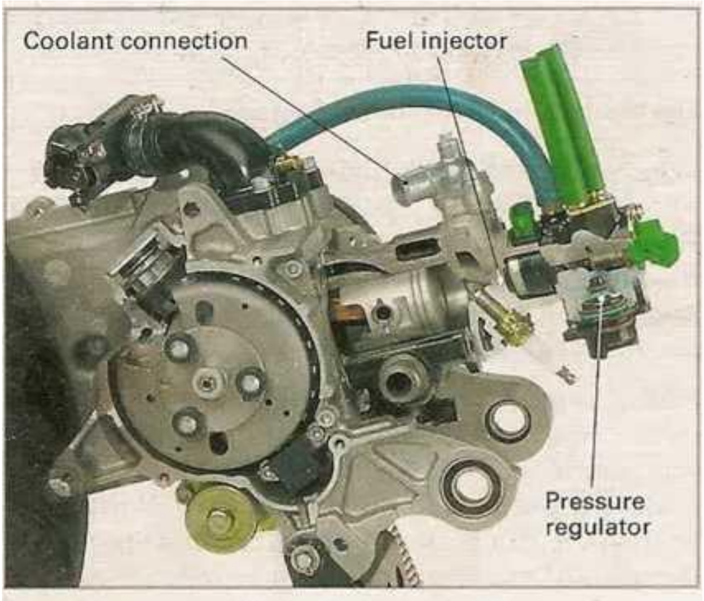


Figure67 : Two stroke direct injection engine

The use of two-stroke engines will in future be confined to racing bikes in small-scale production quantities.

Advantages over a four-stroke engine:

- Simple design. Fewer moving parts (piston, connecting rod, crankshaft)
- More uniform torque, no idle strokes
- Lower-vibration, smoother running with the same number of cylinders
- Compact construction, lighter weight
- Low engine weight-to-power ratio, high power output per litre
- Low manufacturing costs

Disadvantages in comparison with a four-stroke engine:

- Poorer charge
- Exhaust-gas emissions, high HC values Higher thermal load, absence of idle strokes Lower mean piston pressures due to poorer cylinder charge
- Poor idle performance due to residual exhaust gas in the engine
- High specific oil and fuel consumption

Workshop tasks

- Use special two-stroke oils (self-mixing oil) only in accordance with the manufacturer's instructions and in the specified mixture ratio.

- Clean the air filter at regular intervals.
- Do not remove carbon deposits with sharp- edged objects, avoid making scratches.
- When cleaning, do not grind or sand the piston crown to a bright finish as this could cause overheating and increased carbon deposits. Do not damage the piston edges as this would alter the timing.

Faults

Drop in engine power due to e.g.

- Contaminated air filter; carbon deposits.
- Defective ventilation of the fuel tank.
- Insufficient fuel supply.
- Spark plug fouled by oil, coked or incorrect thermal value.
- Incorrect ignition-point setting.
- Poor compression.
- Leaking crank chamber.

Engine too hot due to e.g.

- Contaminated cooling fins.
- Fault in the cooling system.
- Use of excessively lean fuel-air mixture due to incorrect carburettor setting.
- Incorrect mixture ratio of fuel and two-stroke oil. Use of incorrect oil.
- Occurrence of auto-ignition due to incorrect spark plugs or carbon deposits.
- Excessive heat absorption due to a gound or sanded piston crown

Two-Stroke Gasoline Engine

In the past, several imported vehicles have used two stroke engines. As the name implies, this engine requires only two strokes of the piston to complete all four operations: intake, compression, power, and exhaust. This is accomplished as follows:

1. Movement of the piston from BDC to TDC completes both intake and compression.

2. When the piston nears TDC, the compressed air fuel mixture is ignited, causing an expansion of the gases. During this time, the intake and exhaust ports are closed.

3. Expanding gases in the cylinder force the piston down, rotating the crankshaft.

4. With the piston at BDC, the intake and exhaust ports are both open, allowing exhaust gases to leave the cylinder and air-fuel mixture to enter.

Although the two-stroke-cycle engine is simple in design and lightweight because it lacks a valve train, it has not been widely used in automobiles. It tends to be less fuel efficient and releases more pollutants into the atmosphere than four-stroke engines. Oil is often in the exhaust stream because these engines require constant oil delivery to the cylinders to keep the piston lubricated. Some of these engines require a certain amount of oil to be mixed with the fuel.

Learning unit 2 –Disassemble the engine components

LO 2.1 – Select tools, materials and equipment

- Content/Topic 1 Selection of tools

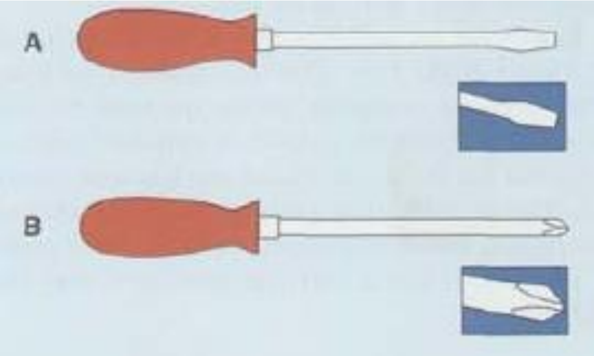
They can be selected according to classification as measuring tools, power tools and hand tools. Tool is an item or implement used for a specific purpose. A **tool** can be a physical object such as mechanical tools including saws and hammers, spanners,

Figure68 : Different tools

The following some hands tools are used during engine overhaul and adjusting

A. Open –end wrench
B. Closed –end (box-end) wrench
C. Combination wrench
D. Tubing or Line wrench

Figure69: Spanners



A. Standard screwdriver B. Phillips screwdriver

Figure70: Screwdrivers

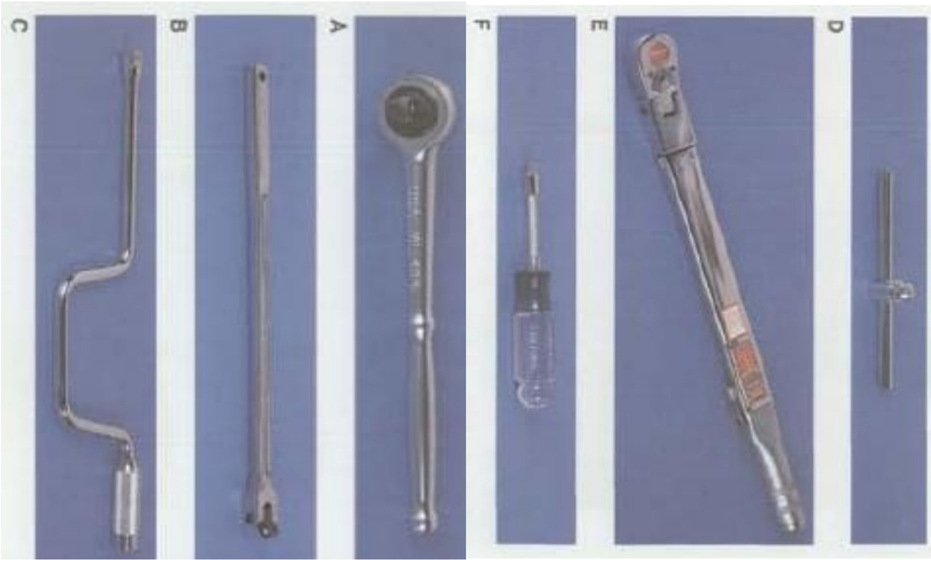


Figure71: handles

A. Ratchet
B. Breaker bar or flex handle
C. Speed handle
D. T –handle
E. Torque wrench
F. Flexible drive

Figure72 : Sockets

- Power tools (Air compressor, Alligator shear, Angle grinder, Band saw, Belt sander, Biscuit joiner, Ceramic tile cutter, Chainsaw)
- Measuring tools: (Calipers, Micrometer, Laser Measure, Ruler, Compass, Square, Measuring Tape, Tailor's Measuring Tape.
- Hand tools: (wrenches, pliers, cutters, files, striking tools, struck or hammered tools, screwdrivers, vices, clamps, snips, saws, drills and knives)

- Content/Topic 2 Selection of materials

- Materials: (Fuel, engine oil, Grease, Lubricants, Oil filter)
- Equipment: (PPE, chain crane, elevator)

Examples of tools, materials and equipment’s
Tools are

- Spanners(8,9,10,12,14,17 and 19)
- Screw drives: star and flat
- Allen keys 8,9 and 10
- Pliers such as long nose, universal and cutting pliers
- Fuel(Diesel or petrol)
- Sand paper
- Grease
- Engine oil
- Water
- Liquid soap

- Content /Topic3 Selection of equipment

Equipment are:

- Hand scanner OBD1 and OBD2
- Wireless printer
- Car lift /pit
- And other required equipment according to the faults identified.

- Floor crane/Chain crane

Figure 73: Chain crane

To pull an engine out of a vehicle, the chain on the lifting crane is attached to another chain secured to the engine.

LO 2.2 – Remove the engine from the car

- Content/Topic 1 Diamantling of auxiliary systems for engine

Before doing anything put the covers on the defenders

Figure74: Cover

Air-Fuel System Remove the air intake ducts and air cleaner assembly. Disconnect and plug the fuel line at the fuel rail. If the engine is equipped with a return fuel line from the fuel pressure regulator, disconnect that as well. Make sure all fuel lines are closed off with pinch pliers or the appropriate plug or cap. Most late-model fuel lines have quick-connect fittings that are separated by squeezing the retainer tabs together and pulling the fitting off the fuel line nipple.

Disconnect all vacuum lines at the engine. Make sure these are labeled before disconnecting them.

Most automobiles have a vacuum wiring diagram decal under the hood. The diagram and the labels (these could be masking tape with the connecting point written on it) will make it easier to reconnect the hoses when the engine is reinstalled.

Now disconnect the throttle linkage at the throttle body and the electrical connector to the throttle position (TP) sensor.

Accessories Remove all drive belts. Unbolt and move the power steering pump and air-conditioning (A/C) compressor out of the way.Do not disconnect the lines unless it is necessary.

Figure 75: After the negative battery cable is disconnected, tape the terminal end to prevent it from accidentally touching the battery.

Battery Install a memory saver before you disconnect the battery to prevent the vehicle's computers and other devices from losing what they have stored in their memory. Disconnect all negative battery cables, tape their connectors, and place them away from the battery. If the battery will be in the way of engine removal, remove the positive cables and the battery.

Underbody Connections While you are under the vehicle to drain the fluids, disconnect the shift linkage, transmission cooling lines, all electrical connections, vacuum hoses, and clutch linkages from the transmission. If the clutch is hydraulically operated, unbolt the slave cylinder and set it aside, if possible. If this is not possible, disconnect and plug the line to the cylinder.

Figure 76 If the transmission will be removed with the engine, disconnect all linkages, lines, and electrical connectors.

Figure 77 Drain the engine's coolant and recycle it.

Fluids Drain the engine's oil and remove the oil filter. Then drain the coolant from the radiator and engine block, if possible. To increase the flow of the coolant out of the cooling system, remove the radiator cap. Make sure the engine is cool before opening the coolant drain and before removing the radiator cap. After collecting the old coolant, recycle it. If the transmission will be removed with the engine, drain its fluid. (ERJAVEC, 2010)

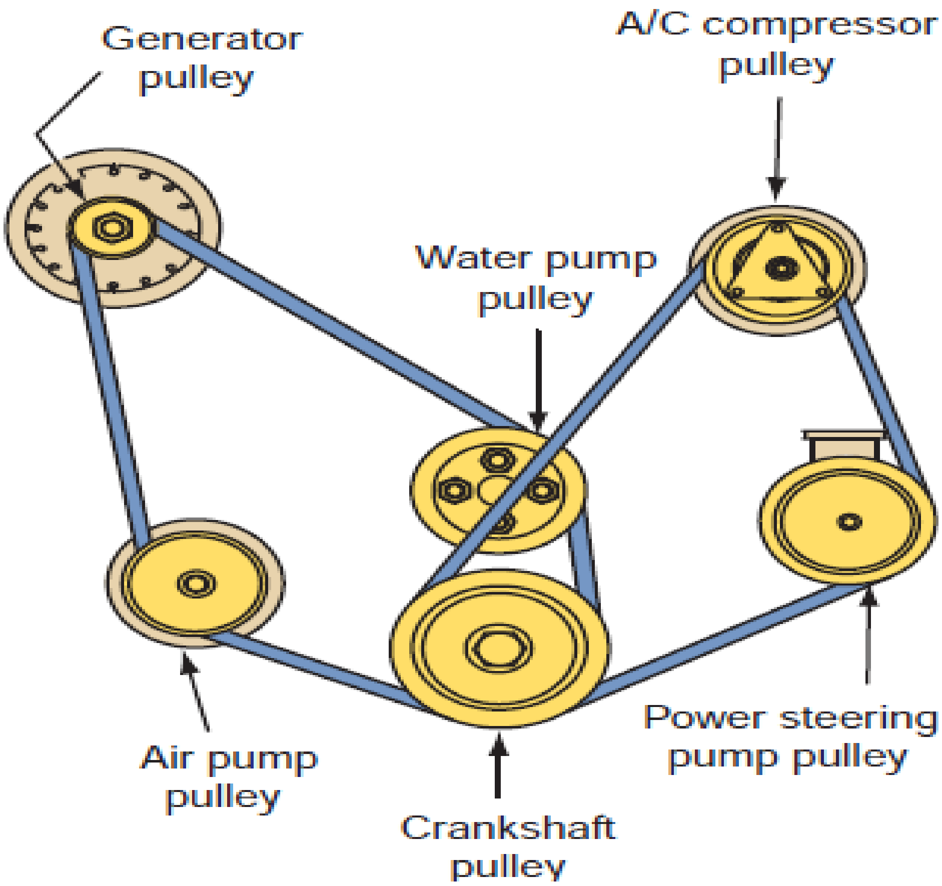


Figure78: Timing belt

Electrical Connections Unplug all electrical wires between the engine and the vehicle. Use masking tape as a label to identify all wires that are disconnected **(Figure 10 –9)**. Some engines have a crankshaft position sensor attached above the flywheel or flex plate. This sensor must be removed before separating the engine from the bell housing. Make sure the engine ground strap is disconnected, preferably at the engine.

Figure79: Electrical connections
(ERJAVEC, 2010)

Cooling System Disconnect the heater inlet and outlet hoses. Then disconnect the upper and lower radiator hoses. If the radiator is fitted with a fan shroud, carefully remove it along with the cooling fan. If the vehicle is equipped with an electric cooling fan, disconnect the wiring to the cooling fan. Then unbolt and remove the radiator mounting brackets and remove the radiator. Normally the electric cooling fan assembly and radiator can be removed as a unit.

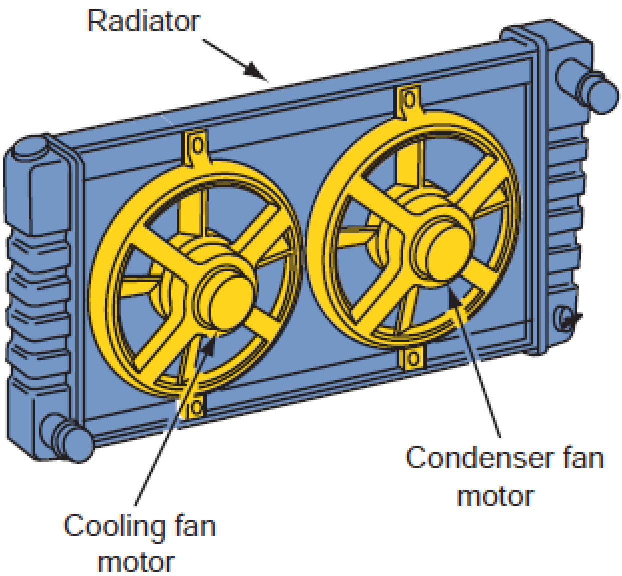


Figure 80 Typically the electric cooling fans can be removed as a unit with the radiator.

Figure 81 The exhaust system must be disconnected to remove the engine. Often this is the condition

Miscellaneous Stuff Disconnect the exhaust system; attempt to do this at the exhaust manifold. When disconnecting the exhaust system, make sure the wires connected to the exhaust sensors are disconnected before the system is moved. Remove any heat shields that may be in the way of moving or removing the exhaust system. Now carefully check under the hood to find and remove anything that may interfere with engine removal.

Removing the engine from a RWD vehicle is more straightforward than removing one from a FWD model, because there is typically easy access to the cables, wiring, and bell housing bolts. Engines in FWD cars can be more difficult to remove because large assemblies such as engine cradles, suspension components, brake components, splash shields, or other pieces may need to be disassembled or removed.

FWD Vehicles

Before removing the engine, identify any special tool needs and precautions that are recommended by the manufacturer. Most often the engine in a FWD vehicle is removed through the bottom of the vehicle. Special tools may be required to hold the transaxle and/or engine in place as it is being disconnected from the vehicle **(Figure 10–12)**. Always refer to the service manual before proceeding to remove the transaxle. You will waste much time and energy if you do not check the manual first. When the engine is removed through the bottom of the vehicle, use an engine cradle and dolly to support the engine. If the manufacturer recommends engine removal through the hood opening, use an engine hoist. Regardless of the method of removal, the engine and transaxle are usually removed as a unit. The transaxle can be separated from the engine once it has been lifted out of the vehicle.

Figure 82 A transverse engine support bar provides the necessary support when removing an engine from a FWD vehicle. *Courtesy of SPX Service Solutions*

Figure 83 Use a large breaker bar to loosen the axle shaft hub nuts.

Drive Axles Using a large breaker bar, loosen and remove the axle shaft hub nuts **(Figure 10 –13)**. It is recommended that these nuts be loosened with the vehicle on the floor and the brakes applied.
Raise the vehicle so you can comfortably work under it. Then remove the wheel and tire assemblies from the front wheels. Tap the splined CV joint shaft with a soft-faced hammer to see if it is loose. Most will come loose with a few taps. Many Ford FWD cars use an interference fit spline at the hub. You will need a special puller for this type of CV joint; the tool pushes the shaft out, and on installation pulls the shaft back into the hub.

Disconnect all suspension and steering parts that need to be removed according to the service manual.

Figure 84 Pull the steering knuckle outward to allow the CV joint shaft to slide out of the hub.

Index the parts so wheel alignment will be close after reassembly. Normally the lower ball joint must be separated from the steering knuckle. The ball joint will either be bolted to the lower control arm or the ball joint will be held into the knuckle with a pinch bolt. Once the ball joint is loose, the control arm can be pulled down and the knuckle can be pushed outward to allow the CV joint shaft to slide out of the hub.

The inboard joint can then either be pried out or will slide out. Some transaxles have retaining clips that must be removed before the inner joint can be removed. Others have a flange-type mounting. These must be unbolted to remove the shafts. In some cases, flange-mounted drive shafts may be left attached to the wheel and hub assembly and only unbolted at the transmission flange. The free end of the shafts should be supported and placed out of the way.
Pull the drive axles out of the transaxle. While removing the axles, make sure the brake lines and hoses are not stressed. Suspend them with wire to relieve the weight on the hoses and to keep them out of the way.

Transaxle Connections Disconnect all electrical connectors and the speedometer cable at the transaxle. Then disconnect the shift linkage or cables and the clutch cable.

Starter Now, remove the starter. The starter wiring may be left connected, or you can also completely remove the starter from the vehicle to get it totally out of the way. The starter should never be left to hang by the wires attached to it. The weight of the starter can damage the wires or, worse, break the wires and allow the starter to fall, possibly on you or someone else. Always securely support the starter and position it out of the way after you have unbolted it from the engine.
(ERJAVEC, 2010)

Figure85: Proppelershaft dismounting

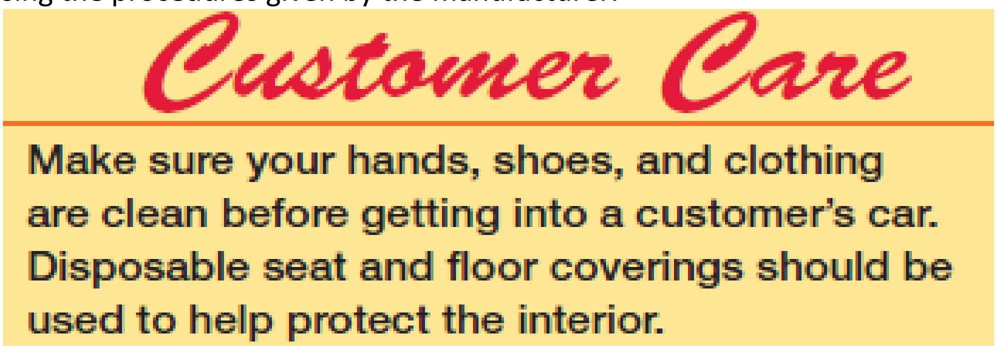
Transmission If the engine and transmission must be separated before engine removal, remove all clutch (bell) housing bolts. If the vehicle has an automatic transmission, remove the torque converter mounting bolts. If the transmission is being removed with the engine, place a drain pan under the transmission and drain the fluid from the transmission. Once the fluid is out, move the drain pan under the rear of the transmission.
Use chalk to index the alignment of the rear U-joint and the pinion flange. Then remove the drive shaft. Disconnect all electrical connections and the speedometer cable at the transmission.

- Content/Topic 2 General procedures of removing engine from the vehicle

Before removing the engine, clean it and the area around it. Also, check the service manual for the correct procedure for removing the engine from a particular vehicle. Make sure you adhere to all precautions given by the manufacturer.

The basic procedures for engine removal vary, depending on whether the engine is removed from the bottom of the vehicle or through the hood opening. Many FWD vehicles require removal of the engine from the bottom, whereas most RWD vehicles require the engine to come out from the hood opening. The engine exit point is something to keep in mind while you are disconnecting and removing items in preparation for engine removal.

When removing an engine, setting the vehicle on a frame contact hoist is recommended. When the vehicle is sitting on the floor, block the wheels so it does not move while you are working. Open the hood and put fender covers on both front fenders. Once the vehicle is in position, relieve the pressure in the fuel system using the procedures given by the manufacturer.


Customer Care

Make sure your hands, shoes, and clothing are clean before getting into a customer's car. Disposable seat and floor coverings should be used to help protect the interior.

(ERJAVEC, 2010)

Figure 86 Use a transmission jack to securely support the transmission before removing the motor mounts.

Figure 87 If the engine is removed with its transmission, remove the transmission mount and cross member.

Figure 88 Once the engine is removed and is hanging on the engine hoist, lower it close to the floor so it can be safely moved to the work area.

Lower the engine close to the floor so it can be transported to the desired location. If the transmission was removed with the engine, remove the bell housing bolts and inspection plate bolts. On vehicles with an automatic transmission, also remove the torque converter-to-flex plate bolts. Use a C-clamp or other brace to prevent the torque converter from falling. Also mark the location of the torque converter in relation to the flex plate.

DISASSEMBLY PROCEDURES:

- Prepare a working place
- Wear protective equipments
- Select correct materials and tools
- Set piston number one to TDC
- Disconnect engine with transmission if necessary and all auxiliary installations
- Bleed all hydraulic fluid and keep them carefully
- Remove the engine from the vehicle
- Unscrew cylinder head cover bolts
- Unscrew cylinder head bolts
- Unscrew camshafts bolts
- Remove valves from cylinder head
- Unscrew oil pan bolts
- Unscrew connecting rod bolts
- Unscrew crankshafts bolt and remove it
- Remove piston and piston rings from the cylinder

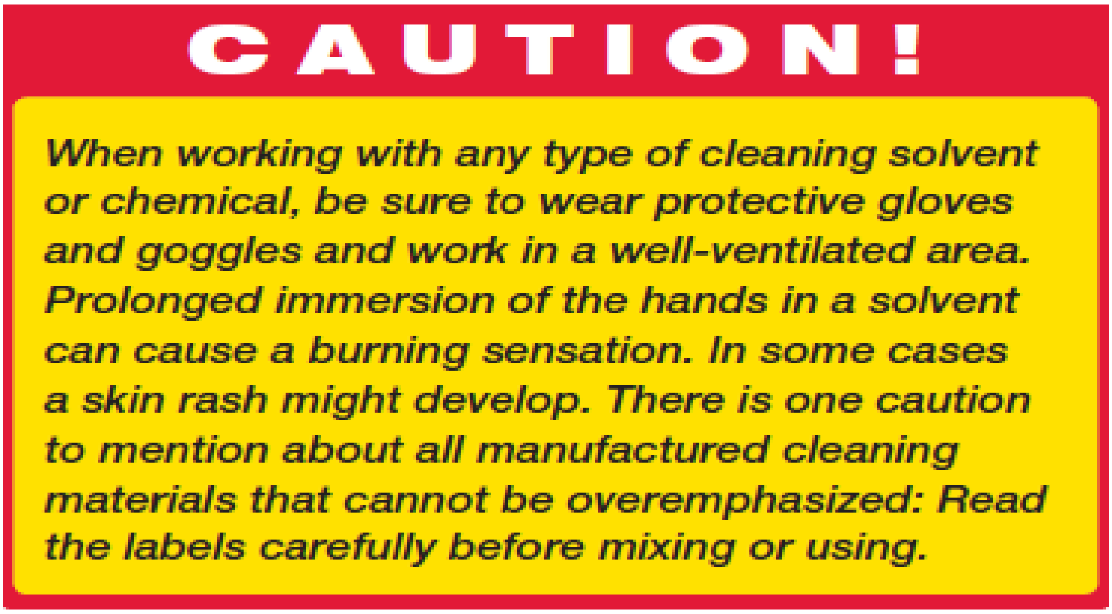
- Check cylinder wall for wear if not good replace
- Piston and piston rings if not good replace
- Connecting rod cups if not good replace
- Bearings shells and bearing cups if not good replace
- Crankshaft friction surface if not good replace
- Camshafts friction surface if not good replace
- Valves and valve springs if not good replace
- Valve sits if not good clean
- Oil holes and water jackets

NB: during this process don't forget to replace oil seals and cylinder head gasket

LO 2.3 – Dismantle and clean the engine components

- Content/Topic 1. General cleaning procedures

There are three basic processes for cleaning automotive engine parts. The first process that is discussed is chemical cleaning. This method of cleaning uses chemical action to remove dirt, grease, scale, paint, and/or rust.



Unfortunately, the most traditional line of defense against soils involves the use of cleaning chemicals. Chlorinated hydrocarbons and mineral spirits may have some health risks associated with their use through skin exposure and inhalation of vapors. Hydrocarbon cleaning solvents are also flammable.
The use of water-based nontoxic chemicals can eliminate such risks.

WARNING!

Prior to using any chemical, read through all of the information given on the material safety data sheet (MSDS) or the Canadian workplace hazardous materials information systems sheets (WHMIS) for that chemical. Become aware of the health hazards presented by the various chemicals.

Hydrocarbon solvents are labeled hazardous or toxic and require special handling and disposal procedures. Many water-based cleaning solutions are biodegradable. Once the cleaning solution has become contaminated with grease and grime, it too becomes a hazardous or toxic waste that can be subject to the same disposal rules as a hydrocarbon solvent. Some manufacturers offer waste-handling and solvent recycling services. The old solvent is recycled by a distillation process to separate the sludge and contaminants. The solvent is then returned to service and the contaminants disposed of. Independent services for maintaining hot tanks and spray washers are also available.

CAUTION!

Care needs to be taken with alloy blocks with sleeves or liners. The different metals react differently to chemicals. Make sure to check with the service manual before using a cleaning solution on these parts. The wrong chemical can cause damage to the block and/or sleeves.

Cleaning by Hand some manual cleaning is inevitable. Heavy buildups of grease and/or carbon should initially be removed by scraping or wire brushing. Cleaning aluminum and other soft metals with either technique should be done with extreme care, especially while using a steel scraper or brush. Steel or plastic scrapers are used to remove old gasket material from a surface and heavy sludge. Power tools with a small sanding disc (normally emery cloth) are available.These are designed to remove all soft materials without damaging the hard metal surface.
After the item has been scraped, an additional cleaning method is used to finalize cleaning.

Carbon can be removed with a handheld wire brush or a wire wheel driven by an electric or air drill motor

Figure 89 Using a power scraper pad will prevent any metal from being removed.

Figure 90 Carbon can be removed with a wire wheel driven by an electric or air drill motor.

Abrasive Blaster Compressed air shot and grit blasters are best used on parts that will be machined after they have been cleaned. Two basic types of media are available: shot and grit. Shot is round; grit is angular in shape. Parts must be dry and grease-free when they go into abrasive machine.

Figure 91 It is often necessary to remove the gallery plugs and hand clean the oil galleries.

- <u>Content/Topic 2 Identifying techniques to dismantle engine components</u>

Make sure you have the tools and equipment required for the job before you begin.
The basic procedures for engine removal vary, depending on whether the engine is removed from the bottom of the vehicle or through the hood opening.
The engine exit point is something to keep in mind while you are disconnecting and removing items in preparation for engine removal.

Engine disassembly and inspection
Raise the engine and position it next to an engine stand. Mount the engine to the engine stand with bolts. Most stands use a plate with several holes or adjustable arms. The engine must be sup supported by at least four bolts that fit solidly into it. The engine should be positioned so that its center is in the middle of the engine stand's adapter plate. This will ensure that the engine is not too heavy when rotated on the engine stand.

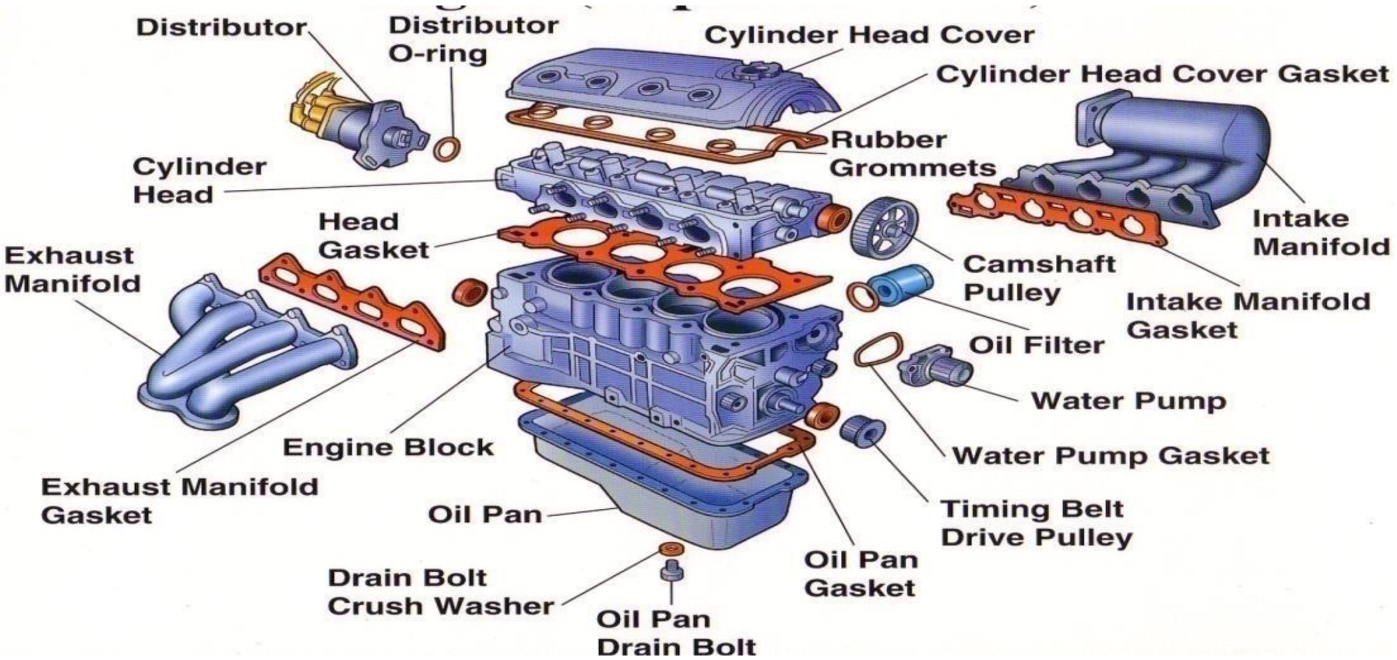


Figure92: Engine exploded view

Cylinder Head Removal
The first step in disassembly of an engine is usually the removal of the intake and exhaust manifolds. On some inline engines, the intake and exhaust manifolds are often removed as an assembly.

SHOP TALK

It is important to let an aluminum cylinder head cool before removing it.

To start cylinder head removal, remove the valve cover or covers and disassemble the rocker arm components according to the guidelines given by the manufacturer. Check the rocker area for sludge. Excessive buildup can indicate a poor maintenance schedule and is a signal to look for wear on other components.

Figure 93 Remove the valve cover and disassemble the rocker arm components. Check the rocker area for sludge. Keep the rocker arms or rocker arm assemblies in the order they were installed.

On OHC engines, the timing belt cover must be removed. Under the cover is the timing belt or chain and sprockets. In the service information, there will be a description of the type and location of the timing marks on the crankshaft and camshaft sprockets. If possible, rotate the crankshaft to check the alignment of the sprockets. If the shafts are not aligned, make note of this for later reference. The valves will hit the pistons on some engines when the timing belt or chain slips, skips, or breaks. These engines are commonly called interference engines. When the valves hit the piston, they will bend. The valves in freewheeling engines will not hit the piston when valve timing is off. However, the keys and keyways in the camshaft sprocket may be damaged. Interference engines typically have a decal on the cam cover that states the belt must be changed at a particular mileage interval. Potential valve and/or piston damage is the reason why timing belt replacement is recommended.

The belt or chain must be removed before removing the cylinder head. Locate and move the belt's tensioner pulley to remove its tension on the belt. Slip the belt off the camshaft and crankshaft sprockets, if possible. When removing the cylinder head, keep the pushrods and rocker arms or rocker arm assemblies in exact order. Use an organizing tray or label the parts with a felt-tipped marker to keep them together and labeled accurately. This type of organization greatly aids in diagnosing valve-related problems.

Remove the lifters from the block and place them in the order they were installed. The cylinder head bolts are loosened one or two turns each, following the pattern specified by the manufacturer. The sequence is typically the opposite of the tightening sequence. If there is no specified procedure, the bolts ought to be loosened one or two turns, beginning in the ends and working toward the center. This prevents the distortion that can occur if bolts are all loosened at once. The bolts are then removed and the cylinder head can be lifted off. The cylinder head gasket should be saved to compare with the new head gasket during re assembly. Set the cylinder head(s) on cardboard or another soft surface to prevent damage to the sealing surfaces.

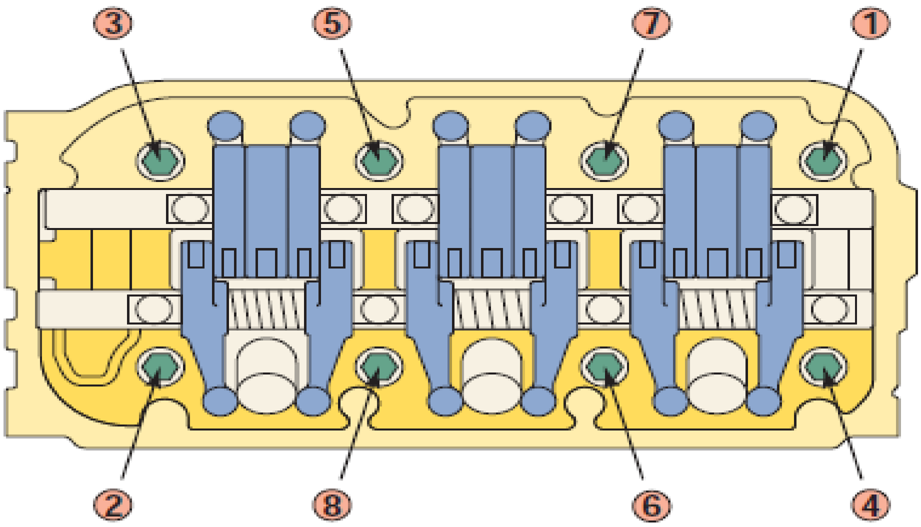


Figure94. When loosening cylinder head bolts; follow the sequence given by the manufacturer.

The sequence is typically the opposite of the tightening sequence. If there is no specified Procedures, the bolts ought to be loosened one or two turns, beginning in the ends and working toward the center. This prevents the distortion that can occur if bolts are all loosened at once.
The bolts are then removed and the cylinder head can be lifted off. The cylinder head gasket should be saved to compare with the new head gasket during re assembly. Set the cylinder head(s) on cardboard or another soft surface to prevent damage to the sealing surfaces.

Gaskets

When parts are bolted together, it is nearly impossible to obtain a positive seal between the parts. Gaskets are used to provide that seal. Some gaskets seal low pressure fluids, such as oil and coolant, while others also seal high-combustion pressures, such as head gaskets. Gaskets also serve as spacers, wear insulators, and vibration dampers. Gaskets are only used between two stationary parts. Seals are used if one of the parts moves. Gaskets can be made of paper, fiber, steel, cork, synthetic rubber, and combinations of these materials.

Figure95: Gaskets

Most late-model engines have molded silicone rubber gaskets and cut plastic gaskets with silicone sealing beads. The gaskets may incorporate flexible graphite cores, specialized surface coatings, asbestos free materials, elastomeric beading, reinforced cork products, wire-ring combustion seals, flat-plate hoop strength constructions, and many other design variations. The goal of all designs is provide long-term leak-free joints.

Figure 96 A major buildup of sludge on the bottom of this oil pan.

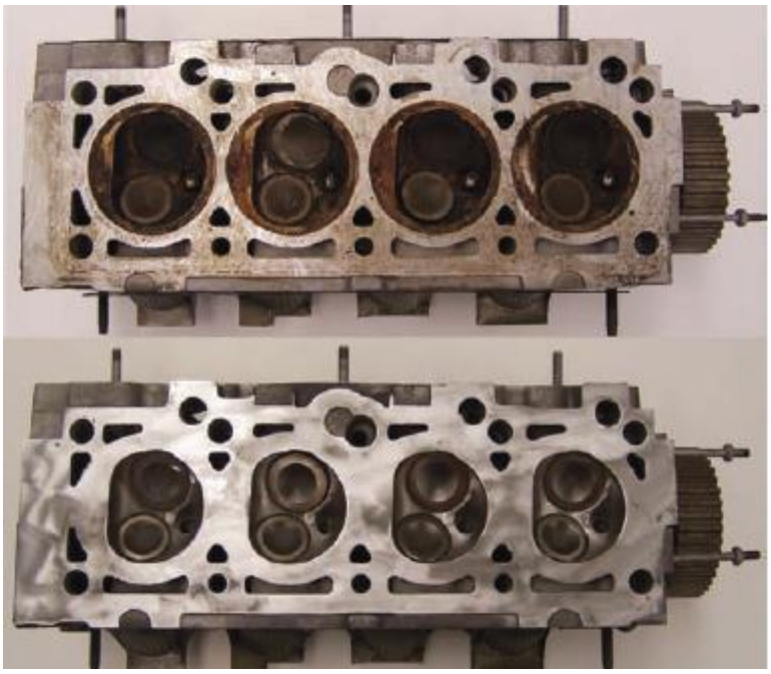


Figure97. From (A) grime to (B) shine.

CLEANING ENGINE PARTS

After the component that needs service has been disassembled, its parts should be thoroughly cleaned. The cleaning method depends on the component and the type of equipment available. An incorrect cleaning method or agent can often be more harmful than no cleaning at all. For example, using caustic soda to clean aluminum parts will dissolve the part. **Caustic soda** is a strong detergent that is commonly found in solvents that are effective in removing carbon.

WARNING!

Always wear the appropriate eye protection and gloves when working with cleaning solvents.

Only after all components have been thoroughly and properly cleaned can an effective inspection be made or proper machining be done.

- <u>Content /Topic3 Identification of arrangement of engine components</u>

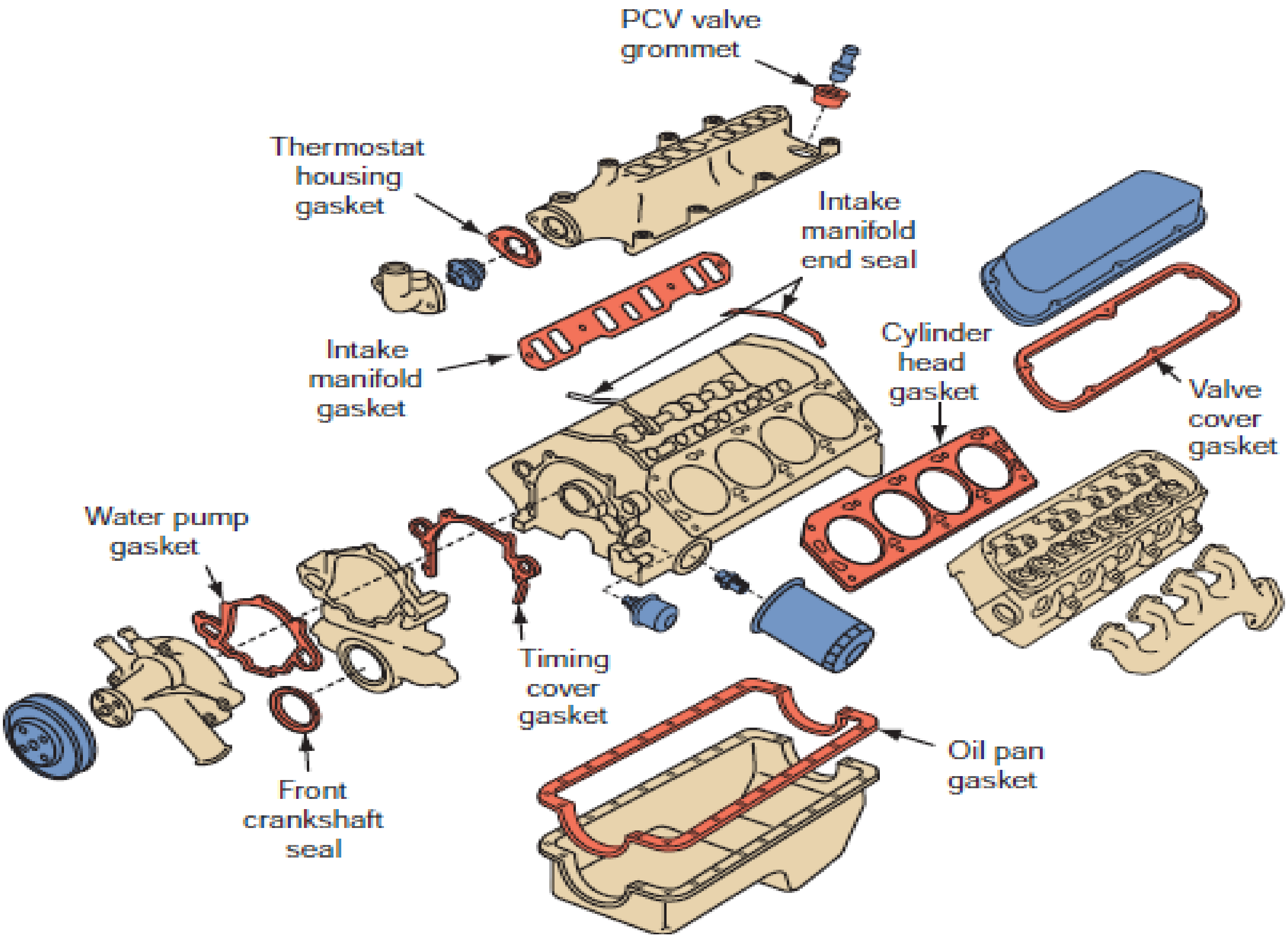


Figure98 : Engine arranged components

Arrange well the engine components according to the sequence of reassembling, make sure the workplace is well ventilated and clear.

Learning Unit 3 – Inspect the engine components

LO 3.1 – Inspect the engine components

- <u>Content/Topic 1Inspection by using assessment method (Visual and functional check)</u>

Visual inspection provides a means of detecting and examining a variety of surface flaws, such as corrosion, burned wires, leak connections, and surface discontinuities on joints.
Visual Inspection is also a method of checking the overall visual appearance or localized visual defects of a product using the naked eye. Safety and quality assurance personnel across different industries perform visual inspections to comply with safety regulations and quality standards. In manufacturing facilities, regular visual inspections ensure conformance with product design requirements and increase customer satisfaction. In that process visual inspection of driver assistance system components can be done.

CRACK DETECTION

Once engine parts have been cleaned, everything should be carefully inspected. This inspection should include a check for cracks, especially in the engine block and cylinder head. If cracks in the metal casting are discovered during the inspection, they should be repaired or the part replaced. Cracks in metal castings are the result of stress or strain in a section of the casting. This stress or strain finds a weak point in that section of the casting and causes it to distort or separate at that point. Such stresses or strains in castings can develop from the following:

- Pressure or temperature changes during the casting procedure may cause internal material structure defects, inclusion, or voids.
- Fatigue may result from fluctuating or repeated stress cycles. It might begin as small cracks and progress to larger ones under the action of the stress.
- Flexing of the metal may result due to its lack of rigidity.
- Impact damage may occur by a solid, hard object hitting a components
- Constant impacting of a valve against a hardened seat may produce vibrations that could possibly lead to fracturing a thin-walled casting.
- Chilling of a hot engine by a sudden rush of cold water or air over the surface may happen.
- Excessive overheating is possible due to improper operation of an engine system.

Figure 99 The topside oil artery crack appeared when an oxyacetylene flame was passed over the casting. Carbon in the flame was trapped in the crack, highlighting it.

Methods

Cracks can be found by visual inspection; however, many are not easily seen. Therefore, engine rebuilders use special equipment to detect cracks, especially if there is reason to suspect a crack.

Pressure Checks Pressure checking a cylinder block or head is done in the same way a tire is checked for leaks. All of the coolant passages are plugged with rubber stoppers or gaskets. Compressed air is injected into a water jacket and the point of air entry is sealed. The block or head is then submerged into water. Bubbles will form in the water if there is a leak. The spot where the bubbles are forming is the location of the leak.

Dye Penetrant Another common way to detect cracks is by using three separate chemicals:

Figure 100 Cracks appear as red lines when a dye penetrant is used. *Courtesy of LOCK-N-STITCH Inc.*

Penetrant, cleaner, and developer. The part to be checked must be clean and dry. This check must be done according to the following sequence:

1. Spray or brush the penetrant onto the surface.
2. Wait 5 minutes.
3. Spray the cleaner onto a clean cloth.
4. Wipe off all visible penetrant.
5. Spray the developer on the tested area.
6. Wait until the developer is totally dry.
7. Inspect the area. Cracks will appear as a red line**.**

Crack Repair

If a crack is found, a decision must be made as to whether the part should be replaced or repaired. This decision should be based on the cost of repair as well as any other repair that the part may need.

- Content/Topic 2 Measurement check

,,,

Checking the compression pressure

The compression tester is used to carry out comparative measurements of the pressure conditions in the individual combustion chambers

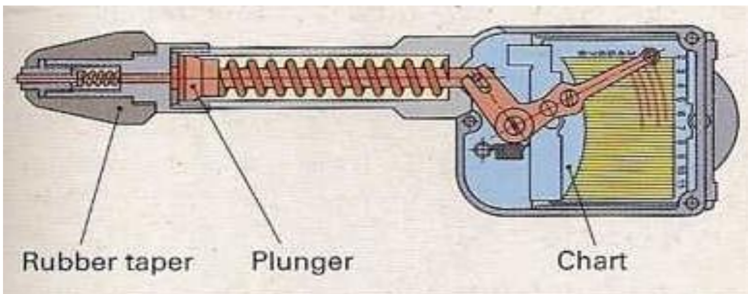


Figure101 : Compression tester

Observe the following during the check:

- Carry out the check only when the engine is at normal operating temperature.
- Deactivate the electronic ignition system (observe the manufacturer's instructions).
- Insert the test chart fn the compression tester so that the pointer is at cylinder 1.
- Unscrew all the spark plugs and briefly crank the engine with the starter to remove combustion residues.
- Press the rubber taper of the compression tester into the spark-plug hole and open the throttle valve fully.
- Crank the engine with the starter by approximately 10 revolutions.
- Vent the compression tester before the test chart is moved to the cylinder 2 position.

When the combustion chambers are in perfect condition, the compression pressures measured in the individual cylinders may only deviate from each other slightly (max. 2 bar).

Conclusions about fault causes:

- If a pressure of below 6 bar (12 bar in diesel engine) is indicated in all the cylinders, the engine is subject to regular wear.
- In the event of deviating compression pressures in the individual cylinders, it is possibleto determine what has caused the pressure loss by spraying some engine oil into the combustion chamber. If the compression pressure increases during the subsequent measurement, the cylinder wall or piston rings is/are subject to wear. If there is no increase in the compression pressure, the valves, valve seats, valve guide, cylinder head or cylinder-head gasket may be defective.

If an equal compression pressure is measured in two cylinders next to each other which is significantly lower than that in the other cylinders, there may be a crack in the cylinder head or a leaking cylinder-head gasket between the two cylinders

ompression-loss test (Fig. 2)

This is carried out if there is a suspected leak in the cylinder chamber after the compression check.

When checking the relevant cylinder, adhere to the following procedure:

- The piston must be atTDC of the compression stroke.
- Connect the pressure-loss tester to the compressed-air system (5 bar ... 10 bar) and calibrate using the knurled screw.
- Connect the tester via the spark-plug thread of the cylinder.
- The pressure loss created by the leak is indicated in per cent at the pressure gauge and must not exceed the values specified by the test- equipment manufacturer.
- In the event of larger leaks, the fault sources can be determined by identifying the air outlet.

Conclusions about fault causes:

- Blowing noises in the intake manifold or exhaust pipe: inlet or exhaust valve leaking.
- Blowing noises at the oil filler neck or at the dipstick opening: leaks due to wear of piston, piston rings and cylinder barrel, faulty cylinder- head gasket.
- Air bubbles in the radiator filler neck or blowing -noises in the spark-plug hole of the adjacent cylinder: leaking cylinder-head gasket, cracks in the cylinder head.

Test hose Pressure-loss tester Pressure-regulating

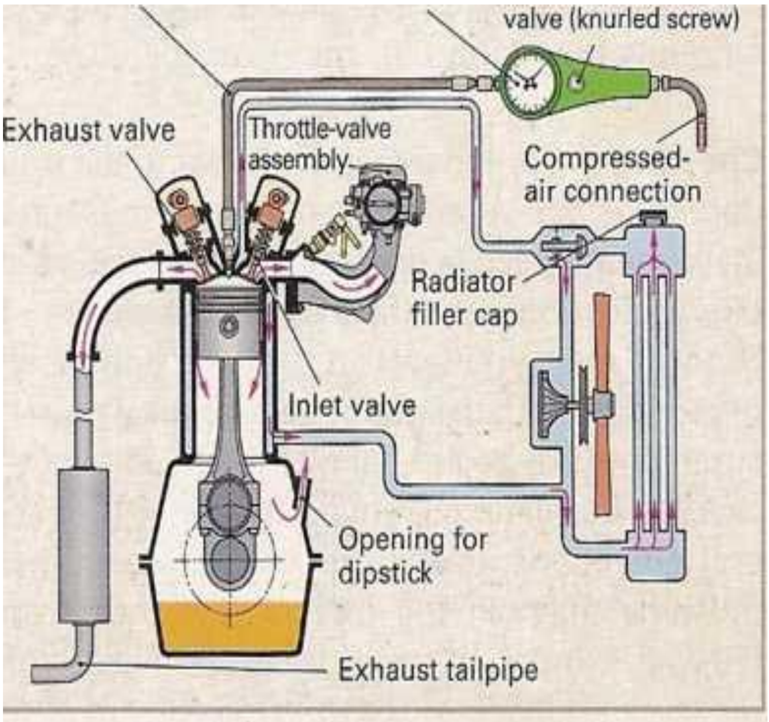


Figure102 : Compression loss tester

- Content /Topic3 Record measurement)

Figure 103 Cylinder bore is checked for outof- oundness with a dial bore gauge.

The record of measurements are carried out by using different instrumemnt, such as dial gauge, Micrometer, Vernier calliper,

Machining the cylinder face. The cylindrical shape must be re-established by fine-boring or honing if the wear in the centre is approx.

- 0.5 mm in four-stroke engines,
- 0.2 mm in two-stroke engines,
- 0.8 mm in CV diesel engines.

Fine-boring is performed in accordance with the piston oversize in stages of 0.25 mm or 0.5 mm. Subsequent honing is performed on a honing machine.

Installing cylinder liners

Dry cylinder liners are usirally finish-machined. The fit is configured as a sliding fit so that the liners can be pushed in with minimal pressure. Liners which are only predrilled are pressed with interference into the bore and finish-machined in the cylinder.The installed cylinder liner must not protrude. It should be level with the top surface or recede by up to 0.1 mm.

Wet cylinder liners are supplied ready for installation.They can usually be inserted with ease.The rubber rings must provide a good seal, but should not be too thick so that the liner does not deform under the pressure, which may cause piston seizure.The collar of the liner generally protrudes up to roughly 0.1 mm **.**

The cylinder-head gasket must not feature an excessive flange; the flange must not press onto the inner liner edge as this will cause the collarto tear off when the cylinder-head bolts are tightened or the liner to distort.

The collar must not recede under any circumstances because then the liner would be able to move.

LO 3.2 – Determine engine components state

- <u>Content/Topic 1 Proper arranging the components to be replaced)</u>

When preparing an engine for removal and disassembly, it is important to always follow the specific service manual procedures for the particular vehicle being worked on.

A hoist and chain are needed to lift an engine out of its compartment. Mount the engine to an engine stand with a minimum of four bolts, or set it securely on blocks.

While an engine teardown of both the cylinder head and block is a relatively standard procedure, exact details vary among engine types and styles. The vehicle's service manual should be considered as the final word.

An understanding of specific soil types can save time and effort during the engine cleaning process. The main categories of contaminants include water-soluble and organic soils, rust, and scale.

Protective gloves and goggles should be worn when working with any type of cleaning solvent or chemical. Read the label carefully before using as well as all of the information provided on material safety data sheets. Parts washers, or solvent tanks, are a popular and inexpensive means of cleaning the metal surfaces of many automotive components and engine parts. Regardless of the type of solvent used, it usually requires some brushing, scraping, or agitation to increase the cleaning effectiveness.

Cold soak tanks are used to clean carburetors, throttle bodies, and aluminum parts. Hot soak tanks, which can accommodate an entire engine block, use a heated cleaning solution to boil out dirt. Hot heat spray washers have the added benefit of moderate pressure cleaning.

Alternatives to caustic chemical cleaning have emerged in recent years, including ultrasonic cleaning, salt baths, and citrus chemical cleaning. These methods are all growing in popularity.

- Content/Topic 2 Proper arrangement of the components to be repaired

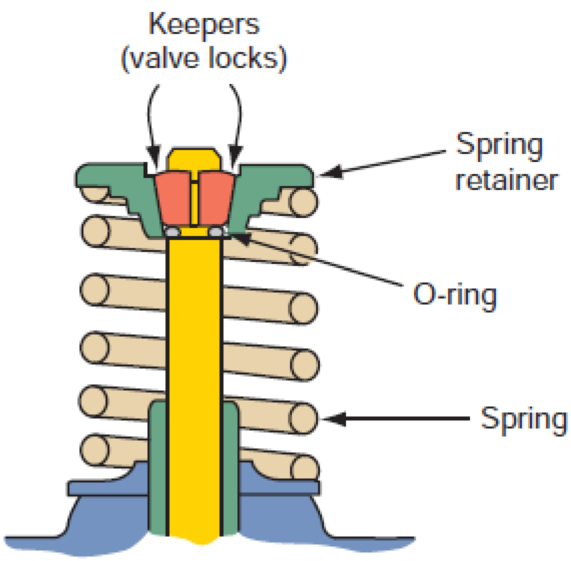


Figure 104 Valve assembly with spring, retainer, seals, and keepers.

Valve Rotators Some engines are equipped with retainers that cause the exhaust valves to rotate. These rotators prevent carbon from building up between the valve face and seat. Carbon buildup can hold the valve partially open, causing it to burn.

Valve Springs

A valve spring closes the valve and maintains valve train contact during valve opening and closing. Some engines have one spring per valve. Others use two or three springs. Often the second or third spring is a flat spring called a **damper spring**, which is designed to control vibrations. To dampen spring vibrations and increase total spring pressure, some engine manufacturers use a reverse wound secondary spring inside the main spring. Low spring pressure may allow the valve to float during high-speed operation. Too much pressure will cause premature valve train or camshaft lobe wear and can also lead to valve breakage.

All mechanical components of engine that need to be repaired are arranged in such way they can be repaired after service in easy way.

Content /Topic3.Identifying clearly the Record of arrangement

The arrangement that carried out in the engine mechanical components required in service and repairing are indicated to the prescribed papers.

LO 3.3 – Replace and repair of engine components

- Content/Topic 1Replacing techniques)

Procedures of replacing damaged components. Make sure that the manufacturer recommendations are followed correctly. Les discuss about engine noise

S/N	Source of engine noise	Possible cause	Required action
1	Misfiring/backfiring	Misfiring/backfiring	Remove the carbon deposit by using fuel additives, check engine timing
2	Valve train faults	Valve timing incorrectly adjusted, timing belt broken	Check valve timing and adjust necessary, replace timing belt
3	Engine components faulty	Pistons, piston rings, cylinder head gasket and big end bearing	Check the components and replace if necessary
4	Ancillary components	Engine components or ancillary components loose or broken	Check all that components are secure.

- Content/Topic 2 Repairing techniques

SERVICING CYLINDER HEADS

Service to the cylinder head can involve many different procedures. These procedures vary with the metal used to make the head and the design of the engine. Always refer to the appropriate service information from the manufacturer before starting any work on the head.

Crack Repair

Common locations of cracks in a cylinder head include: between the spark plug bore and the valve seat, between the valve seats, around the valve guides, and in the exhaust ports. In most cases, a cracked head should be replaced. However, some cracks can be effectively repaired. Crack repair is normally done by specialty shops.

It is important to keep in mind that most cracks are caused by something other than a defect in the head. The cause of the cracking needs to be identified and corrected. No matter what caused the crack, the crack needs to be repaired if the head is reused. Crack repair is done by the cold process of pinning or the hot process of welding.

Furnace Welding Crack Repairs Furnace welding is considered the best way to repair cracks in a cast-iron head. To furnace weld, the head is first preheated in an oven. This minimizes thermal shock when the flame of a welding torch contacts the head. After the crack has been filled with metal, the head is allowed to slowly cool before it is used.

Flame Spray Welding Flame spray (powder) welding is also used to repair cast-iron heads. This process uses nickel-based powders and a special torch to fill the crack.

Repairing Aluminum Heads Defects in aluminum heads are commonly found as:

- Cracks between the valve seat rings
- Cracks in coolant passages
- Cracks across the main oil artery
- Detonation damage inside the combustion chamber
- Melted or deformed metal in the chamber
- Coolant-related metal erosion

- Content /Topic3 Work report

It is important to go over the new vehicle warranty with your customer and what they are required to do in order to keep the warranty valid. Your customer will be required to maintain the vehicle to the manufacturer's specifications to validate the warranty. Every vehicle is different, but they all have minimum maintenance requirements that need to be followed. After you have gone over the owner's manuals, communicate the customer if there are remaining faults so that he/she can proceed the specialist. And guarantying the resolved faults.

Learning unit 4 – Assemble the engine

LO 4.1 – Determine engine components state

- Content/Topic 1 Perform clearly the assembling of engine components

When reassembling an engine, the sequence is essentially the reverse of the teardown sequence given in a previous chapter. Always refer to the service manual before assembling an engine. Sequence given in a previous. Always refer to the service manual before assembling an engine.

REASSEMBLY PROCEDURE:

- Insert piston rings and piston in their cylinders
- Retighten crankshaft on crank case
- Connect connecting rods and their cups
- Fixe oil filter on crank case
- Fixe oil pan carefully
- Set piston number one to TDC
- Insert valves and valve springs in their place
- Retighten cylinder head bolts
- Retighten camshaft bolts
- Connect timing belt on distribution gears after checking all marks weather are flushed
- Retighten cylinder head cover
- Fixe distribution part cover
- Clean engine
- Start engine in idle speed
- Check for all leaks
- Move vehicle but don’t exceed partial load

Proper sealing of an engine keeps the low pressure liquids in the cooling system away from the cylinders and lubricating oil. It also keeps the high pressure of combustion in the cylinders. It prevents both internal and external

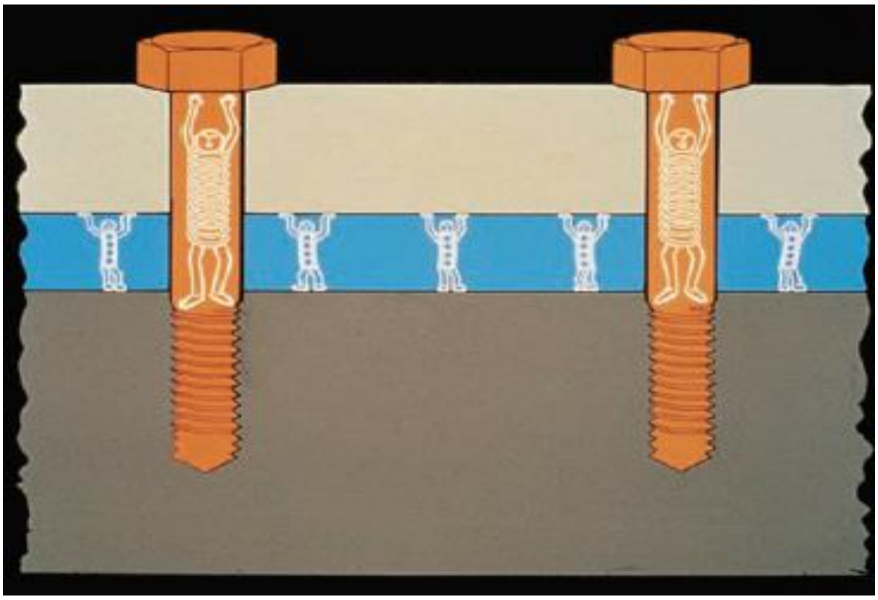


Figure 105 Clamping force results from bolt stretch. *Courtesy of Federal-Mogul Corporation*

If a bolt with a reduced shank diameter (for example, a connecting rod bolt) is specified by the OEM, never replace it with a standard, straight shank bolt. A reduced shank diameter bolt looks "dog-boned." Its function is to reduce the stress on the threads by transferring it to the shank. A standard bolt under similar conditions would break very quickly at the threads.

Keep the following points in mind:

1. Visually inspect the bolts.

- Threads must be clean and undamaged. Discard all bolts that are not acceptable.
- Use liquid sealant or engine oil on the threads and seating face of cylinder head bolts to prevent seizure from rust and corrosion. This is particularly important for an aluminum block or head. Use sealant on those bolts that hold in coolant or oil.
- Install bolts in their proper holes.
- Run a nut over the bolt's threads by hand. Discard it if any binding occurs.
- Clean bolt and cylinder block threads with a thread chaser or tap.

2. Apply a light coat of 10W engine oil to the threads and bottom face of the bolt head. A sealer is required for a bolt that enters a water jacket.

Figure 106 Cleaning bolt holes with tap. *Used with permission of Detroit Gaskets*

This will stop seepage around the bolt threads. Seeping coolant could get in the oil or cause corrosion that might damage parts, resulting in engine failure.

3. Tighten bolts in the recommended sequence.

This is important to prevent war page of the parts.

- Use an accurate torque wrench.
- Tighten bolts according to the recommended steps.

4. If bolt heads are not tight against the surface, the bolts should be removed and washers installed.

5. Make sure the bolt is the proper length (not too long).

Bolt hole threads often pull up, leaving a raised edge around the hole **(Figure 13–4)**. If a part has been resurfaced, the threads might run up to the surface. In either case, the bolt holes should be tapered at the surface by chamfering and the threads cleaned with an appropriate size bottoming tap. Always repair damaged threads.

Final Reassembly Steps

The final steps in engine assembly involve installing various covers, pulleys, sensors, and other related items that mount directly to the engine.

Coolant Drains and Plugs Make sure all coolant drains and plugs are installed in the block. Drains are normally threaded into the block with a thread.

- Content/Topic2 Perform clearly tightening torque

Tightening the cylinder-head bolts

These bolts are tightened in a particular sequence which is always specified in the repair handbooks. Deviations from this sequences will result in distortion of the cylinder head and in leakage. Generally speaking, the cylinder-head bolts are tightened

- from the inside outwards in a spiral-shaped progression or
- from the inside outwards diagonally.

When the bolts are being tightened, the torque and if necessary the angle of rotation specified by the manufacturer must be observed. As a rule, a new set of bolts must be used.

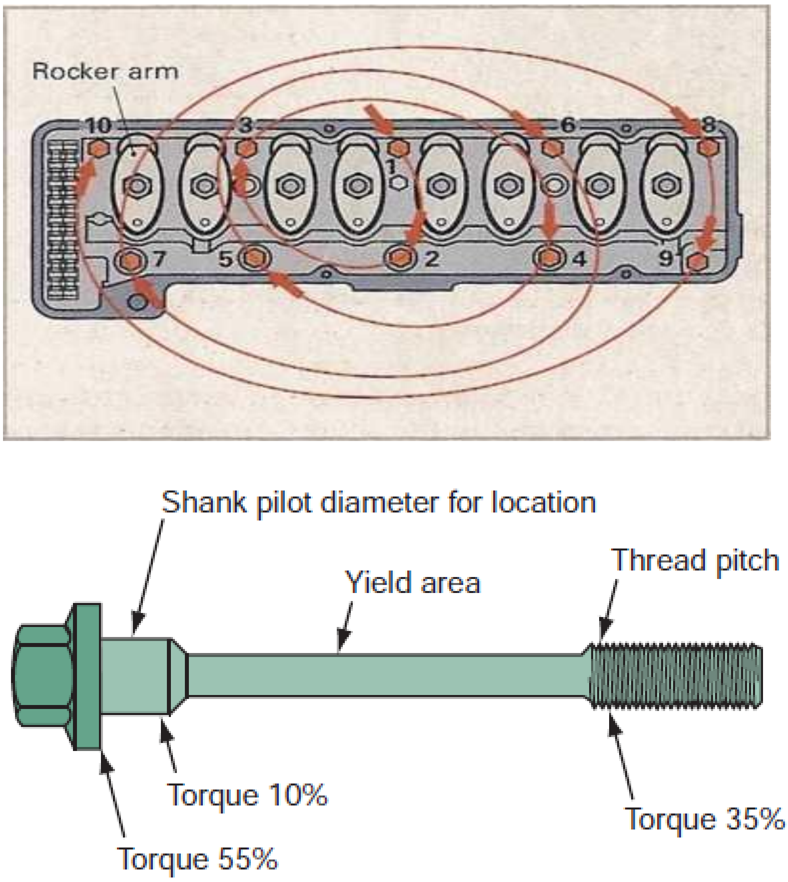


Figure107: Exemple of tightening cylinder head and bolts

TTY bolts are designed with a reduced shank diameter; this is where the intended stretch occurs.

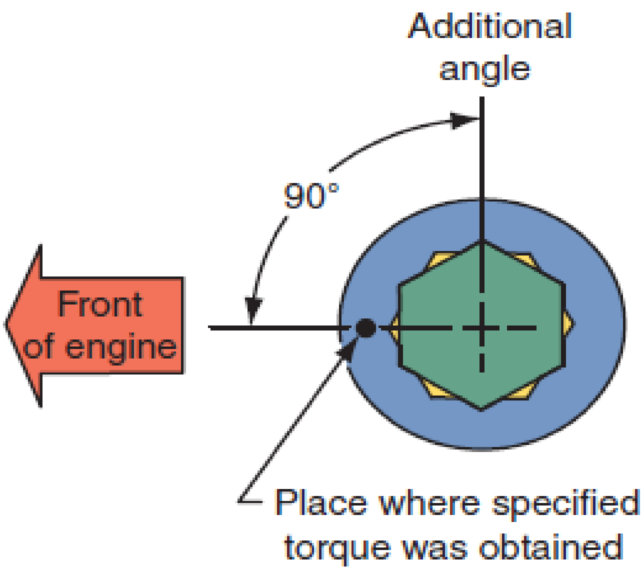


Figure 108 TTY bolts are tightened to a specified torque and then turned to an additional number of degrees.

GASKETS

When parts are bolted together, it is nearly impossible to obtain a positive seal between the parts. **Gaskets** are used to provide that seal. Some gaskets seal low pressure fluids, such as oil and coolant, while others also seal high-combustion pressures, such as head gaskets. Gaskets also serve as spacers, wear insulators, and vibration dampers. Gaskets are only used between two stationary parts. Seals are used if one of the parts moves. Gaskets can be made of paper, fiber, steel, cork, synthetic rubber, and combinations of these materials. Most late-model engines have molded silicone rubber gaskets and cut plastic gaskets with silicone sealing beads. The gaskets may incorporate flexible graphite cores, specialized surface coatings, asbestos free materials, elastomeric beading, reinforced cork products, wire-ring combustion seals, flat-plate hoop strength constructions, and many other design variations. The goal of all designs is provide Long-term leak-free joints.

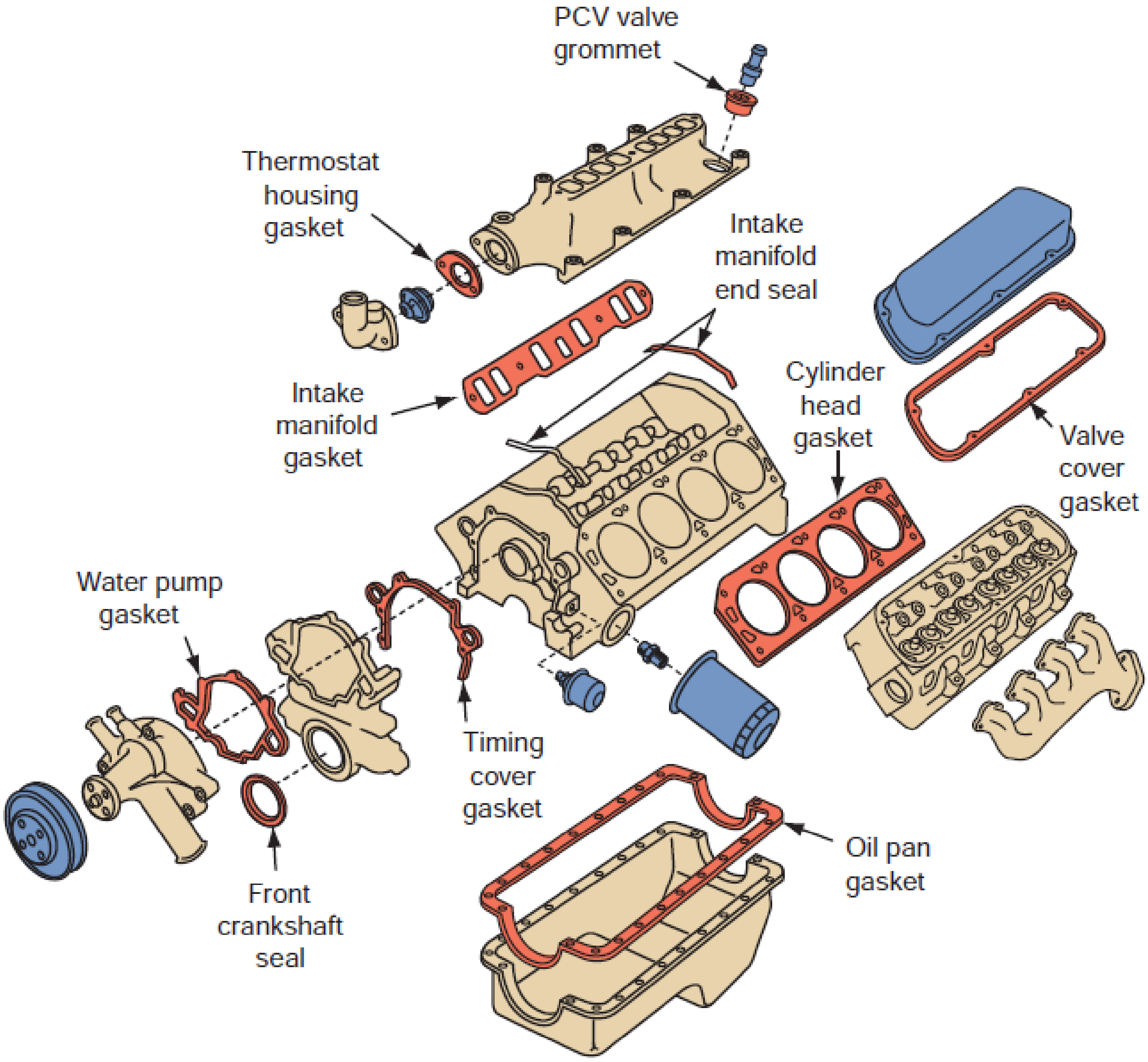


Figure 109 Typical engine gasket and seal locations.

- Content/Topic 3 perform correctly adjustment of engine timing

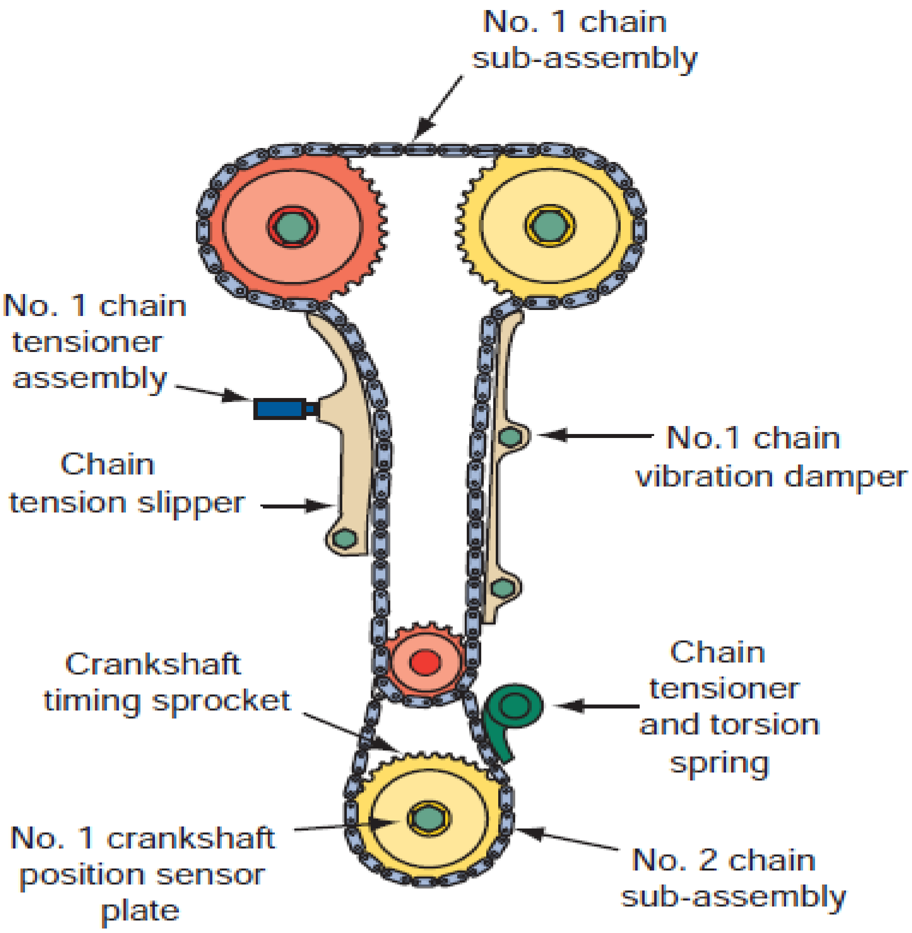


Figure 110 Timing chain components.

Timing Chains

Each drive chain should be inspected and replaced if it is damaged. The length of the chain should also be checked. Some manufacturers recommend measuring the entire length of the chain and comparing that to specifications. The chains on other engines should be measured in sections while they are being stretched. To do this, pull the chain with the specified tension. Then measure the length of the specified number of chain links. This measurement is taken at three random sections of the chain. The average length is then compared to specifications. The chain should be replaced if it is not within specifications.

Belt Idler Pulley

All idler pulleys should be rotated by hand. They are okay if they move smoothly. The pulley should also be checked for signs of lubricant leakage. Check around the seal. If leakage is evident, the idler should be replaced.

Tensioners

The tensioners of belt and chain drive systems should be checked. There are many types of tensioners used in today's engines; refer to the service information for the correct inspection procedure. Check the surface of the tensioner's pulley. It should be smooth and have no buildup of grease or oil. Most belt tensioners should also be checked for signs of lubricant leakage. Check around the seal. If any damage or leakage is evident, the tensioner should be replaced.

The action of a belt tensioner should be checked. Make sure the spring is free to move the tensioner pulley. If the tensioner spring is defective, replace the tensioner. On plunger-type tensioners, hold the tensioner with both hands and push the pushrod strongly against a flat surface. The pushrod should not move. If it does, replace the tensioner. Measure the distance the pushrod extends from the housing. Compare that distance to specifications. If this measurement is not within specifications, replace the tensioner.

Chain drive systems have a variety of dampers and guides in addition to a tensioner. The dampers and guides should be checked for wear. In most cases, their width is measured and compared to specifications. If they are worn, they should be replaced. Again, there are different types of chain tensioners, each with a unique inspection procedure. The plunger in ratchet-type tensioners should be able to be smoothly moved out by hand but should not be able to be pushed in by hand.

Adjustment of valve clearance

There are different ways of adjusting the valve clearance, depending on the engine type and make. It can be carried out when the engine is cold or even when it is running at low speed.

In the case of an overhead camshaft and rocker arms, the valve clearance can be adjusted with an adjusting screw and lock nut. By adjusting the ball pressure pin in the self-locking thread on the bearing of the finger type rocker. The valve clearance is checked at the gap between the cam base circle and finger type rocker.

In the case of an overhead camshaft and barrel tappet, hardened adjusting shims of varying thicknesses are placed in the tapped in order to adjust the correct valve clearance, which can be checked directly at the gap between the cam base circle and adjusting shims.

Depending on the manufacturer's specifications, the valve clearance is roughly 0.1mm to 0.3mm. If it is not correctly adjusted, the opening and closing times of the valves will be shifted or deferred.

Adjusting the valves on an engine that uses shims for valve clearance.

1. Rotate the crankshaft until piston #1 is at TD.

2. Check the camshaft alignment marks; if they are not aligned, rotate the crankshaft one full turn until they are aligned.

3. Refer to the service manual to identify the valves that are closed at this point. With a feeler gauge, measure and record the valve lash of those valves.

4. Rotate the crankshaft one full turn with piston #1again at TDC.

5. Measure and record the valve lash on the valves not measured in the previous step. Compare all measured clearances to specifications.

6. For any valves that do not have the proper lash, follow the rest of this procedure.

7. Rotate the camshaft so that the cam lobe for the valve needing adjustment is facing up.

8. Using a screwdriver, rotate the notch of the valve follower and shim assembly so that it is to the side of the camshaft.

9. While holding the camshaft in place, depress the valve lifter assembly.

10. Using a small screwdriver and a magnetic finger, remove the adjusting shim

11. Measure the thickness of the shim with a micrometer

12. Calculate the size of the required shim by adding the measured clearance to the size of the old shim. Then subtract the desired clearance from that total. That total is the required shim size. To correct excessive clearance, a thicker shim is installed. If reduced clearance is needed, a thinner shim must be installed.

13. Install the new shim and recheck the valve lash. Then move to the next valve that needs adjustment and repeat the process.
14. When all valves have been adjusted, reinstall the camshaft covers, timing belt cover, and anything else that has been removed.

Insert Valve Seat Removal and Replacement
STEP 1 To remove the damaged insert, use a puller or a pry bar
STEP 2 After removal, clean up the counter bore or recut it to accommodate oversized inserts.
STEP 3 Insert the counter boring pilot into the valve guide. Then mount the base and ball shaft assembly to the gasket face angle of the cylinder head.
STEP 4 Use an outside micrometer to accurately expand the cutter head to a predetermined size of the counter bore. Remember that the counter bore should have a slightly smaller ID than the OD of the insert to provide for an interface fit.
STEP 5 Place the valve insert counter boring tool over the pilot and ball-shaft assembly. Preset the depth of the valve seat insert at the feed screw.
STEP 6 Cut the insert by turning the stop-collar until it reaches the present depth. Use a lubricant on the cutters for a smoother finish
STEP 7 To install the insert, heat the head in a parts cleaning oven to approximately 350°F to 400°F (176°C to 204°C). Chill the insert in a freezer or with dry ice before installation.
STEP 8 Press the seat with the proper interference fit using a driver.
STEP 9 When the installation is complete, the edge around the outside of the insert is staked as shown in **Figure 12–74**. By doing so, the insert will be secured more effectively in the counter bore.

LO 4.2 – Install the engine

- **Content/Topic 1 Respect of safety and precautions**

Follow the manufacturer instructions during working. The safety and precautions to be followed are:

- Engine is correctly assembled
- Workplace is well ventilated
- Wear a personnel protective equipment (Hand grooves, safety boot, overall,...)
- Make sure the supports are safe.
- Surfaces must be rough

- **Content/Topic 2 Mounting vehicle accessories to the engine**

Likewise the dismounting process, mount the engine accessories

- **Fuel system**
- **Lubrication system**
- **Cooling system**
- **Charging system**
- **Starting system**
- **Ignition system**

Thermostat and Water Outlet Housing Install the thermostat with the temperature sensor facing into the block. If the thermostat is installed upside down, the engine will overheat. Also install any coolant pipes and hoses that route the coolant in and out of the engine.

Exhaust Manifold When installing the exhaust manifold(s), tighten the bolts in the center of the manifold first to prevent cracking it. If there are dowel holes in the exhaust manifold that align with dowels in the cylinder head, make sure these holes are larger than the dowels. If the dowels do not have enough clearance because of the buildup of foreign material, the manifold will not be able to expand properly and may crack. Be sure to install all heat shields

Flywheel or Flex plate Reinstall the engine sling. Raise the engine into the air on a suitable lift, and remove the engine stand mounting head. Set the assembled engine on the floor and support it on blocks of wood while attaching the flywheel or flex plate. Be sure to use the right flywheel bolts and lock washers. The bolts and washers are very thin. If normal bolts or washers are used, they may cause interference with the clutch disc or the torque converter.

Installing an Engine into a FWD Vehicle

If the engine will be installed through the top, connect the engine to a sling and then connect the sling to the crane. Slowly lower the engine into the engine compartment. Guide the engine around all wires and hoses to make sure nothing gets damaged. As the engine approaches its position in the engine compartment, align the engine and transmission mounts. Then, lower the engine so you can connect the engine and transmission

Prelubrication

Not prelubing a new or rebuilt engine before starting it can cause premature bearing failure due to poor lubrication. Other parts such as pistons, rings, and cylinder walls need immediate lubrication to prevent scuffing, scoring, and damage. It can take as long as 5 minutes after the engine has started before oil is distributed through all of the vital parts of an engine.

It is claimed that more than 80% of all engine wear occurs when an engine is first started. These problems can be prevented by lubricating the parts as they are assembled and by forcing oil into the oil galleries. This is the purpose of prelubing. A **prelubricator** forces oil throughout the engine before it is started. There are several ways to prelubricate, or prime, an engine. One of the most common ways is to use an air-operated prelubricator.

The procedure for using this type of prelubricator follows:

1. Fill the oil filter with clean engine oil and install it.
2. If the oil pressure sensor is installed, remove it.
3. Install an appropriately sized fitting for the preluber in the sensor's bore.
4. Connect the preluber hose to the fitting.
5. Open the valve on the preluber.
6. Fill the container for the preluber with at least
2 quarts of clean oil.
7. Pump the handle on the preluber until all of the oil in it has moved into the engine.
8. Close the valve and disconnect the hose from the fitting.
9. Remove the fitting and install the oil pressure sensor. Be sure to tighten it to specifications.
10. Check the oil level in the engine and add oil as needed.

- <u>Content/Topic 3. Engine installation techniques</u>

Elasticity means that a bolt can be stretched a certain amount and it returns to its original size when the load is reduced.
Bolt yield means that a stretched bolt takes a permanent set and never returns to normal.
Some fasteners are intentionally torqued into a yield condition. These torque-to-yield (TTY) bolts are designed to stretch when properly tightened. When a bolt is stretched to its yield point, it exerts its maximum clamping force. TTY bolts should not be reused.
Gaskets serve as sealers, spacers, wear insulators, and vibration dampeners.
Gaskets can be made of paper, fiber, steel, cork, synthetic rubber, and combinations of these materials.
General recommendations for installing gaskets include: Never reuse old ones; handle new ones carefully; use sealants only when instructed; thoroughly clean all mating surfaces; and use the right gasket in the right position.
Cylinder head gaskets must seal all of the combustion chambers and the coolant and oil passages between the head and the block.
Common causes of cylinder head gasket failure include improper installation, overheating, hot spots, and detonation or preignition.
Adhesives are used to hold a gasket in place during component assembly.
Bolts that pass through a liquid passage should be coated with Teflon thread or a brush-on thread sealant.
Silicone gasketing, of which RTV is the best known, is used on oil pans, valve covers, thermostat housing, timing covers, and water pumps.
Anaerobic formed-in-place sealants are used for both thread locking and gasketing.
Oil seals keep oil and other fluids from escaping around a rotating shaft.
All engines with mechanical lifters have some method of adjustment to bring valve lash (clearance) back into specification.
The steps in final engine assembly involve installing various engine covers, prelubing the engine, and installing manifolds and related items that mount directly to the engine assembly.
The best method of prelubricating an engine under pressure without running it is to use a prelubricator, which consists of an oil reservoir attached to a continuous air supply. A proper break-in procedure is necessary to ensure
Good initial oil contact and long engine life.

LO 4.2 – Test the engine

- **<u>Content/Topic 1 Perform different methods of starting engine</u>**

Starting Procedure
On engines with an ignition distributor, set the ignition timing as accurately as possible before starting the engine. The timing can be properly set after it has been started by using an engine analyzer or timing light. Fill the gasoline tank with several gallons of fresh gasoline. Start the engine and run it at around 1,500 rpm. When the engine coolant reaches normal operating temperature, turn off the engine. Recheck all adjustments, ignition timing, and valve clearance. Look for signs of coolant or oil leaks.

- **<u>Content/Topic 2 Perform and check engine indicators</u>**

Timing Sensors Proper installation of the crankshaft and camshaft timing sensors is critical. Make sure to coat new O-rings with clean oil before they are installed. Some sensors have a specified gap that must be set during installation. Also make sure that the trigger wheel for each sensor is properly aligned. Refer to the service manual. Make sure that the engine indicator on vehicle out dashboard displayed.

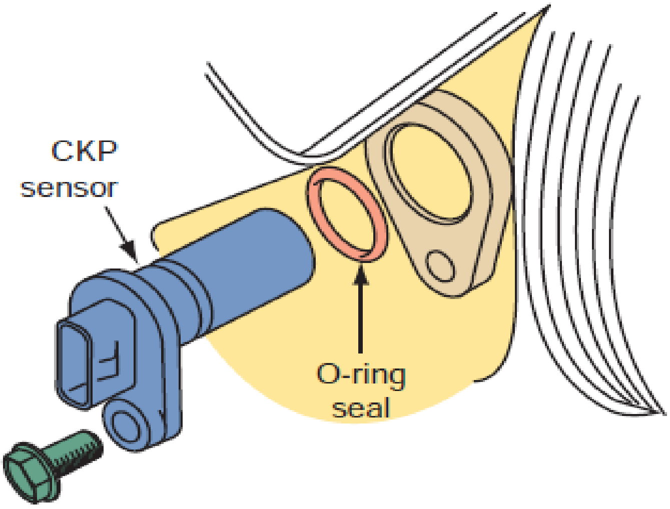


Figure 111 A crankshaft position sensor.

- <u>Content/Topic 2 Perform and check engine exhaust system</u>

Exhaust Manifold When installing the exhaust manifold(s), tighten the bolts in the center of the manifold first to prevent cracking it. If there are dowel holes in the exhaust manifold that align with dowels in the cylinder head, make sure these holes are larger than the dowels. If the dowels do not have enough clearance because of the buildup of foreign material, the manifold will not be able to expand properly and may crack. Be sure to install all heat shields

Customer Care

After the engine has been totally checked over, return it to the owner with the following instructions:

1. Drive the vehicle normally but avoid sustained high speed during the first 500 miles (break-in period).
2. Do not allow the engine to sit idling for a long time.
3. Check the oil level frequently during the break-in period. It is not unusual to use 1 or 2 quarts of oil during this time.
4. The oil and oil filter should be changed at the end of the break-in time.
5. The cylinder head and intake manifold bolts may need to be retorqued.
6. Some adjustments, such as valve adjustments and ignition timing, may also need to be checked.

Reference(s):

BOSCH. (2005). *Advanced Automotive Fault Diagnosis Third Edition.* New york.

ERJAVEC, J. (2010). *AUTOMOTIVE TECHNOLOGY 5Th Edition.* New york.

R.Gscheidle. (2006). *Modern Automotive Technology.* Stuttgart: Germany.

www.wikipedia.org. (2015, may 10). *www.wikipedia.org*. Retrieved from www.wikipedia.org.