N1

Motor Trade Theory

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4

Fundamentals of engine operations

What is covered?

Internal combustion engines can be classified into four-stroke and two-stroke diesel and petrol engines. This module looks at how these engines work and examines the differences between them.

Learning outcomes

After studying this module, you should be able to:

Unit 1

- Explain the operation of the four-stroke and two-stroke petrol engine
- Explain the operation of the four-stroke and two-stroke diesel engine
- Draw and label four-stroke and two-stroke petrol engines
- Draw and label four-stroke and two-stroke diesel engines
- Explain the differences between the petrol and diesel engines

Unit 1: Engine cycles

LEARNING OUTCOMES

- Explain the operation of the four-stroke and two-stroke petrol engine
- Explain the operation of the four-stroke and two-stroke diesel engine
- Draw and label four-stroke and two-stroke petrol engines
- Draw and label four-stroke and two-stroke diesel engines
- Explain the differences between the petrol and diesel engines

Introduction

The engine is the source of power for the vehicle. An energy source, the fuel, is burned inside the engine to produce heat. The heat causes expansion of the fuel **vapour** or gasses in the engine combustion chambers and cylinders. This expansion creates pressure which pushes on pistons in the engine, creating movement. Two main types of fuel are used – petrol and diesel. And there are two main engine types – two-stroke and four-stroke. This gives rise to four different engine design combinations:

Keyword
Vapour Matter that is suspended or floating in the air

- four-stroke petrol
- two-stroke petrol
- four-stroke diesel
- two-stroke diesel

Explain the operation of the four-stroke and two-stroke petrol engine

Four stroke petrol engine

The most usual kind of internal combustion engine consists of a series of cylinders. Inside the cylinders are tightly fitting pistons which move up and down. This up and down movement is caused by the explosion of highly flammable petrol vapour in the enclosed space above the piston. After being fed into the cylinder through a valve, the petrol vapour is compressed by the rising piston. Burning is started by a carefully timed electrical spark. As the vapour burns, heat is produced and the heated gas expands and drives the piston downwards. Valves then let the exhaust gas out of the cylinder through ports.

Most internal combustion engines in use today use the four-stroke sequence. A four-stroke engine uses four piston strokes to complete one operating cycle. Each stroke has a different function:

- intake
- compression
- power
- exhaust.

The four-stroke cycle is shown in this series of figures.

1. Inlet stroke

As the piston moves down, a vacuum is created in the chamber, which lets the mixture of petrol vapour and air in through the open inlet valve.

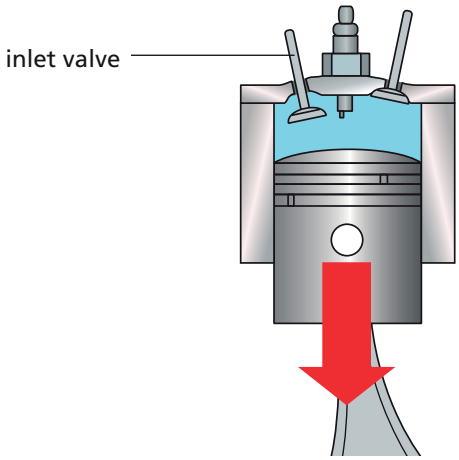

Figure 4.1 Inlet stroke

2. Compression stroke

When the piston moves upwards, both valves close and the air-fuel mixture is compressed.

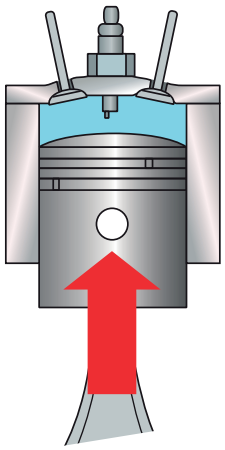

Figure 4.2 Compression stroke

3. Power stroke

As the piston reaches close to top dead centre, the spark plug ignites the mixture. The pressure in the cylinder increases and forces the piston downwards.

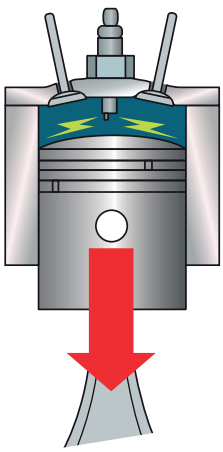

Figure 4.3 Power stroke

4. Exhaust stroke

As the piston moves upwards again, the exhaust valve opens and the spent mixture is forced through the valve, clearing the chamber.

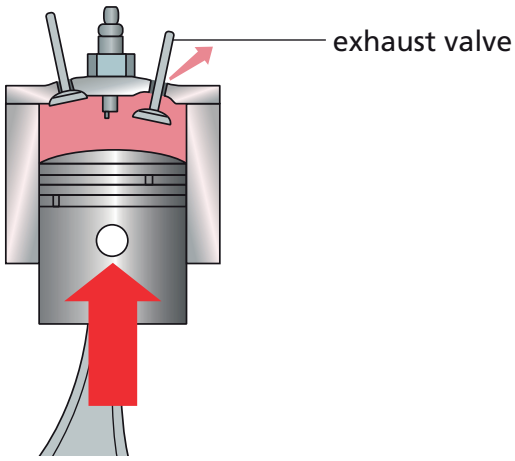

Figure 4.4 Exhaust stroke

Two-stroke petrol engine

Keyword
Ports Openings

Engines used in motorcycles, lawnmowers, and small boats use the two-stroke sequence. There are usually no valves to control the fuel input and exhaust output. The piston itself acts as a valve, covering and uncovering the **ports** as it moves up and down.

Two-stroke engines are relatively cheap to manufacture but they are fairly inefficient in converting fuel into the energy of movement. For this reason, larger engines work on the four-stroke sequence.

The following figures show the two-stroke petrol cycle.

1. Power stroke

1 The exhaust port is covered by the upward-moving piston.
2 The air-fuel mixture in the chamber is ignited by the spark plug.
3 The inlet port opens and the crank is filled with the mixture.

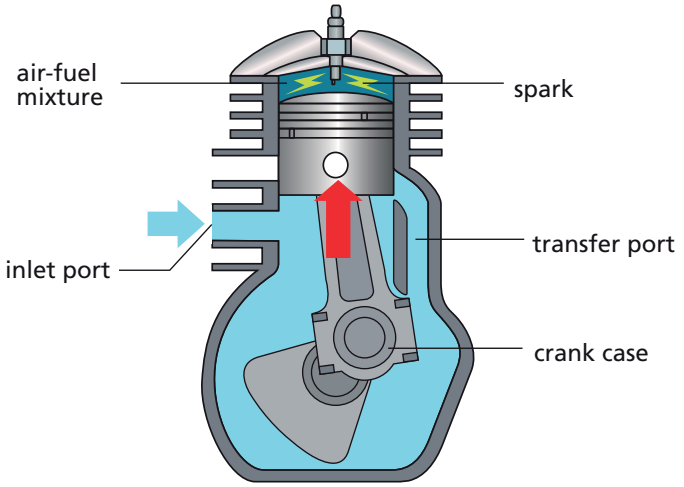

Figure 4.5 Power stroke

2. Exhaust stroke

1 The exhaust port is uncovered by the downward moving piston.
2 The mixture in the transfer port is forced into the cylinder.
3 The exhaust gases are forced out of the cylinder by the mixture.

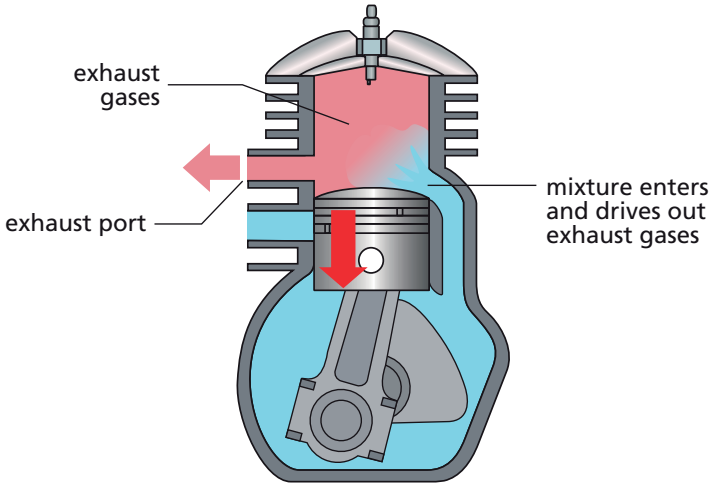

Figure 4.6 Exhaust stroke

Four-stroke diesel engine

Petrol and diesel engines both convert fuel into energy through combustion. The main difference between the two engine types is the way the combustion happens. In a petrol engine, fuel is mixed with air and is then compressed and ignited by the spark plugs. In a diesel engine, air is compressed first and then the fuel is forced into the cylinder through injectors. The compressed air is hot enough to ignite the diesel fuel, so no spark plug is required.

Diesel engines are more expensive to produce because they have to compress the air to about twice the pressure of that in a petrol engine and so require a more robust construction. However, diesel engines tend to last longer.

This sequence of figures shows the four-stroke diesel cycle.

1. Induction stroke

The piston is moving downwards creating a partial vacuum in the cylinder. Pure air is forced through the open inlet port by atmospheric pressure.

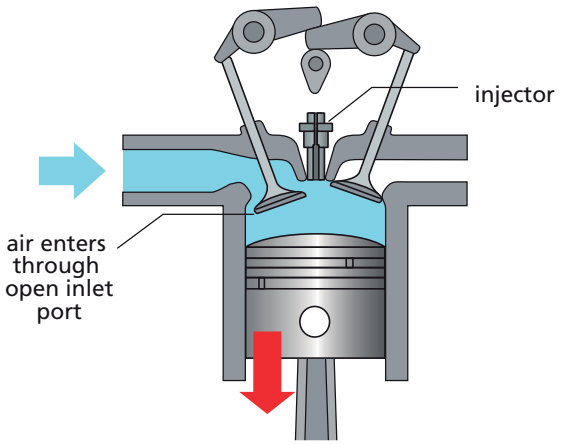

Figure 4.7 Induction stroke

2. Compression stroke

The piston moves up and both valves are closed. Air in the cylinder is compressed and the temperature rises.

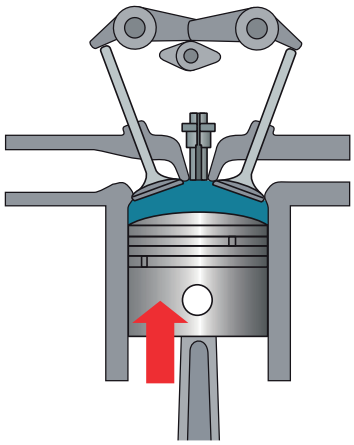

Figure 4.8 Compression stroke

3. Power stroke

Just before the piston reaches top dead centre, the injector sprays diesel oil under pressure into the cylinder. Both ports are still closed. The diesel mixes with the hot air and ignites, forcing the piston downwards.

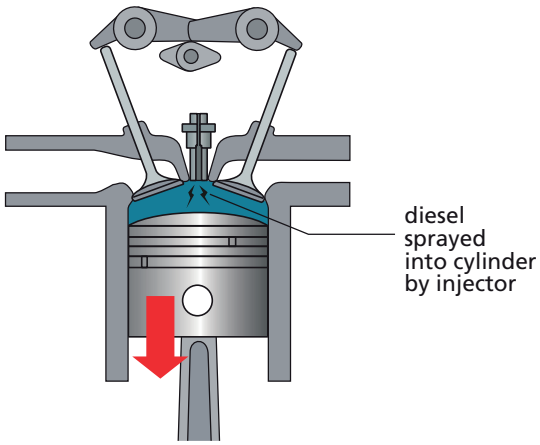

Figure 4.9 Power stroke

4. Exhaust stroke

The exhaust port opens and the upward-moving piston forces the burnt gases out of the cylinder.

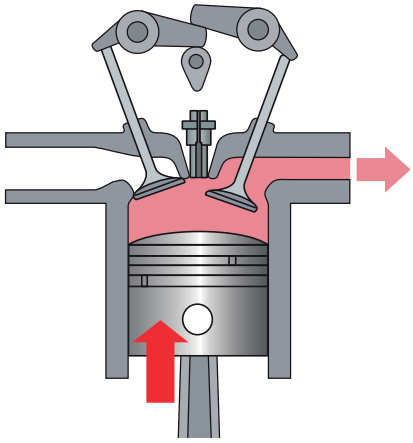

Figure 4.10 Exhaust stroke

Two-stroke diesel engine

Low-speed engine

These figures show the cycle for a low-speed two-stroke diesel engine

1. Induction/exhaust

The blower supplies compressed air into the cylinder at relatively low pressure. The inlet port is open. Because of high cylinder pressure, most of the spent gas is blown out of the open exhaust port. At the same time, the air blows out the remaining spent gases.

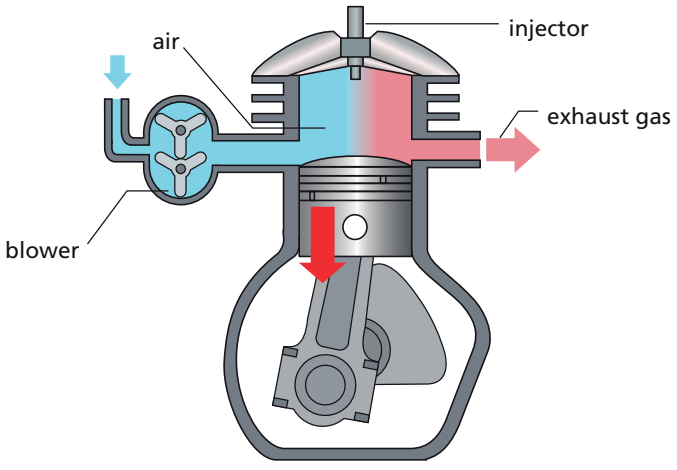

Figure 4.11 Induction/exhaust stroke

2. Compression/power

The air in the cylinder is compressed by the upward moving piston. As the air compresses it heats up. Just before top dead centre, the injector sprays diesel into the cylinder. The fuel is ignited by the hot air, causing an explosion that forces the piston downwards.

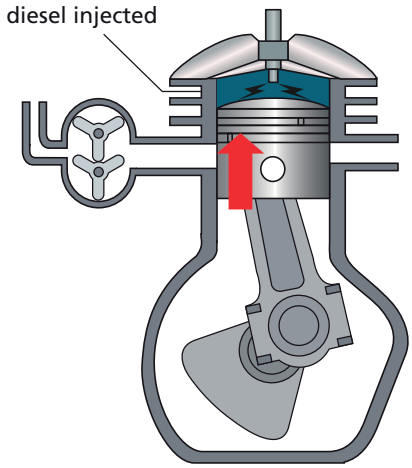

Figure 4.12 Compression/power stroke

High-speed engine

These figures show the cycle for a high-speed two-stroke diesel engine.

1. Induction/exhaust stroke

Air enters the combustion chamber through the open port.

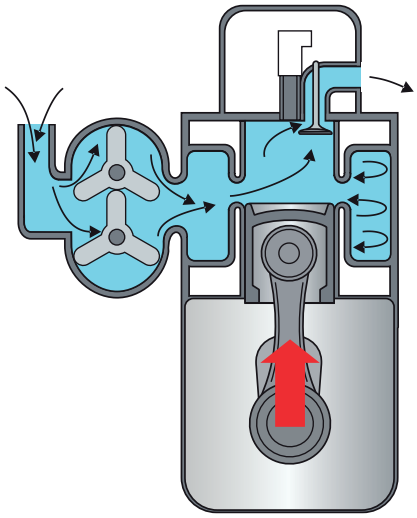

Figure 4.13 Induction/exhaust stroke

2. Compression stroke

Air is compressed by the upward moving piston because the exhaust valve and ports are closed.

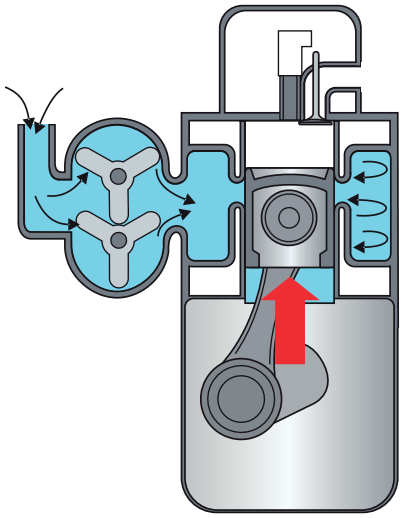

Figure 4.14 Compression stroke

3. Power stroke

The injector discharges fuel into the chamber.

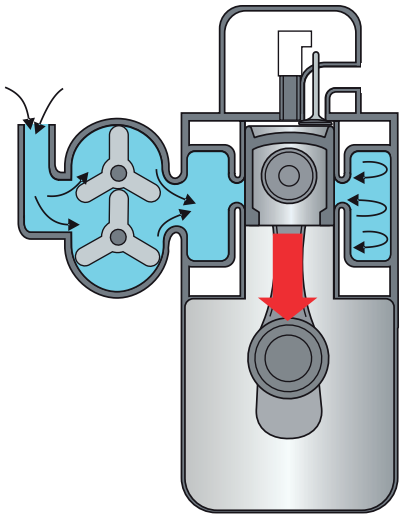

Figure 4.15 Power stroke

4. Beginning of exhaust stroke

The exhaust valve opens and the cylinder is about to be swept with clean, scavenging air.

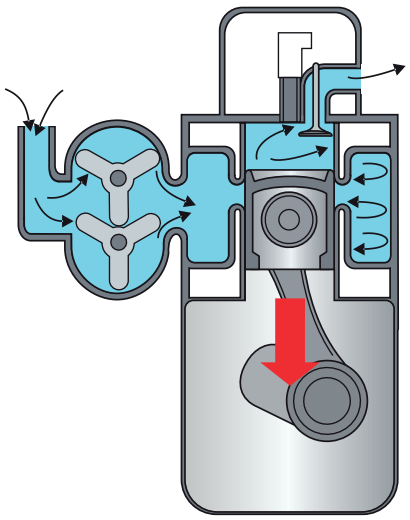

Figure 4.16 Beginning of exhaust stroke

Draw and label four-stroke and two-stroke petrol engines

You were introduced to the basic operating cycles of petrol engines earlier in this unit. Now practise your knowledge by doing this Activity.

ACTIVITY 4.1 **Petrol engines**

1. Draw and label a four-stroke petrol engine during the intake stroke and indicate the direction of the piston.
2. Draw and label a two-stroke petrol engine during the power stroke and indicate the direction of the piston.

Draw and label four-stroke and two-stroke diesel engines

You were introduced to the basic operating cycles of diesel engines earlier in this unit. Now practise your knowledge by doing this Activity.

ACTIVITY 4.2 **Diesel engines**

1. Draw and label a four-stroke diesel engine during its exhaust stroke and indicate the direction of the piston.
2. Draw and label a two-stroke diesel engine during its induction stroke and indicate the direction of the piston.

Explain the differences between the petrol and diesel engines

The main differences between petrol and diesel engines concern the method of ignition, the degree of compression required on the compression stroke, and the fuel delivery method. See Table 4.1 for a detailed comparison.

Table 4.1 Differences between petrol and diesel engines

Petrol engines	Diesel engines
Petrol engines use carburettors to control and deliver fuel.	Diesel engines use an injector pump to control and deliver fuel.
As part of the ignition system, a petrol engine uses spark plugs.	The diesel engine uses a fuel injector as part of the ignition system.
The combustion chamber is large compared to the diesel engine.	The combustion chamber is small compared to that of the petrol engine.
The accelerator butterfly in the carburettor of the petrol engine is directly connected to the accelerator pedal.	The diesel engine is equipped with an engine governor.
Petrol engine components tend to be lighter than those in diesel engines.	Diesel engine components tend to be heavier and stronger than those in petrol engines.
During the induction stroke, the petrol engine takes in a mixture of fuel and air.	During the induction stroke, the diesel engine takes in clean air only.
During the compression stroke, the air and fuel mixture is compressed.	During the compression stroke, only air is compressed.
Combustion takes place by means of a spark over the electrodes of the spark plug.	Combustion takes place when diesel fuel is injected into the compressed hot air.

ACTIVITY 4.3 **Petrol engines vs diesel engines**

In your own words, explain the difference between petrol and diesel engines.
Do this as a short writing exercise or as a discussion in pairs.

Module summary

- A four-stroke engine uses four piston strokes to complete one operating cycle.
- Engines used in motorcycles, lawnmowers, and small boats use the two-stroke sequence.
- The main differences between petrol and diesel engines concern the method of ignition, the degree of compression required on the compression stroke, and the fuel delivery method.

Exam practice questions

1. Make a large, neat sectional sketch of a four-stroke diesel engine during power stroke. Name all the parts of the engine and indicate the direction of piston travel. (5)
2. Explain in detail the compression stroke of the four-stroke petrol engine. In your explanation, refer to the position of the pistons, valves and characteristics of the mixture charge and direction of piston movement. (8)
3. State the four strokes of an engine and what happens during each stroke. (8)

Total: 30 marks