UNIT-2

IC Engine

I C Engines

- **An internal combustion engine is a device in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work.**

Examples:

- Piston Engines
- Gas Turbine Engines (Open Cycle)
- Rocket Engines

History of IC engines:

1700s - Steam engines (external combustion engines)

1860 - Lenoir engine (= 5%)

1867 - Otto-Langen engine (= 11%, 90 RPM max.)

1876 - Otto four stroke “spark ignition” engine
(= 14%, 160 RPM max.)

1880s - Two stroke engine

1892 - Diesel four stroke “compression ignition” engine

1957 - Wankel “rotary” engine

Historical IC Engines

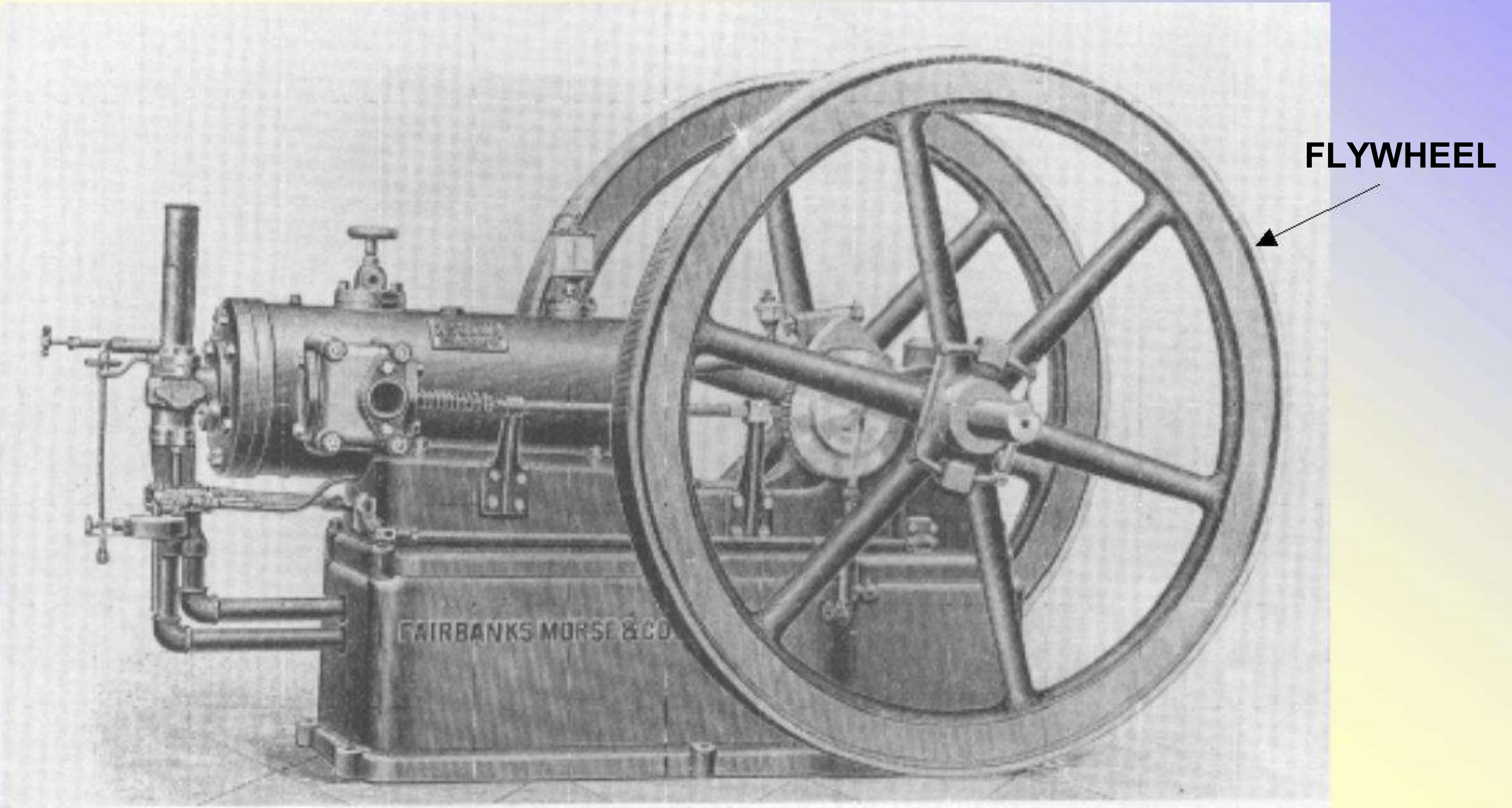
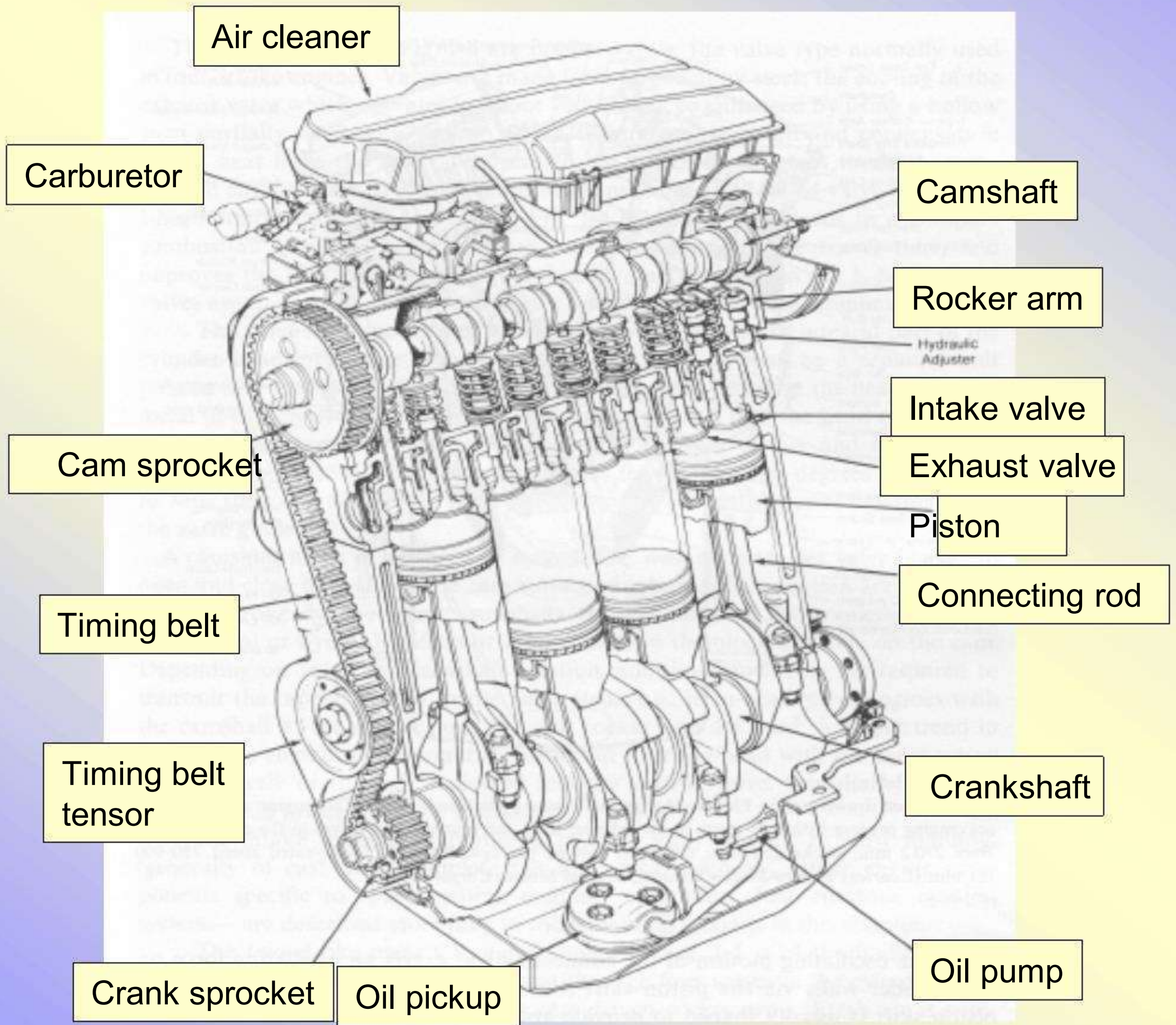
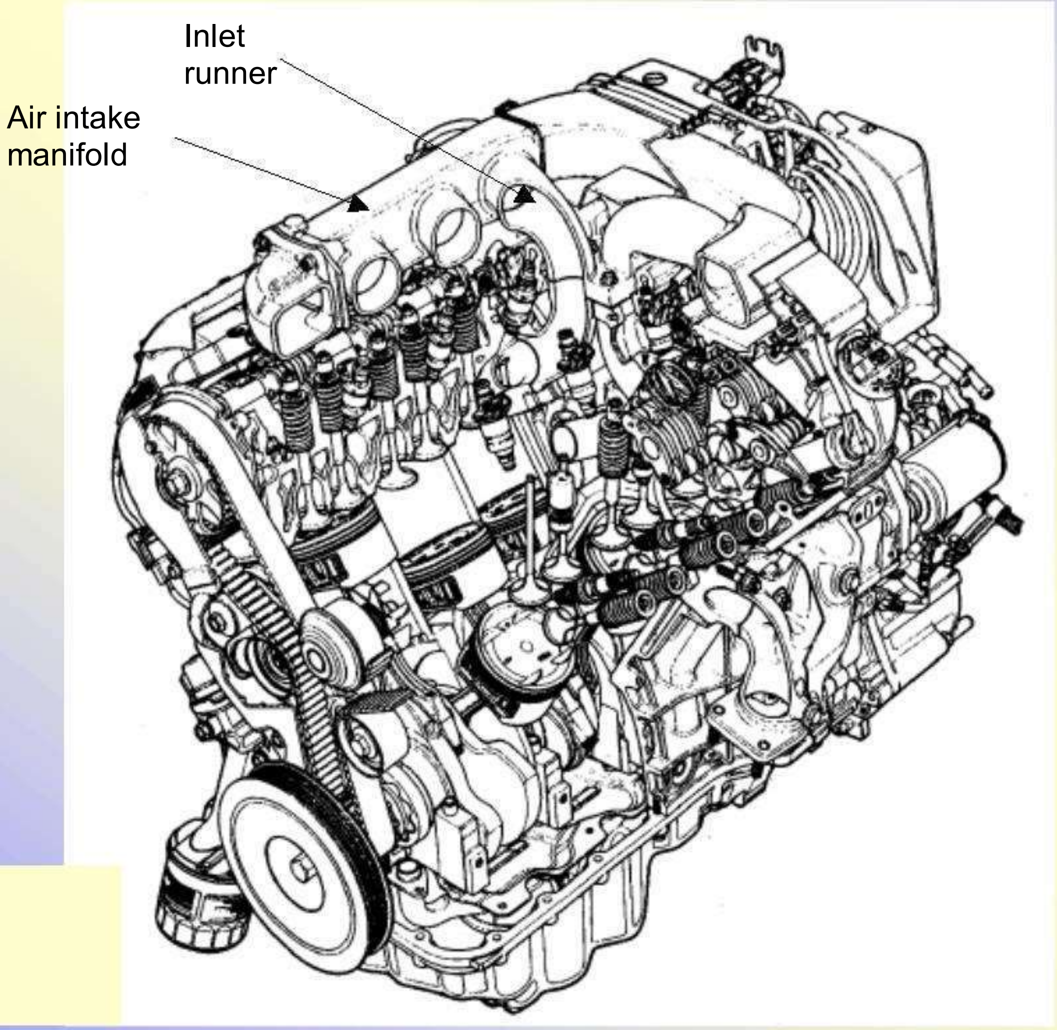


Figure 1-1 The Charter Engine made in 1893 at the Beloit works of Fairbanks, Morse & Company was one of the first successful gasoline engine offered for sale in the United States. Printed with permission, Fairbanks Morse Engine Division, Coltec Industries.

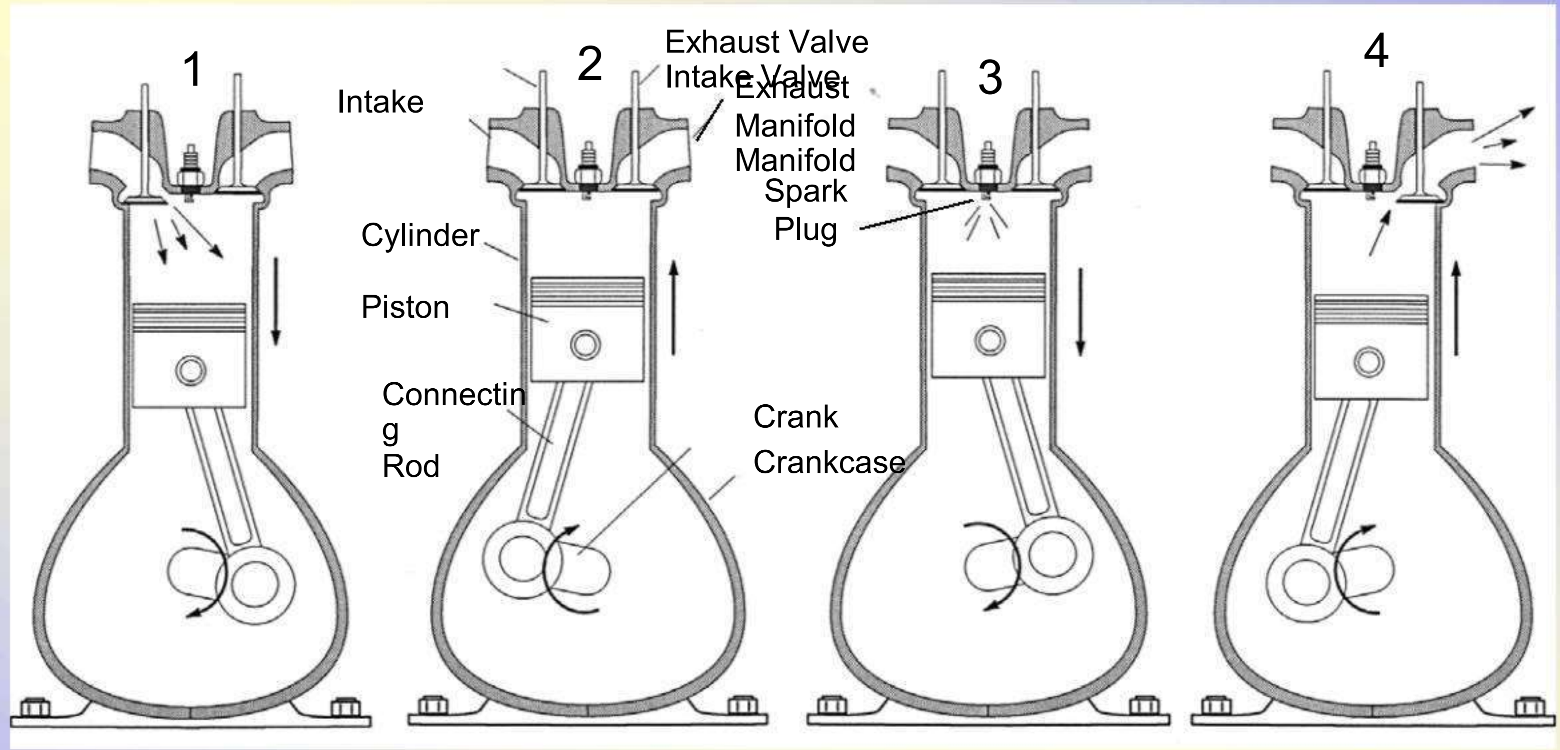
Engine Anatomy



V-6 Engine



4 Stroke SI Engine Cycle



Intake Stroke
Intake valve opens, admitting fuel and air.
Exhaust valve closed for most of stroke

Compression Stroke
Both valves closed, Fuel/air mixture is compressed by rising piston. Spark ignites mixture near end of stroke.

Power Stroke
Fuel-air mixture burns, increasing temperature and pressure, expansion of combustion gases drives piston down. Both valves closed - exhaust valve opens near end of stroke

Exhaust Stroke
Exhaust valve open, exhaust products are displaced from cylinder.
Intake valve opens near end of stroke.

Four-Stroke Diesel Engine

- **Intake stroke**
  - Intake valve open, exhaust valve shut
  - Piston travels from TDC to BDC
  - Air drawn in
- **Compression stroke**
  - Intake and exhaust valves shut
  - Piston travels from BDC to TDC
  - Temperature and pressure of air increase
- **Power stroke**
  - Intake and exhaust valves shut
  - Fuel injected into cylinder and ignites
  - Piston forced from TDC to BDC
- **Exhaust stroke**
  - Intake valve shut, exhaust valve open
  - Piston moves from BDC to TDC
  - Combustion gases expelled

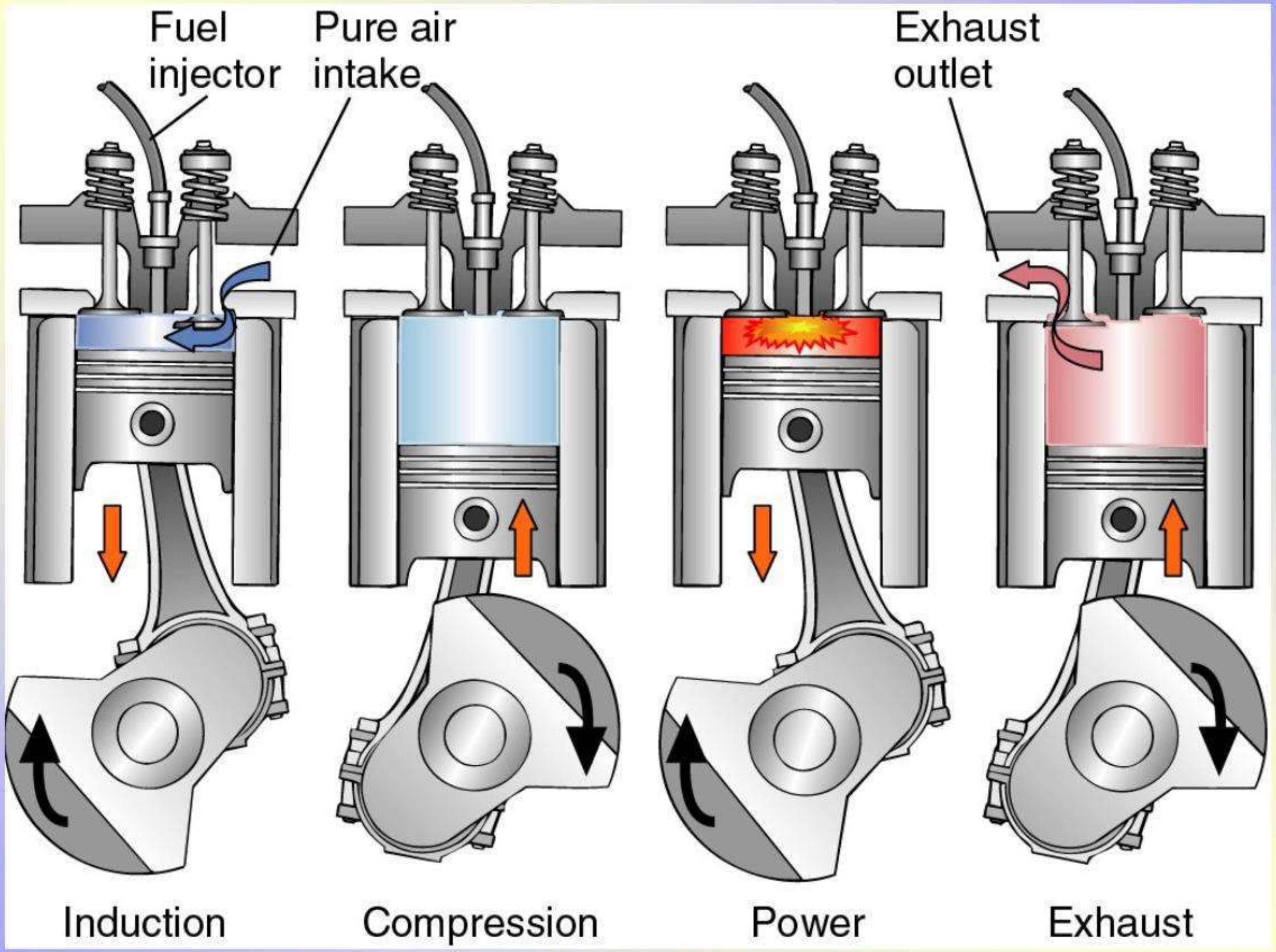

Fuel injector
Pure air intake
Exhaust outlet
Induction
Compression
Power
Exhaust

Table 1.1 Comparison of SI and CI Engines

Description	SI Engine	CI Engine
Basic cycle	Works on Otto cycle or constant volume heat addition cycle.	Works on Diesel cycle or constant pressure heat addition cycle.
Fuel	Gasoline, a highly volatile fuel. Self-ignition temperature is high.	Diesel oil, a non-volatile fuel. Self-ignition temperature is comparatively low.
Introduction of fuel	A gaseous mixture of fuel-air is introduced during the suction stroke. A carburettor and an ignition system are necessary. Modern engines have gasoline injection.	Fuel is injected directly into the combustion chamber at high pressure at the end of the compression stroke. A fuel pump and injector are necessary.
Load control	Throttle controls the quantity of fuel-air mixture introduced.	The quantity of fuel is regulated. Air quantity is not controlled.

Ignition	Requires an ignition system with spark plug in the combustion chamber. Primary voltage is provided by either a battery or a magneto.	Self-ignition occurs due to high temperature of air because of the high compression. Ignition system and spark plug are not necessary.
Compression ratio	6 to 10. Upper limit is fixed by antiknock quality of the fuel.	16 to 20. Upper limit is limited by weight increase of the engine.
Speed	Due to light weight and also due to homogeneous combustion, they are high speed engines.	Due to heavy weight and also due to heterogeneous combustion, they are low speed engines.
Thermal efficiency	Because of the lower CR, the maximum value of thermal efficiency that can be obtained is lower.	Because of higher CR, the maximum value of thermal efficiency that can be obtained is higher.
Weight	Lighter due to lower peak pressures.	Heavier due to higher peak pressures.

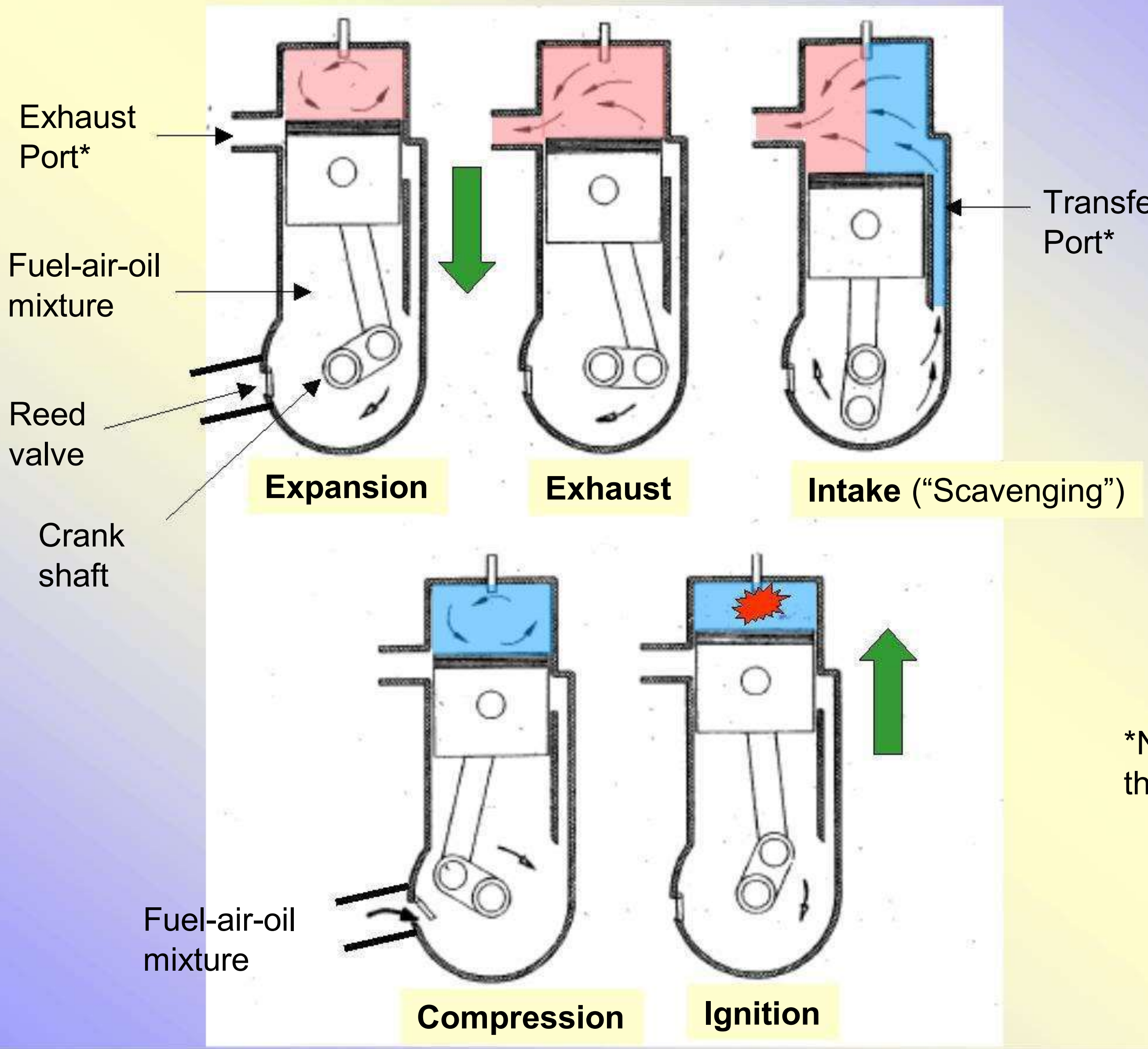
Two Stroke Spark Ignition Engines

Stroke 1: Fuel-air mixture is introduced into the cylinder and is then compressed, combustion initiated at the end of the stroke

Stroke 2: Combustion products expand doing work and then exhausted

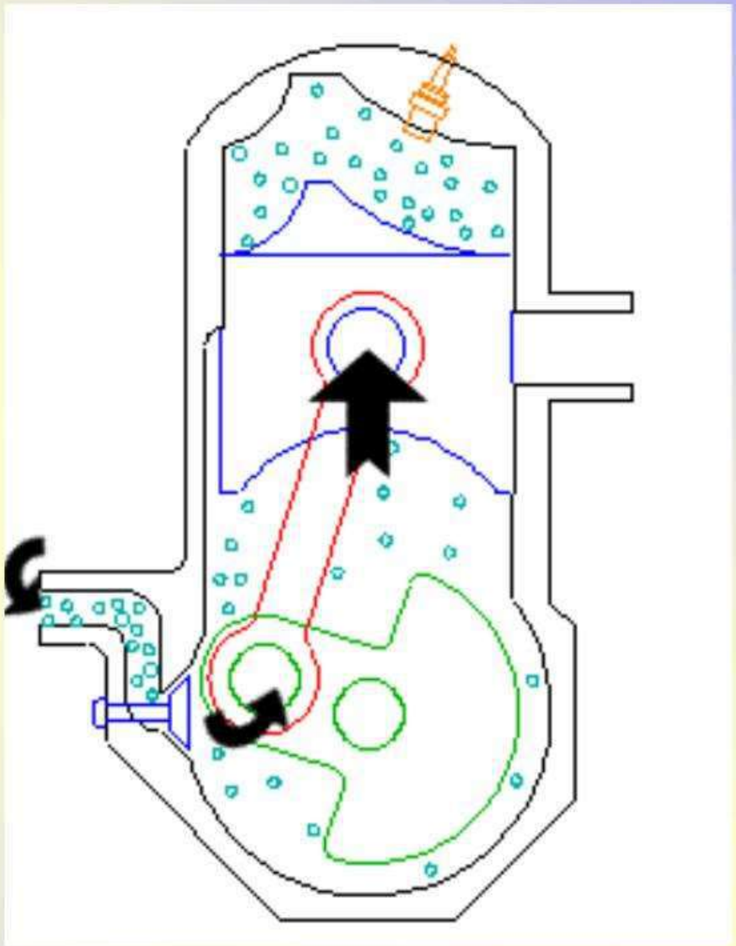
- Power is delivered to the crankshaft on every revolution

Two Stroke Spark Ignition Engine

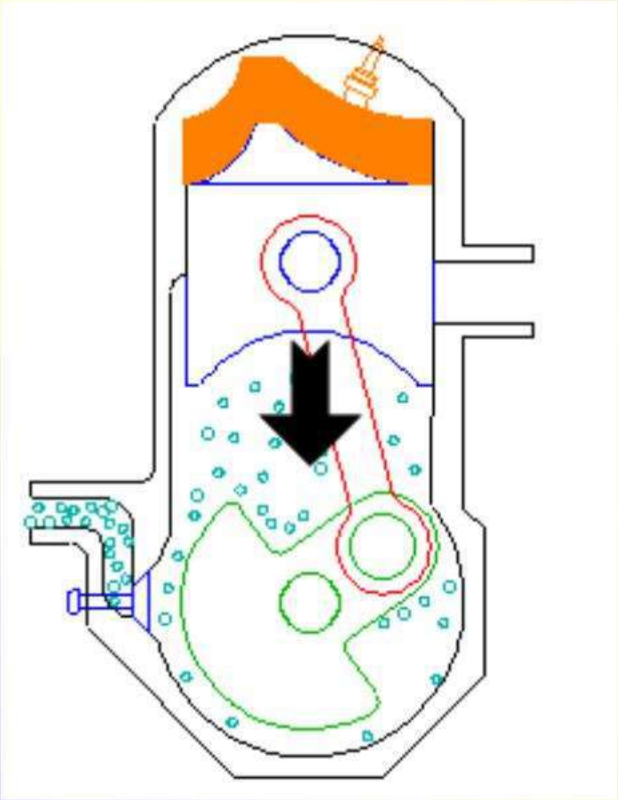


*No valves and thus no camshaft

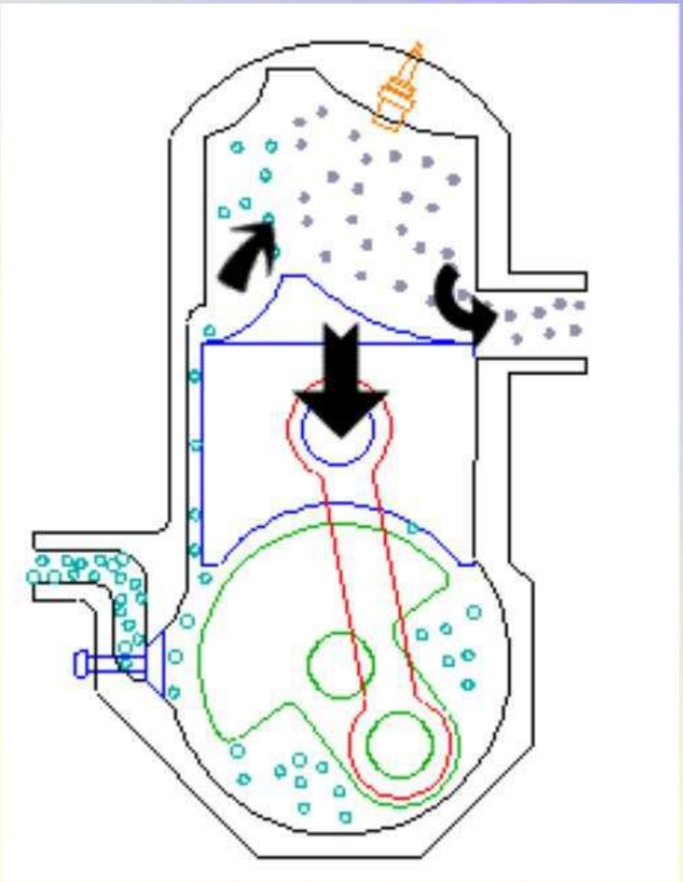
Intake: The fuel/air mixture is first drawn into the crankcase by the vacuum created during the upward stroke of the piston. The illustrated engine features a poppet intake valve, however many engines use a rotary valve incorporated into the crankshaft.



During the downward stroke the poppet valve is forced closed by the increased crankcase pressure. The fuel mixture is then compressed in the crankcase during the remainder of the stroke.

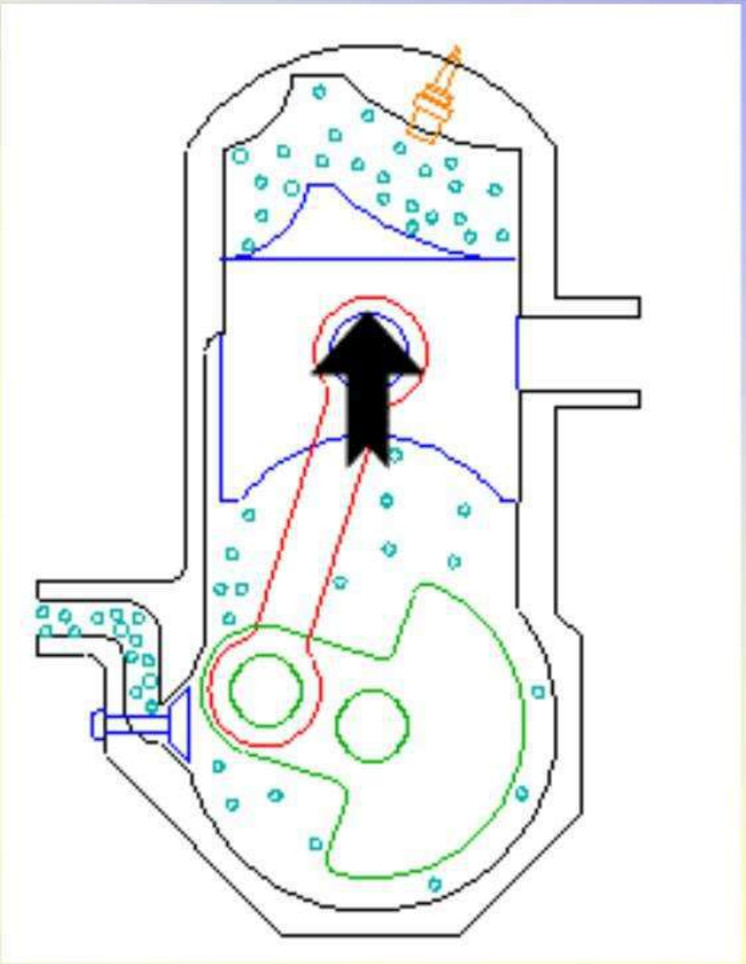


Transfer/Exhaust: Towards the end of the stroke, the piston exposes the intake port, allowing the compressed fuel/air mixture in the crankcase to escape around the piston into the main cylinder. This expels the exhaust gasses out the exhaust port, usually located on the opposite side of the cylinder. Unfortunately, some of the fresh fuel mixture is usually expelled as well.

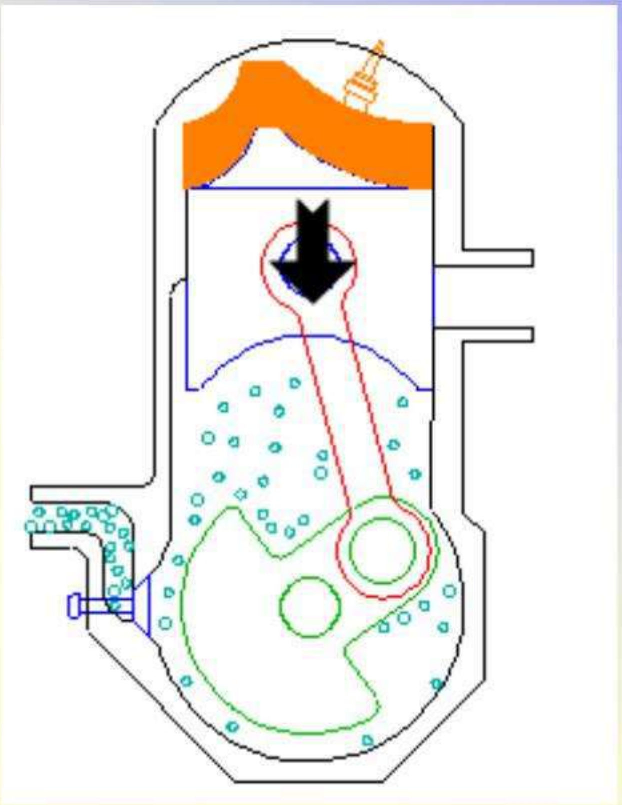


Compression: The piston then rises, driven by flywheel momentum, and compresses the fuel mixture.

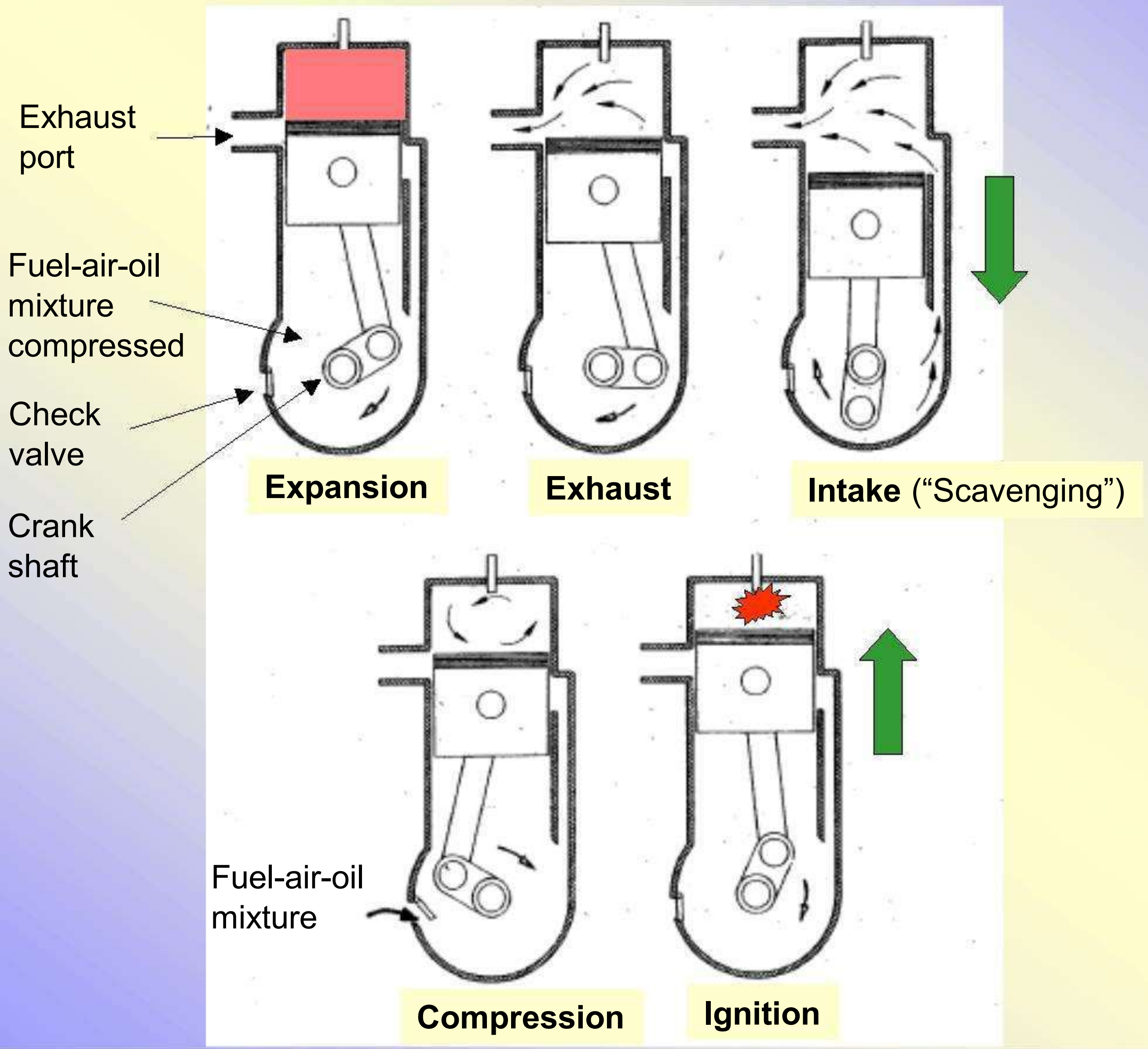
(At the same time, another intake stroke is happening beneath the piston).



Power: At the top of the stroke the spark plug ignites the fuel mixture. The burning fuel expands, driving the piston downward, to complete the cycle.



Two Stroke Spark Ignition Engine



Two Stroke Engines

- **Small Engines –** Absence of valve mechanism makes cheaper, compact and lighter engines
- **Large Engines –** That operates at a low RPM. Requires a power stroke from every revolution for smooth operation.

Two Stroke Engines

- Two stroke engines have advantages over four stroke:
  - simplified construction (no valves)
  - fire once every revolution for a significant power boost
- Great power to weight ratio

The two stroke cycle

- The two stroke engine ignites every revolution of the crankshaft. These engines overlap operations to reduce parts while maintaining power.
- In simpler words, in a two stroke engine there are only:
  - Compression
  - Combustion
- Thus, Two Strokes.

2 stroke compared to 4 stroke

- In two stroke engines the crankcase is a pressurization chamber to force fuel/oil/air into the cylinder. Here, we mix oil and gas to lubricate internal parts.

- In four stroke engines the crankcase is separate from the compression chamber. This allows the use of heavy oil for lubrication.

Disadvantages of a two-stroke

- The engines do not last as long due to poor lubrication.
  - Increased heating due to more number of strokes limits the maximum speed.
- The engines do not use fuel efficiently.
- These engines produce a lot of pollution.

Summary

- **During scavenging** ***(when inlet and exhaust ports remain open for sometime),*** **some fresh charge may escape through exhaust. This leads to higher fuel consumption and lower thermal efficiency.**

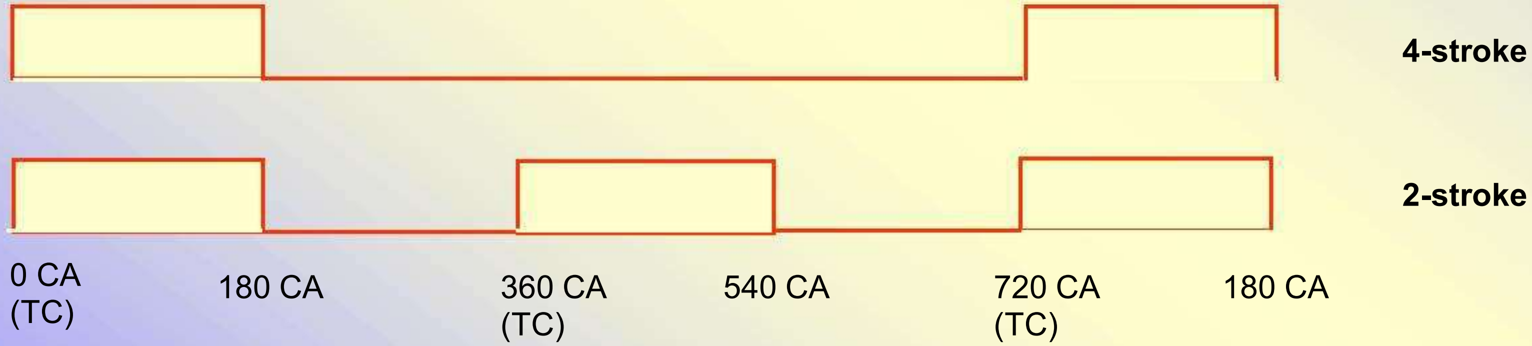
- **Greater cooling & lubrication requirements.**

- **Power output is only more than 30 % and not doubled.**

Single Cylinder Engine

Single-cylinder engine gives one power stroke per crank revolution (360 CA) for 2 stroke, or every two revolutions for 4 stroke.

The torque pulses on the crank shaft are widely spaced, and engine vibration and smoothness are significant problems.



Used in small engine applications where engine size is more important

Table 1.2 Comparison of Four and Two-Stroke Cycle Engines

Four-Stroke Engine	Two-Stroke Engine
The thermodynamic cycle is completed in four strokes of the piston or in two revolutions of the crankshaft. Thus, one power stroke is obtained in every two revolutions of the crankshaft.	The thermodynamic cycle is completed in two strokes of the piston or in one revolution of the crankshaft. Thus one power stroke is obtained in each revolution of the crankshaft.
Because of the above, turning moment is not so uniform and hence a heavier flywheel is needed.	Because of the above, turning moment is more uniform and hence a lighter flywheel can be used.
Again, because of one power stroke for two revolutions, power produced for same size of engine is less, or for the same power the engine is heavier and bulkier.	Because of one power stroke for every revolution, power produced for same size of engine is twice, or for the same power the engine is lighter and more compact.

Because of one power stroke in two revolutions lesser cooling and lubrication requirements. Lower rate of wear and tear.	Because of one power stroke in one revolution greater cooling and lubrication requirements. Higher rate of wear and tear.
Four-stroke engines have valves and valve actuating mechanisms for opening and closing of the intake and exhaust valves.	Two-stroke engines have no valves but only ports (some two-stroke engines are fitted with conventional exhaust valve or reed valve).
Because of comparatively higher weight and complicated valve mechanism, the initial cost of the engine is more.	Because of light weight and simplicity due to the absence of valve actuating mechanism, initial cost of the engine is less.
Volumetric efficiency is more due to more time for induction.	Volumetric efficiency is low due to lesser time for induction.

4 Stroke vs. 2 Stroke

- 2 Stroke needs a blower and will usually use a supercharger
- 2 Stroke combustion process not as complete (more pollution)
- 2 stroke engines weigh less and have higher RPM operating speeds.
- 4 stroke engine has Intake, Compression, Power, and Exhaust strokes.
- 2 stroke has power and compression.
- 2 strokes used more for emergencies, 4 strokes used more for propulsion

Characteristics of Four Stroke Compression Ignition & Spark Ignition Engines

Characteristics	Compression-Ignition Engine	Spark- Ignition Engine
Compression Ratio	14-22 : 1	5-8 : 1
Ignition	Compression	Electric Spark
Thermal Efficiency	30-60%	25-30%
Fuel induction	Injector	Carburettor (Fuel Injection)
Fuel System	Fuel Oil / Diesel	Gasoline (LP gas)
Fire Hazard	Less	Greater
Power Variation	Increase in Fuel	Increase in Air/Fuel Mixture
Air Induction	Constant	Variable
Air-Fuel Ratio	15-100 : 1	10-20 : 1
Relative Fuel Consumption	Lower	Higher
Energy per litre of fuel	Higher	Lower
Manifold Throttle	Absent	Present
Exhaust Gas Temperature	482° C / 900 F	704° C / 1300 F
Starting	Harder	Easier
Lubricants	Heavy duty oils	Regular and Premium Oils
Speed Range	Limited (600-3200 rpm)	Wide range (400-6000 rpm)
Engine Mass per Horsepower	8 kg (17.5 lb)	Average 4 kg (9 lb)
Initial Cost	High	Much Lower
Lugging ability (Torque)	Excellent	Less
Time Before Maintenance	Good	Fair
Continuous Duty	Good	Fair