ME-417

INTERNAL COMBUSTION ENGINES

Md. Hasibul Islam

June 5, 2023

Kazi Arafat Rahman Sir

Contents

1 Lecture 01: Introduction

Date: 04/06/2023

Basics

IC Engines → CI (Compression ingition), SI (Spark Ignition), Gas Turbine engines [1]

Key points

- pressure force will give thrust to piston.
- combustion will result in expansion.
- piston mechanism → mechanical movement.

Free Piston Engine

Drag Mechanism

clutch Mechanism

Methods of ignition

Spark Ignition

spark ignition (SI) is the method used in gasoline engines to ignite the fuel-air mixture using a spark plug.

Compression Ignition

compression ignition (CI) is the process in diesel engines where the fuel ignites due to the high temperature and pressure generated by compressing the air inside the combustion chamber, without the use of a spark plug.

Cycle

2 Stroke

Combustion process completed in two strokes—compression and ignition, followed by exhaust and intake.

4 Stroke

Combustion process completed in four strokes—intake, compression, power, and exhaust.

[1] But this course will cover only CI & SI engines

Valve

In Head

Valves positioned in the cylinder head for efficient airflow control.

In Block

Valves integrated into the engine block for simplified construction and maintenance.

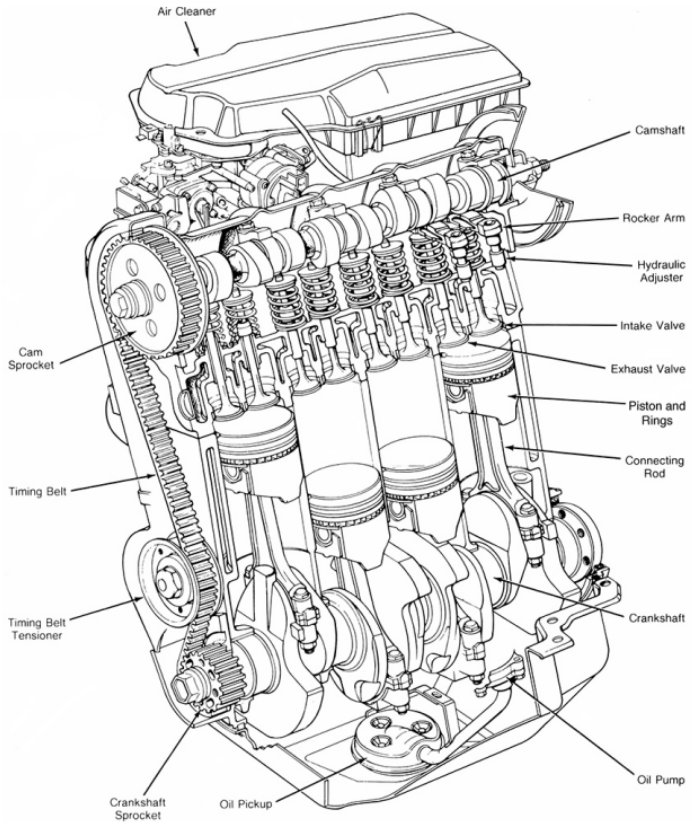

Figure 1: Basic Design of IC engines.

Types of Cooling

Air Cooling

Uses air circulation around engine components for heat dissipation.

Liquid Cooling

- **Water Cooling**: Circulates water as a coolant.
- **Liquid-Glycol Cooling**: Mixture of water and glycol to prevent freezing.

Oil Cooling

Uses engine oil to absorb heat from components.

Position and number of Cylinders of reciprocating engines

Position of cylinders

- **Inline**: Cylinders are arranged in a straight line, typically in a row or series.
- **V-Type**: Cylinders are arranged in two banks or rows at an angle, forming a "V" shape.
- **Flat/Boxer**: Cylinders are horizontally opposed, positioned on opposite sides of the engine and lying flat.
- **Radial**: Cylinders are arranged in a circular pattern around a central crankshaft, resembling spokes of a wheel.

Number of Cylinders

- Single-cylinder: One cylinder in the engine.
- Twin-cylinder: Two cylinders.
- Inline (e.g., 4-cylinder, 6-cylinder): Multiple cylinders arranged in a straight line.
- V-Type (e.g., V6, V8): Multiple cylinders arranged in a "V" configuration.
- Flat/Boxer (e.g., 4-cylinder boxer): Multiple horizontally opposed cylinders.
- Radial (e.g., 9-cylinder radial): Multiple cylinders arranged in a circular pattern.

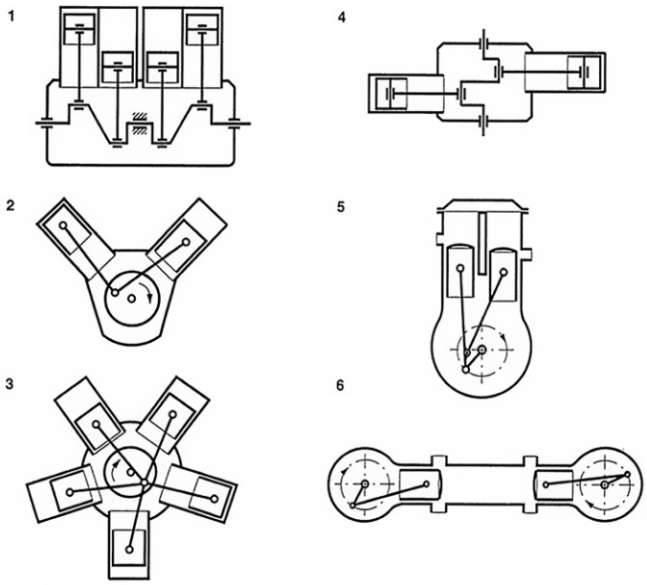

Figure 2: position & number of cylinders in reciprocating engines.

Methods of fuel input for spark ignition engines

Port Fuel Injection (PFI):

Fuel is injected into the intake ports or manifold before entering the combustion chamber.

Direct Fuel Injection (DI):

Fuel is injected directly into the combustion chamber for precise control and improved efficiency.

Air Intake process

- Air is filtered to remove contaminants.
- Throttle valve controls air flow.
- Intake manifold distributes air to cylinders.
- Air enters combustion chamber for mixing with fuel.

Supercharged

- **Mechanism**: A supercharger is a mechanical device driven by the engine's crankshaft that forces more air into the combustion chamber. It uses a belt or chain connected to the engine to compress the intake air, resulting in increased air density and more fuel combustion.
- **Advantage**: Supercharging provides instant power boost across the entire RPM range, improving engine performance and responsiveness. It can deliver higher power outputs compared to naturally aspirated engines.
- **Disadvantage**: Supercharging requires engine power to drive the compressor, which results in increased mechanical load on the engine. This can reduce overall engine efficiency and increase fuel consumption.

Turbocharged

- **Mechanism**: A turbocharger uses the engine's exhaust gases to drive a turbine connected to a compressor. The turbine spins the compressor, compressing the intake air before it enters the combustion chamber. This allows more air and fuel to be burned, resulting in increased power output.
- **Advantage**: Turbocharging improves engine power and efficiency by utilizing wasted exhaust energy. It provides a good balance of power and fuel economy, especially at high RPMs.
- **Disadvantage**: Turbo lag, which is the delay in boost response, can occur due to the time it takes for the exhaust gases to spool up the turbocharger. Additionally, the increased complexity and heat generated by the turbocharger system may require additional cooling measures.

Engine components & Materials

Components of 4 stroke cycle SI engine

- **Cylinder Block**: The main body of the engine that houses the cylinders.
- **Cylinder Head**: Covers the top of the cylinder block and contains the combustion chamber, valves, and spark plugs.
- **Piston**: Moves up and down within the cylinder, transmitting the force generated by combustion to the connecting rod.
- **Connecting Rod**: Connects the piston to the crankshaft, converting the reciprocating motion of the piston into rotary motion.
- **Crankshaft**: Converts the linear motion of the pistons and connecting rods into rotary motion, providing power to the drivetrain.
- **Intake Valve**: Controls the flow of air-fuel mixture into the combustion chamber during the intake stroke.
- **Exhaust Valve**: Controls the flow of exhaust gases out of the combustion chamber during the exhaust stroke.
- **Spark Plug**: Provides an electrical spark to ignite the air-fuel mixture in the combustion chamber during the power stroke.
- **Intake Manifold**: Distributes the air-fuel mixture to the individual cylinders.
- **Exhaust Manifold**: Collects and channels the exhaust gases away from the combustion chamber.
- **Camshaft**: Controls the opening and closing of the intake and exhaust valves.
- **Timing Belt/Chain**: Synchronizes the rotation of the crankshaft and camshaft to ensure proper valve timing.
- **Lubrication System**: Supplies oil to lubricate engine components and reduce friction.
- **Cooling System**: Helps regulate engine temperature by circulating coolant to remove excess heat.
- **Fuel Injection System**: Delivers the precise amount of fuel to the combustion chamber for efficient combustion.

Materials of 4 Stroke cycle SI engine

- **Cylinder Block**: Typically made of cast iron or aluminum alloy.
- **Cylinder Head**: Usually made of aluminum alloy or cast iron.
- **Pistons**: Often made of aluminum alloy with steel reinforcement in critical areas.
- **Connecting Rods**: Commonly made of steel or aluminum alloy.
- **Crankshaft**: Typically made of forged steel for strength and durability.

- **Intake and Exhaust Valves**: Made of materials such as stainless steel, steel alloys, or even titanium alloys for high-performance engines.
- **Valve Springs**: Typically made of steel.
- **Camshaft**: Made of steel or cast iron.
- **Timing Belt/Chain**: Timing belts are usually made of rubber with embedded cords made of materials like fiberglass or kevlar. Timing chains are typically made of steel.
- **Bearings**: Main and connecting rod bearings are often made of steel with a thin layer of bearing material such as aluminum or bronze.
- **Gaskets and Seals**: Made of materials such as rubber, cork, or metal composites to ensure proper sealing.
- **Engine Block Skirt**: Made of cast iron or aluminum alloy.
- **Oil Pan**: Typically made of stamped steel or cast aluminum.
- **Cooling System Components**: Radiator, hoses, and coolant reservoir are commonly made of materials like aluminum, plastic, or rubber.
- **Fuel Injection System Components**: Fuel injectors are usually made of materials such as stainless steel, while fuel rails and fuel pump housings are often made of aluminum alloy or plastic.

These topics are associated with the book: Heywood (IC Engine Fundamentals, 2018)
Chapter: 1.1, 1.2, 1.4, 1.5, 1.7.3

2 Lecture 2: Topic

Date: DD/MM/YYYY

Content of the lecture goes here.