Internal Combustion Engines

Introduction

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Engine

- Energy Conversion Device (One Form to the Other)

Heat Engine

- Convert Thermal Energy in fuel into Mechanical Energy for motion
Classifying Engines

- Classification is based on:
  - The location of the combustion
    - Internal / External
  - The type of combustion
    - Intermittent / Continuous
  - The type of internal motion
    - Reciprocating
    - Rotational
Internal Combustion Engines

• Combustion occurs **Inside** the engine
• Internal combustion directly touches the parts that must be moved in order to produce mechanical energy
• Examples: Lawnmower engines, Motorcycle engines, automotive engines
External Combustion Engines

- Combustion occurs indirectly on the parts that must be moved
- Thermal energy heats another fluid (water), turns it into steam, and the steam pushes on a piston or part

Example: Steam locomotives, Boilers
External Combustion

(a) Reciprocating type
Intermittent Combustion Engines

- Combustion within the engine STARTS and STOPS many times during operation
Continuous Combustion Engine

• Combustion process that continues constantly without stopping

• It remains burning continuously

• Examples:
  - Turbine engines
  - Rocket engines
  - Jet engines
IC Engines

• An internal combustion engine is defined as a device in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel.
History

• The internal combustion engine was first conceived and developed in the late 1800’s.

• The man who is considered the inventor of the modern IC engine is pictured to the right ...Nikolaus Otto (1832-1891).

• Otto developed a four-stroke engine in 1876, most often referred to as a Spark Ignition, since a spark is needed to ignite the fuel air mixture.
• Another important cycle is the Diesel cycle developed by Rudolph Diesel in 1897. This cycle is also known as a compression ignition engine.

• Almost all travel and transportation is powered by the IC engine: trains, automobiles, airplanes are just a few.
Reciprocating Engines

- Motion produced from within the fuel (combustion) moves parts up and down
- Piston or internal parts are moved back and forth
- Examples: lawn mowers, cars, trucks, etc...
Rotary Engines

• Has continuous rotation of the parts that are moving

• The combustion is pushing an internal part around in a circular path

Examples:
Wankel engines
Turbine engines
Forms of Kinetic Energy

- **Reciprocation**
  - Motion that is defined on a linear path
  - Up-and-down; back-and-forth

- **Rotation**
  - Motion that is defined on a circular path
  - Spinning; turning
Kinetic Energy within Intermittent Combustion Engines

- **Piston Movement**
  - intermittent
  - Reciprocating
  - Not useful enough

- **Crank shaft**
  - Connected to piston
  - turns linear motion into rotation motion
Thermodynamic Principles

• All internal combustion
  – Open cycle, heated engine

• Gasoline (Otto) engine
  – Spark ignition
  – Compresses air-fuel mixture

• Diesel engine
  – Compressed ignition
  – Compresses air only
Name as many parts as you can

Parts of an I C Engine

Your name: ____________________

CROSS SECTION OF OVERHEAD VALVE FOUR CYCLE SI ENGINE
**Structural Components**

- **Cylinder Block**
  - Part of engine frame that contains cylinders in which piston moves
  - Supports liners & head
Structural Components

- **Cylinder Head/Assembly**
  - Serves to admit, confine, and release fuel/air
  - Cover to cylinder block
  - Supports valve train

- **Crankcase**
  - Engine frame section that houses the crankshaft

- **Oil sump**
  - Reservoir for collecting and holding lube oil
Moving Components

• Three Groups - according to motion
  - Reciprocating only (pistons and valves)
  - Reciprocation & rotary (connecting rods)
  - Rotary only (crankshafts and camshafts)
Moving Components

- **Piston**
  - Acted on by combustion gases
  - Lightweight but strong/durable
- **Piston Rings**
  - Transfer heat from piston to cylinder
  - Seal cylinder & distribute lube oil
- **Piston Pin**
  - Pivot point connecting piston to connecting rod
- **Connecting Rod**
  - Connects piston & crankshaft
  - Reciprocating → rotating motion
Moving Components

- **Crankshaft**
  - Combines work done by each piston
  - Drives camshafts, generator, pumps, etc.

- **Flywheel**
  - Absorbs and releases kinetic energy of piston strokes, and smoothens rotation of crankshaft
Moving Components

• **Valves**
  - **Intake**: open to admit air to cylinder (with fuel in Otto cycle)
  - **Exhaust**: open to allow gases to be rejected

• **Camshaft & Cams**
  - Used to time the addition of intake and exhaust valves
  - Operates valves via pushrods & rocker arms
Parts of an I C Engine

Air cleaner
Choke
Throttle
Intake manifold
Exhaust manifold
Piston rings
Piston
Wrist pin
Cylinder block
Connecting rod
Oil gallery to piston
Oil gallery to head
Crankcase
Crankpin
Crankshaft
Breather cap
Rocker arm
Valve spring
Valve guide
Pushrod
Sparkplug
Combustion chamber
Tappet
Dipstick
Cam
Camshaft
Water jacket
Wet liner
Connecting rod bearing
Main bearing
Oil pan or sump

CROSS SECTION OF OVERHEAD VALVE FOUR CYCLE SI ENGINE
Definitions

• **Stroke** - the number of times the piston travels the length of the cylinder

• **Cycle** - composed of 4 parts
  - **Intake** - working substance is introduced
  - **Compression** - working substance is compressed by upward movement of the piston
  - **Power** - ignition $\Rightarrow$ forcing the piston down
  - **Exhaust** - removal of exhaust gases
Definitions - cont'd.

- **Top Dead Center** - when the piston is at its highest point in the cylinder. The volume of the working fluid is a minimum.

- **Bottom Dead Center** - when the piston is at its lowest point in the cylinder. The volume of the working fluid is a maximum.
Some Engine Terms

- **Bore** - diameter of the cylinder

- **Engine Displacement** - the volume of air that is displaced by all the pistons during one upward stroke.

- **Compression Ratio** - the comparison of the cylinder volume when the piston is at BDC and the volume when the piston is at TDC.

- **Engine stroke**
  - A stroke is a single traverse of the cylinder by the piston (from TDC to BDC)
  - 1 revolution of crankshaft = 2 strokes of piston
Engine Power

- IC engines can deliver power in the range from 0.01 kW to $20 \times 10^3$ kW, depending on their displacement.

- Number of Cylinders may vary from 1 to 20 with different geometric configurations.

4 and 2 Stroke Engines

- A 4 stroke engine requires 2 full revolutions of the crankshaft to complete the cycle.

- While the 2 stroke only requires 1 revolution of the shaft complete the same cycle.
Operation

- Increased pressure of combustion gases acts on piston, and is converted to rotary motion.

- Can be 2 or 4 stroke engines:
  - 2-stroke: 1 power stroke per 1 crankshaft rev
  - 4-stroke: 1 power stroke per 2 crankshaft rev
Four Stroke SI Engine

- **Induction Stroke**: fill cylinder with fuel and air
- **Compression Stroke**: squeeze mixture
- **Power Stroke**: burn and extract work
- **Exhaust Stroke**: empty cylinder of exhaust
**Induction Stroke**

- Engine pulls piston out of cylinder
- Low pressure inside cylinder
- Atmospheric pressure pushes fuel and air mixture into cylinder
- Engine does work on the gases during this stroke

**Compression Stroke**

- Engine pushes piston into cylinder
- Mixture is compressed to high pressure and temperature
- Engine does work on the gases during this stroke
**Power Stroke**

- Mixture burns to form hot gases
- Gases push piston out of cylinder
- Gases expand to lower pressure and temperature
- Gases do work on engine during this stroke

**Exhaust Stroke**

- Engine pushes piston into cylinder
- High pressure inside cylinder
- Pressure pushes burned gases out of cylinder
- Engine does work on the gases during this stroke
Ignition System

- Car stores energy in an electromagnet
- Energy is released as a high voltage pulse
- Electric spark ignites fuel and air mixture
- Two basic types of ignition
  - Battery
  - Magneto
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
Fig. 1.1 Classification of Heat Engines
Four Stroke Spark Ignition Engine

Four Stroke Compression Ignition Engine
References

Web Resources

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