

11.1 The Piston Engine

- A stroke is defined as the linear distance the piston moves within the cylinder¹. When the piston is at the very top of its travel, it is at
- Top Dead Centre (TDC), and when it is at the bottom, it is at Bottom Dead Centre
- (BDC)². The piston is connected to a crankshaft, and one full stroke from TDC to BDC
- rotates the crankshaft 180° ³.
- The piston engine operates on a four-stroke cycle, commonly known as the Otto Cycle. This
- complete cycle requires two full rotations of the crankshaft (720°)⁴.

11.2 The Four-Stroke Otto Cycle

- The practical Otto cycle is modified from the theoretical version to be more efficient by
- adjusting when the valves open and close⁵.
- 1. Induction (Intake) Stroke:
- The inlet valve opens, and the piston moves down from TDC to BDC, drawing a fuel/air
- mixture into the cylinder⁶.
- The cylinder pressure decreases below ambient pressure, and the temperature of the charge
- decreases⁷.
- To improve efficiency, the inlet valve opens slightly
- before TDC and closes slightly after BDC⁸⁸⁸⁸.
- 2. Compression Stroke:
- Both the inlet and exhaust valves are closed⁹.
- The piston moves up from BDC to TDC, compressing the fuel/air mixture¹⁰¹⁰¹⁰.
- This compression increases the pressure and temperature of the charge¹¹.
- 3. Power Stroke:
- Just before the piston reaches TDC on the compression stroke, the mixture is ignited by a
- spark plug¹².

- The rapid combustion causes a massive increase in pressure and temperature, forcing the
- piston down from TDC to BDC¹³. This is the stroke that produces power.
- Because the piston is momentarily stationary at TDC during ignition, combustion occurs at a
- nearly constant volume, which is why the piston engine is known as a 'Constant Volume
- Engine'¹⁴.
- 4. Exhaust Stroke:
- The exhaust valve opens, and the piston moves up from BDC to TDC, pushing the burnt
- gases out of the cylinder¹⁵.
- The pressure in the cylinder during this stroke is slightly higher than ambient due to 'Exhaust
- Back Pressure'¹⁶.

11.3 Valve Timing and Overlap

- ☐ Valve Lead: When a valve opens before its theoretical timing (e.g., intake valve opening
- before TDC)¹⁷.
- ☐ Valve Lag: When a valve closes after its theoretical timing (e.g., exhaust valve closing after
- TDC)¹⁸.
- ☐ Valve Overlap: The period when both the inlet and exhaust valves are partially open at the
- same time (around TDC at the end of the exhaust stroke)¹⁹. This improves the engine's
- volumetric efficiency by using the momentum of the outgoing exhaust gases to help draw in
- the new fuel/air charge²⁰.

11.4 Engine Power and Performance Metrics

- ☐ Power Control: The pilot controls engine power by using the throttle, which is a valve that
- varies the quantity of the fuel/air mixture entering the cylinders²¹.
- ☐ Indicated Horsepower (IHP): The theoretical power produced within the cylinders²².
- ☐ Friction Horsepower (FHP): The power lost due to friction from moving parts²³.
- ☐ Brake Horsepower (BHP): The actual, usable power delivered to the propeller shaft.
- $BHP = IHP - FHP$ ²⁴.

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