Steam enters chamber from left, leaving from right. Both valves closed, piston moves to the right.

Steam enters from right, leaving from left. Piston moves back to the left.

Steam Engine

Sliding valve
Simple steam power plant cycle

- **Heat in**
  - Boiler
  - $p_1 = 8.0 \text{ MPa}$
  - Saturated vapor

- **Work out**
  - Turbine
  - $\dot{W}_t$
  - Condenser
  - Cooling water

- **Heat in**
  - Condensing back to liquid form for easy transportation
  - Pump
  - $\dot{W}_p$

- **Heat out to cooling water**
  - Saturated liquid at 0.008 MPa

- **Work in by pump**
  - 4

- **Work out**
  - 1

- **T**
  - 8.0 MPa
  - 0.008 MPa
Superheated steam
Saturated water
liquid+vapor
Compressed (subcooled) liquid

Phase Change

Above critical point, there is no clear distinction between liquid and vapor phases
Melting
vaporization
sublimation

Fig. 2-1 The solid, liquid, and vapor phases of a substance.

Fig. 2-2 The T-v diagram.
Fig. 2-3  The $P$-$v$-$T$ rendering of a substance that contracts on freezing.
(a) P-v diagram: Along the constant temperature line, increasing vapor pressure will lead to higher density (lower specific volume) due to compression. After it reaches the saturation pressure at that temperature, the vapor will condense into liquid while the pressure remains constant until all vapor condense into liquid.

(b) T-v diagram: Along the constant pressure line, increasing liquid temperature will lead to lower density (higher specific volume) due to thermal expansion. At the saturation temperature, the liquid will vaporize into gaseous form at a constant pressure until all liquid vaporize.
Substances that expand on freezing, e.g., water. Higher pressure makes it more difficult to freeze, thus requiring a lower freezing temperature. The reverse is true for substances that contract on freezing.

Critical point: A limiting state above which there is no clear distinction between liquid and vapor phases.