Given

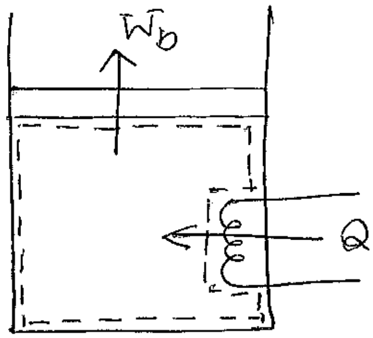
A piston-cylinder device with air and electric resistance heater

Find

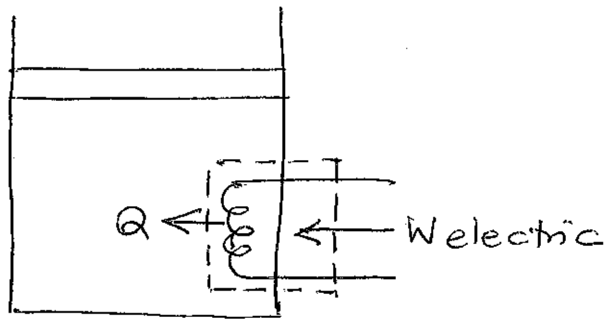
Mass and energy flows at the boundary

System

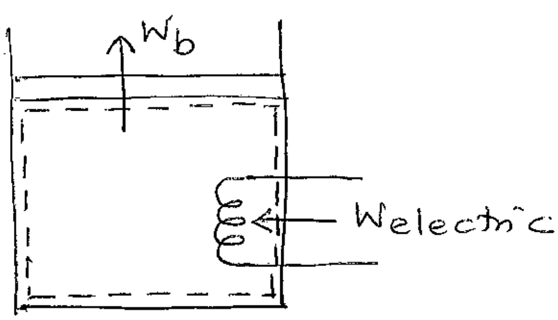
(a) Only air inside the cylinder



(b) Only electric resistance heater



(c) Air and electric resistance heater



Assumptions

- Closed system (m = constant)
- Well-insulated ($Q = 0$) externally

Basic Equations

N/A

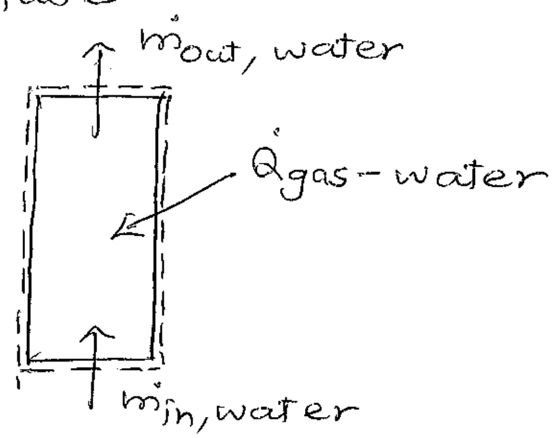
Solution

See system diagrams

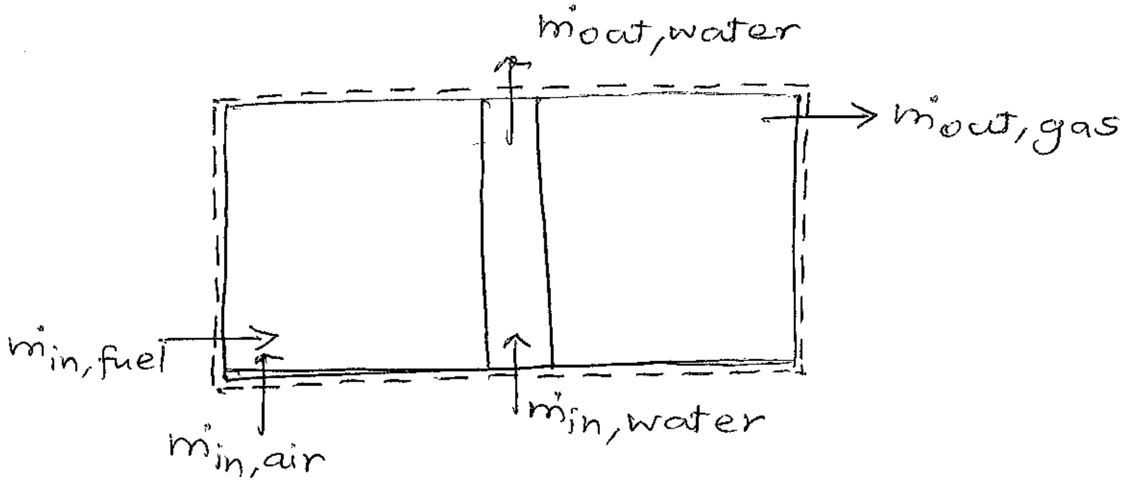
Given
A water-tube boiler in a thermal power plant

Find
Mass and energy flows at the boundary

System
(a) Only water tube



(b) Water tubes and furnace



Assumptions
- Open system
- Well-insulated ($\dot{Q}=0$) externally

Basic Equations
N/A

Solution
See system diagrams

(a) False

A closed system (control mass) has no mass interactions; energy interactions may occur

(b) False

A closed system (control mass) has no mass interactions; mass remains constant but volume may change due to moving boundary

(c) True

A closed system (control mass) has no mass interactions; mass remains constant but chemical reactions may change composition

(d) False

An open system (control volume) has mass and energy interactions

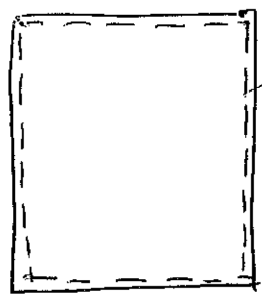
Given A rigid tank containing a gas

Find

(a) Two extensive and four intensive properties

(b) Values of properties with units

System



Gas inside the tank is the system

Assumptions

N/A

Basic Equations

N/A

Solution

(a) Extensive Properties : $\boxed{\text{Mass , Volume}}$

Intensive Properties : $\boxed{\text{Pressure , Temperature, Specific Volume , Density}}$

(b)

$$\boxed{\begin{aligned} m &= 5\ kg \\ V &= 2\ m^3 \end{aligned}}$$

$$\boxed{\begin{aligned} p &= 100\ kPa \\ T &= 27^\circ C \\ v &= 0.4\ \frac{m^3}{kg} \\ \rho &= 2.5\ \frac{kg}{m^3} \end{aligned}}$$

$v = \frac{V}{m}$

$\rho = \frac{m}{V}$

Given

Steam separated into two compartments by a partition inside a closed, ~~rigid~~ rigid, insulated tank

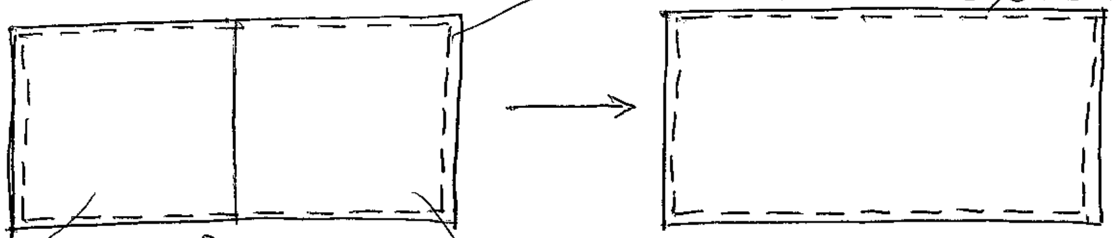
Find

(a) Final specific volume $\left(\frac{m^3}{kg}\right)$

(b) Final density $\left(\frac{kg}{m^3}\right)$

System

Steam inside the tank is the system



$V_{A,1} = 0.5\ m^3$ | $V_{B,1} = 0.5\ m^3$

$v_{A,1} = 3.5655\ \frac{m^3}{kg}$ | $\rho_{B,1} = 0.0981\ \frac{kg}{m^3}$

Assumptions

- closed system (m = constant)

Basic Equations

N/A

Solution

(a) Mass of steam in A: $m_{A,1} = \frac{V_{A,1}}{v_{A,1}} = 0.140\ kg$

Mass of steam in B: $m_{B,1} = \rho_{B,1} V_{B,1} = 0.0491\ kg$

Total mass in the tank: $m_1 = m_{A,1} + m_{B,1} = 0.1891\ kg$

Mass remains constant $\Rightarrow m_2 = m_1$

Final volume occupied by steam: $V_2 = V_{A,1} + V_{B,1}$
$= 1\ m^3$

Final specific volume: $v_2 = \frac{V_2}{m_2} = \frac{1\ m^3}{0.1891\ kg}$

$$\boxed{v_2 = 5.29\ \frac{m^3}{kg}}$$

(b) Final density: $\rho_2 = \frac{1}{v_2}$

$$\boxed{\rho_2 = 0.1891\ \frac{kg}{m^3}}$$

Given

A rocket accelerated either in horizontal or in vertical direction

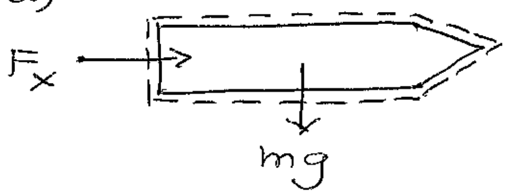
Find

(a) Force (kN) required when the rocket moves horizontally

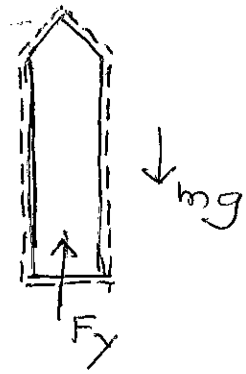
(b) Force (kN) required when the rocket moves vertically

System

(a)



(b)



Assumptions

- Ignore friction
- Uniform acceleration due to gravity

Basic Equations

N/A

Solution

(a) Considering force balance for horizontal motion

$$\Sigma F_x = m a \Rightarrow F_x = 150\ kg * 10\ \frac{m}{s^2} = 1500\ N$$

$$\boxed{F_x = 1.5\ kN}$$

(b) Considering force balance for vertical motion

$$\Sigma F_y = ma \Rightarrow F_y - mg = m a$$

$$F_y = m(a+g) = 150\ kg * 20\ \frac{m}{s^2} = 3000\ N$$

$$\boxed{F_y = 3\ kN}$$