MECHANICAL ENGINEERING SCIENCE (UE25ME141A/B)

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Numericals on Moving Boundary Work

A mass of 1.5 kg of air is compressed in a quasi-static process from 0.1 MPa to 0.7 MPa during which PV=constant. If the initial density of air is 1.16 kg/ m³, determine the work done by the system.

Important Observations

Process is isothermal since PV=constant

$$p_1V_1 = p_2V_2 \text{ OR } \frac{p_1}{p_2} = \frac{v_2}{v_1}$$

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

Data provided

$$m = 1.5\ \text{kg};\ p_1 = 0.1\ \text{MPa};$$

$$p_2 = 0.7\ \text{MPa};\ \rho_1 = 1.16\frac{kg}{m^3}$$

Solution

$$W_{1-2} = p_1V_1\ln\frac{V_2}{V_1} = p_1V_1\ln\frac{\mathbf{p_1}}{\mathbf{p_2}}$$

$$= p_1(\mathbf{mv_1})\ln\frac{p_1}{p_2} = m \times p_1\ v_1 \times \ln\frac{p_1}{p_2}$$

$$W_{1-2} = 1.5 \times 0.1 \times \left(\frac{1}{1.16}\right)\ln\frac{0.1}{0.7}$$

$$\mathbf{W_{1-2} = -0.2516\ MJ}$$

Numericals on Moving Boundary Work

A mass of gas is compressed in a quasi static process from 80 kPa, 0.1m³ to 0.4MPa , 0.03m³. Assuming the P & V are related by up PV^n = constant, determine the work done by the system.

Important Observations

Process is polytropic → PV^n = constant

Data provided

$p_1 = 80\ \text{kPa};\ V_1 = 0.1\ m^3$

$p_2 = 0.4\ \text{MPa};\ V_2 = 0.03\ m^3$

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Solution

1. Determination of polytropic index n

$$p_1 V_1^n = p_2 V_2^n$$

$$\left(\frac{p_1}{p_2}\right) = \left(\frac{V_2}{V_1}\right)^n$$

Taking log on both sides

$$\text{Log}\left(\frac{p_1}{p_2}\right) = n \times \text{Log}\left(\frac{V_2}{V_1}\right)$$

$$\text{Log}\left(\frac{80}{400}\right) = n \times \text{Log}\left(\frac{0.03}{0.1}\right)$$

Solving we get **n = 1.337**

2. Determination of work done

$$W_{1-2} = \frac{p_1 V_1 - p_2 V_2}{n-1} \text{ for a polytropic process}$$

$$W_{1-2} = \frac{(80 \times 0.1) - (400 \times 0.03)}{1.337 - 1}$$

$$\mathbf{W_{1-2} = -11.87\ kJ}$$

THANK YOU

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