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FREE APP CLASS SCHEDULE

MECHANICAL ENGINEERING

GATE

HMT	MONDAY Live @11AM	YOGESH SIR
PRODUCTION	TUESDAY Live @11AM	GAURAV SIR
SOM	WEDNESDAY Live @8PM	MUKESH SIR
THERMODYNAMICS	THURSDAY Live @11AM	KANISTH SIR
ENGINEERING MATHEMATICS	FRIDAY Live @11AM	ANANT SIR

ISRO | BHEL | DRDO & OTHER PSUs

GATE

Thermodynamics

Open System Analysis

MOST EXPECTED QUESTIONS

Live@ 3pm

PART-2

Kanisth sir

The air with enthalpy of 100 kJ/kg is compressed by an air compressor to a pressure and temperature at which its enthalpy becomes 200 kJ/kg. The loss of heat is 40 kJ/kg from the compressor as the air passes through it. Neglecting kinetic and potential energies the power required for an air mass flow of 0.5 kg/s is

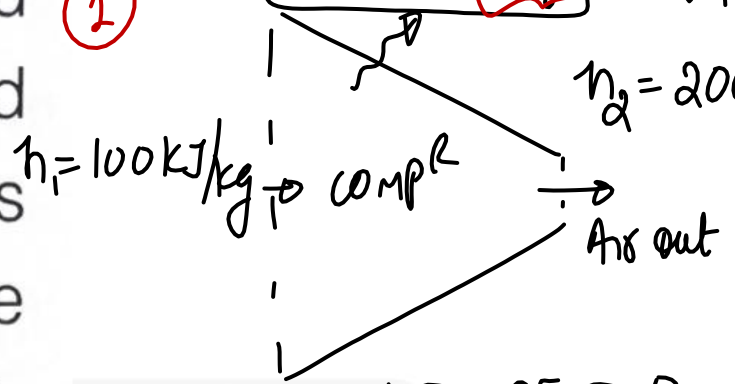
(a) 30 kW (b) 50 kW

(c) 70 kW ✓ (d) 90 kW

[ESE : 2000]

(1)

$q_{out} = 40$ kJ/kg, $\dot{Q}_{out} = q_{out} \times \dot{m} = 40 \times 0.5 = 20$ kJ/sec



$\Delta KE, \Delta PE = 0$

$\dot{m} = 0.5$ kg/s $= \dot{m}_{in} = \dot{m}_{out}$

SFEE

$\dot{E}_{in} = \dot{E}_{out}$

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}\left(h_1 + \frac{V_1^2}{2} + gz_1\right) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}\left(h_2 + \frac{V_2^2}{2} + gz_2\right)$ (kJ/sec)

$\dot{W}_{in} + \dot{m}h_1 = \dot{Q}_{out} + \dot{m}h_2$

$\dot{W}_{in} = 20 + 0.5(200 - 100) = 70$ kW

During steady flow compression process of a gas with mass flow rate of 2 kg/s, increase in specific enthalpy is 15 kJ/kg and decrease in kinetic energy is 2 kJ/kg. The rate of heat rejection to the environment is 3 kW. The power needed to drive the compressor is

(a) 23 kW (b) 26 kW

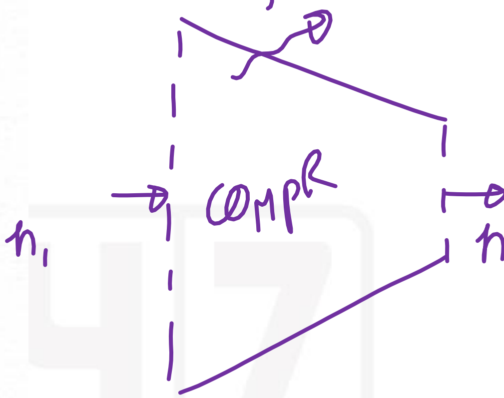
(c) 29 kW (d) 37 kW

[ESE : 2003]

(2) → (c)

$\dot{m} = 2\ kg/s$

$\dot{Q} = 3\ kW$ or $\frac{kJ}{sec}$



$h_2 - h_1 = 15\ \frac{kJ}{kg}$

$\frac{1}{1000}\left(\frac{V_2^2}{2} - \frac{V_1^2}{2}\right) = -2\ \frac{kJ}{kg}$

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}\left(h_1 + \frac{V_1^2}{2} + gz_1\right) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}\left(h_2 + \frac{V_2^2}{2} + gz_2\right)$

$\dot{W}_{in} = \dot{Q}_{out} + \dot{m}(h_2 - h_1) + \dot{m}\left(\frac{V_2^2}{2} - \frac{V_1^2}{2}\right)\frac{1}{1000}$

$= 3 + 2\times15 + 2\times(-2)$

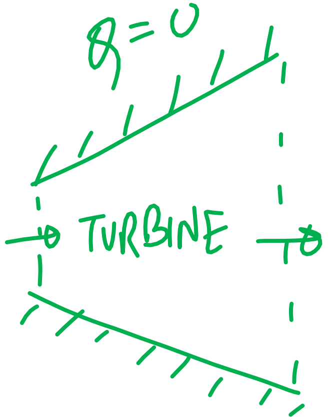
$= 3 + 30 - 4 \Rightarrow 29$

In a steady-flow adiabatic turbine, the changes in the internal energy, enthalpy, kinetic energy and potential energy of the working fluid, from inlet to exit, are –100 kJ/kg, –140 kJ/kg, –10 kJ/kg and 0 kJ/kg respectively. Which one of the following gives the amount of work developed by the turbine?

(a) 100 kJ/kg (b) 110 kJ/kg

(c) 140 kJ/kg (d) 150 kJ/kg

[ESE : 2004]



$\Delta U = u_2 - u_1 = -100$ kJ/kg

$\Delta h = h_2 - h_1 = -140$ kJ/kg

$\Delta KE = \left(\frac{V_2^2}{2} - \frac{V_1^2}{2}\right)\frac{1}{1000} = -10$ kJ/kg

$\Delta PE = 0$

SFEE

$Q_{in} + W_{in} + m\left(h_1 + \frac{V_1^2}{2} + gz_1\right) = Q_{out} + W_{out} + m\left(h_2 + \frac{V_2^2}{2} + gz_2\right)$

$h_1 + \frac{V_1^2}{2000} = W_{out} + h_2 + \frac{V_2^2}{2000}$

$W_{out} = 140 + 10 = 150$ kJ/kg

Which one of the following is the steady flow energy equation for a boiler?

(a) $h_1 + \frac{V_1^2}{2gJ} = h_2 + \frac{V_2^2}{2gJ}$

(b) $Q = h_2 - h_1$

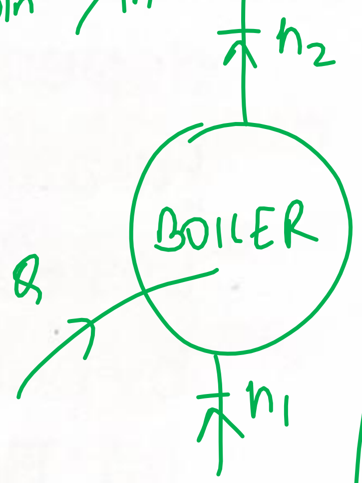
(c) $h_1 + \frac{V_1^2}{2gJ} + Q = h_2 + \frac{V_2^2}{2gJ}$

(d) $W_s = (h_2 - h_1) + Q$

[ESE : 2005]

SFEE

$\dot{E}_{in} = \dot{E}_{out}$



$Q = h_2 - h_1$

$\dot{Q}_{in} = \dot{m}(h_2 - h_1)$ kJ/sec

$Q = h_2 - h_1$ kJ/kg

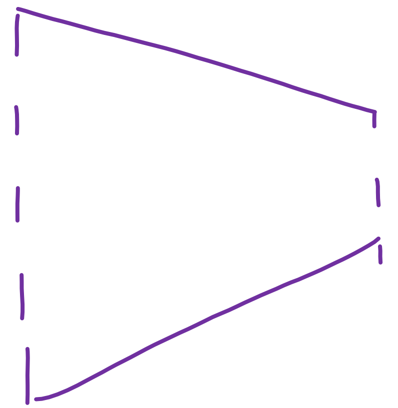
The enthalpy drop for flow through convergent horizontal nozzles is 100 kJ/kg. If the velocity of approach at inlet to the nozzle is negligible, the exit velocity of the fluid is

(a) 20 m/s (b) 400 m/s

(c) 447.2 m/s (d) 520.8 m/s

[ESE : 2012]

5 → C



$h_1 - h_2 = 100$ kJ/kg

SFEE

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}\left(h_1 + \frac{v_1^2}{2} + gz_1\right) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}\left(h_2 + \frac{v_2^2}{2} + gz_2\right)$

$h_1 + \frac{v_1^2}{2000} = h_2 + \frac{v_2^2}{2000}$

$\sqrt{16} = 4$

$\sqrt{20}$

$100 \times 2000 = v_2^2$

$v_2 = \sqrt{200000}$

$= 100$

Which of the following statements are correct for a throttling process ?

1. It is an adiabatic steady flow process ✓
2. The enthalpy before and after throttling is same ✓
3. In the process, due to fall in pressure, the fluid velocity at outlet is always more than inlet velocity ✗

(a) 1 and 2 only ✓ (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

[ESE : 2016]

(b) → (a)

JOULE THOMSON EXP

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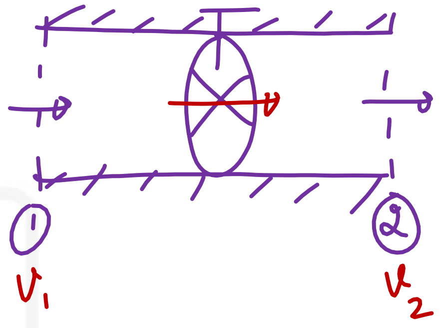
$h_1 = h_2$ ***

REV & IRRE



7

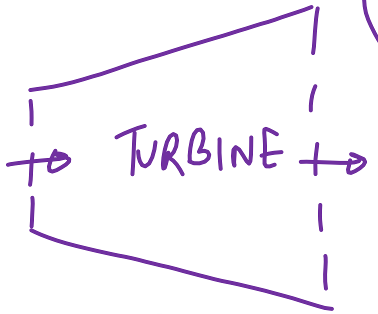
In a steam turbine with steam flow rate of 1 kg/s, inlet velocity of steam of 100 m/s, exit velocity of steam of 150 m/s, enthalpy at inlet of 2900 kJ/kg, enthalpy at outlet of 1600 kJ/kg, the power available from the turbine will be nearly

(a) 1575.5 kW (b) 1481.6 kW

(c) 1387.7 kW (d) 1293.8 kW

[ESE : 2019]

$\frac{V_2^2}{2000} - \frac{V_1^2}{2000} \Rightarrow 625$



SFEE

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}\left(h_1 + \frac{V_1^2}{2000} + gz_1\right) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}\left(h_2 + \frac{V_2^2}{2000} + gz_2\right)$

$h_1 + \frac{V_1^2}{2000} = \dot{W}_{out} + h_2 + \frac{V_2^2}{2000}$

$\dot{W}_{out} = 2900 - 1600 - \frac{150^2 - 100^2}{2000}$

$= 1300 - 625$

In an isentropic flow through a nozzle, air flows at the rate of 600 kg/hr. At inlet to nozzle, the pressure is 2 MPa and the temperature is 127 °C. The exit pressure is of 0.5 MPa. If the initial velocity of air is 300 m/s, the exit velocity will be

(a) 867 m/s (b) 776 m/s

(c) 685 m/s (d) 594 m/s

[ESE : 2019]

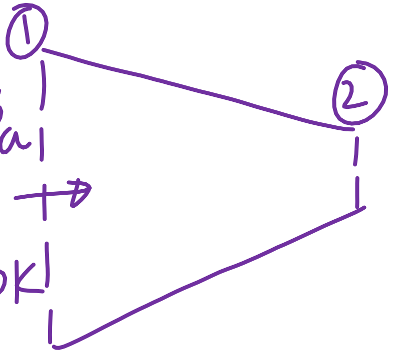
(8) $P_1 = 2$ MPa $= 2000$ kPa

Air

$T_1 = 127 + 273 = 400$ K

$\dot{m} = \frac{600}{3600} \frac{kg}{sec} = \frac{1}{6} \frac{kg}{sec}$

$v_1 = 300$ m/s



$P_2 = 500$ kPa

$v_2 = ?$

ISENTROPIC FLOW $\Rightarrow \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

$T_2 = \left(\frac{500}{2000}\right)^{0.4/1.4} = \left(\frac{1}{4}\right)^{2/7} = \left(\frac{1}{16}\right)^{1/7}$

$h_1 + \frac{v_1^2}{2000} = h_2 + \frac{v_2^2}{2000}$

$C_p(T_1 - T_2) + \frac{v_1^2}{2000} = \frac{v_2^2}{2000}$

$1005(400 - \quad)$

$v_2 =$

Consider the following statements:

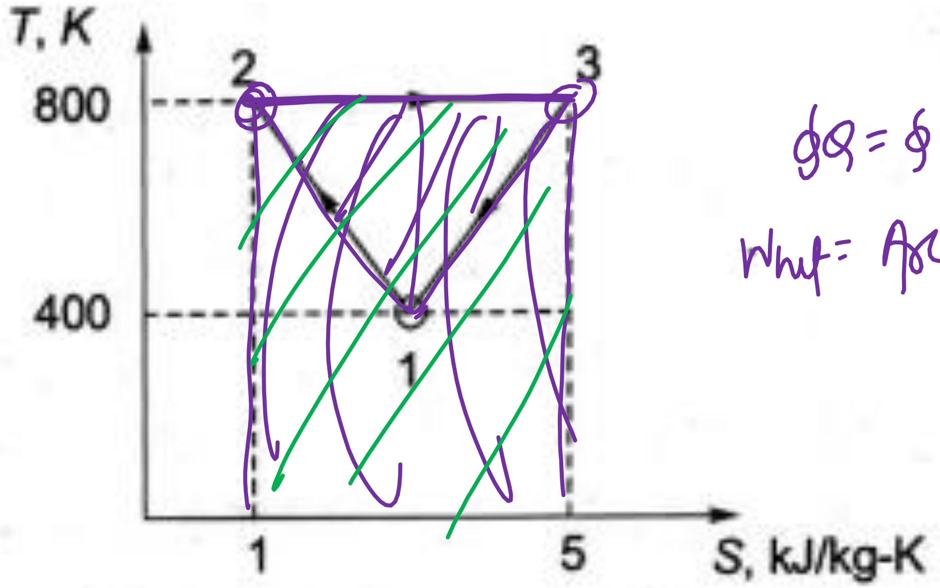
1. Zeroth law of thermodynamics is related to temperature.
2. Entropy is related to first law of thermodynamics.
3. Internal energy of an ideal gas is a function of temperature and pressure.
4. Van der Waals equation is related to an ideal gas.

Which of thes statements is/are correct?

(a) 1 only
(b) 2, 3 and 4
(c) 1 and 3
(d) 2 and 4

[ESE : 2003]

9 → a



10

The thermal efficiency of the hypothetical heat engine cycle shown in the given figure is

(a) 0.5 (b) 0.45

(c) 0.35 (d) 0.25

[CSE-Pre : 2000]

$\oint Q = \oint W =$

$W_{net} = \text{Area} = \frac{1}{2}(800-400)(5-1)$

$= 400 \times 2$

$= 800$

$\eta = \frac{W_{net}}{Q_s} = \frac{800}{800 \times 4}$

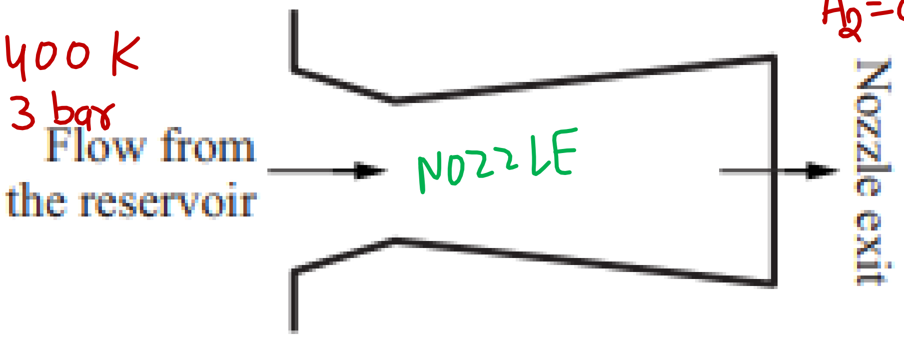
$= 0.25$ (d)

11.

The temperature and pressure of air in a large reservoir are 400 K and 3 bar respectively. A converging diverging nozzle of exit area 0.005 m^2 is fitted to the reservoir as shown in the figure. The static pressure of air at the exit section for isentropic flow through the nozzle is 50 kPa. The characteristic gas constant and the ratio of specific heats of air are 0.287 kJ/kg K and 1.4 respectively.

$T_1 = 400$ K

$P_1 = 3$ bar



$A_2 = 0.005\ m^2$

$P_2 = 50$ kPa

$\rho_2 = ?$

$\dot{m} = ?$ $= \rho_1 A_1 v_1 = \rho_2 A_2 v_2$

$PV = mRT$

$P_2 = \rho_2 R T_2$

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow T_2 = 400\left(\frac{50}{300}\right)^{\frac{1.4-1}{1.4}}$

$T_2 = 239.7$ K

$\rho_2 = \frac{50}{0.287 \times 239.7} \Rightarrow 0.727$ kg/m^3

$h_1 + \frac{v_1^2}{2000} = h_2 + \frac{v_2^2}{2000}$ ($v_1 \to 0$)

$\sqrt{c_p(T_1 - T_2) \times 2000} = v_2$

$v_2 = \sqrt{1.005 \times (400 - 239.7) \times 2000}$

$\Rightarrow 567.56$ m/s

$= 0.727 \times 0.005 \times 567.56$

$\Rightarrow 0.206$ kg/s

The density of air in kg/m^3 at the nozzle exit is (11) **[2 Marks]**

(A) 0.560 (B) 0.600

(C) 0.727 (D) 0.800

The mass flow rate of air through the nozzle kg/s is (12) **[2 Marks]**

(A) 1.30 (B) 1.77

(C) 1.85 (D) 2.06

In free expansion of a gas between two equilibrium states, the work transfer involved

(a) can be calculated by joining the two states on p-v coordinates by any path and estimating the area below

(b) can be calculated by joining the two states by a quasistatic path and then finding the area below

(c) is zero ✓

(d) is equal to heat generated by friction during expansion

Q. Internal energy of system containing perfect gas depends on

(13)

(a) Pressure only

(b) Temperature only ✓

(c) Pressure and temperature

(d) Pressure temperature and specific heat

$\Delta U = m C_v \Delta T$

Q. Which of the following equations is incorrect? (where V,P,T and Q are volume, pressure, temperature and heat transfer respectively)

(a) $\oint dV = 0$

(b) $\oint dP = 0$

(c) $\oint dT = 0$

(d) $\oint dQ = 0$

14 → d

Q. A polytropic process with n = –1, initiates with P = V = 0 and ends with P = 600 kPa and V = 0.01 m3. The work done is

(a) 2 kJ

(b) 3 kJ ✓

(c) 4 kJ

(d) 6 kJ

15 → b

$$W_{poly} = \frac{P_1V_1 - P_2V_2}{n-1}$$

$$= \frac{0\times0 - 600\times 01}{-1-1}$$

$$= \frac{6}{2} = \underline{\underline{3}}$$

Q. For an ideal gas, enthalpy is represented by

(a) H = U – RT

(b) H = U + RT ✓

(c) H = RT – U

(d) H = –(U + RT)

16 → b

H = U + PV

PV = RT

H = U + RT

Q. Certain quantities cannot be located on the graph by a point but are given by the area under the curve corresponding to the process. These quantities in concepts of thermodynamics are called as

(a) cyclic functions

(b) point functions

(c) path functions ✓

(d) real functions

17 → C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