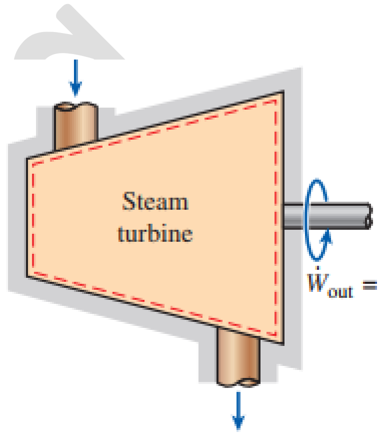
H.W1/ A steam turbine receives a steam flow of 1.35 kg/s and delivers 500 KW. The heat loss from casing is negligible. Calculate

1) the change of specific enthalpy across turbine when the velocities at entrance and exit and the difference in elevation are negligible.
2) the change of specific enthalpy across the turbine when the velocity at entrance is 60 m/s, the velocity at exit is 360 m/s and the inlet pipe is 3m above the exhaust pipe.

Solution



1)

Assumptions

1. Neglect heat transfer a cross boundary Q=0
2. Neglect the variation in potential energy
3. Neglect the variation in kinetic energy

Applied these assumptions on SFEE we get

$$\dot{Q} - \dot{W} = \dot{m}\left[h_2 - h_1 + \frac{V_2{}^2 - V_1{}^2}{2} + g(Z_2 - Z_1)\right]$$

$$\dot{W} = \dot{m}\,[h_1 - h_2]$$

$$\Delta h = \frac{-500}{1.35} = -3704\ \frac{KJ}{Kg}$$

2)

Assumptions

1. Neglect heat transfer a cross boundary Q=0

Applied these assumptions on SFEE we get

$$\dot{Q} - \dot{W} = \dot{m}\left[h_2 - h_1 + \frac{V_2{}^2 - V_1{}^2}{2} + g(Z_2 - Z_1)\right]$$

$$-\dot{W} = \dot{m}\left[h_2 - h_1 + \frac{V_2{}^2 - V_1{}^2}{2} + g(Z_2 - Z_1)\right]$$

$$\Delta h = \frac{-\dot{W} - \dot{m}\left[\frac{V_2{}^2 - V_1{}^2}{2} + g(Z_2 - Z_1)\right]}{\dot{m}} = \frac{-5000000 - 1.35\left[\frac{30^2 - 60^2}{2} + 9.81(3-0)\right]}{1.35} = -3705.024\ \frac{KJ}{Kg}$$

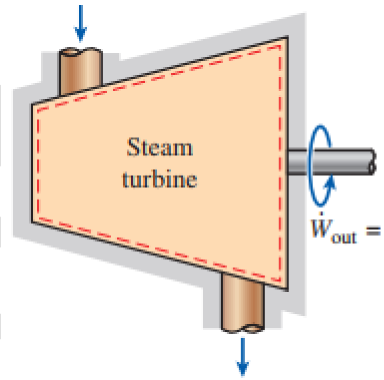
H.W2/ in the turbine of a gas turbine unit, the gases flow through the turbine at 17 kg/s and the power developed by the turbine is 14000 KW. The enthalpies of the gases at inlet and outlet are 1200 kJ/kg and 360 kJ/kg respectively, and the velocities of the gases at inlet and outlet are 60 m/s and 150 m/s respectively. Calculate the rate at which heat is rejected from the turbine. Find also the area of the inlet pipe given that the specific volume of the gases at inlet is 0.5 m^3/kg.

SOLUTION

Assumptions

1. Neglect the variation in potential energy

Applied these assumptions on SFEE we get



$$\dot{Q} - \dot{W} = \dot{m}\left[h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} + g(Z_2 - Z_1)\right]$$

$$\dot{Q} - 14000000 = 17\left[360 - 1200 + \frac{150^2 - 60^2}{2}\right] = 119.85\ KW$$

$$\dot{m} = \frac{V_1 A_1}{v_1} \qquad A_1 = \frac{V_1 \dot{m}}{v_1} = \frac{60 \times 17}{0.5} = 0.142 m^2$$

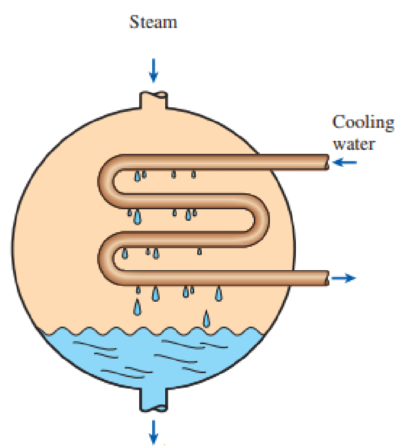
H.W3/ A steady flow of steam enters a condenser with an enthalpy of 2300 kJ/kg and a velocity of 350 m/s. The condensate leaves the condenser with an enthalpy of 160 kJ/kg and a velocity of 70 m/s. find the heat transfer to the cooling water per kilogram of steam condensed.

Solution

Assumptions

1. Neglect the variation in potential energy

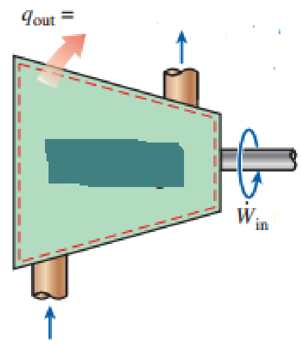
Applied these assumptions on SFEE we get



$$q - W = \left[h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} + g(Z_2 - Z_1)\right] \qquad \textbf{(KJ/Kg)}$$

$$q = \left[160 - 2300 + \frac{70^2 - 350^2}{2}\right] = -60.940\ KJ/Kg$$

H.W4/ In an air compressor the compression takes place at a constant internal energy 50 KJ and heat rejected to the cooling water for every kilogram of air are negligible. Find the work required for the compression.



Assumptions

1. Neglect heat transfer a cross boundary Q=0
2. Neglect the variation in potential energy
3. Neglect the variation in kinetic energy

Applied these assumptions on SFEE we get

Q-W=ΔU

W= ΔU = -50 KJ/Kg

H.W5/ A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3026 kJ/kg and the velocity is 60 m/s. At the exit from the nozzle the enthalpy is 2790 kJ/kg. The nozzle is horizontal and there is negligible heat loss from the turbine.

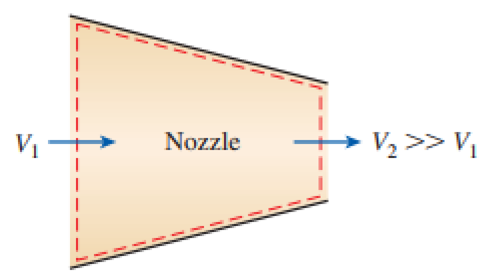
(a) Find the velocity at the nozzle exists.

(b) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.19 m^3/kg, find the mass flow rate.

(c) If the specific volume at the nozzle exit is 0.5 m^3/kg, find the exit area of the nozzle.

Solution

A)



Assumptions

1. Neglect the variation in potential energy

Applied these assumptions on SFEE we get

$$\dot{Q} - \dot{W} = \left[h_2 - h_1 + \frac{V_2{}^2 - V_1{}^2}{2} + g(Z_2 - Z_1)\right]$$

$$0 = \left[h_2 - h_1 + \frac{V_2{}^2 - V_1{}^2}{2}\right]$$

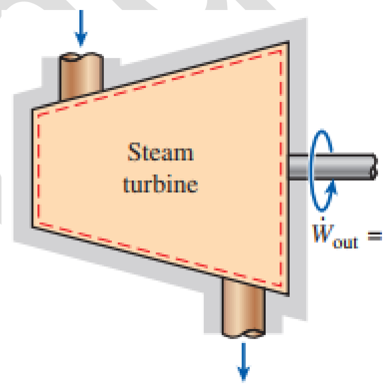
$$V_2{}^2 = 2\left[h_1 - h_2 + \frac{V_1{}^2}{2}\right] = 3026 - 2790 + \frac{60^2}{2} = 4072$$

$$V_2 = 63.81\ m/s$$

b) $\dot{m} = \frac{V_1 A_1}{v_1} = \frac{60 \times 0.001}{0.19} = 0.3157\ Kg/s$

c) $A_2 = \frac{V_2 \dot{m}}{v_2} = \frac{63.81 \times 0.3157}{0.5} = 40.289\ m^2$

H.W6/ A turbine operating under steady flow conditions receives steam at the following state. Pressure 13.8 bar, specific volume 0.143 m^3/kg, internal energy 2590 kJ/kg, and velocity 30 m/s. The state of the steam leaving the turbine is pressure 0.35 bar, specific volume 4.37 m^3/kg, internal energy 2360 kJ/kg, velocity 90 m/s. Heat is lost to the surroundings at the rate of 0.25 kJ/s. If the rate of steam flow is 0.38 kg/s, what is the power developed by the turbine?



Assumptions

1. Neglect the variation in potential energy

Applied these assumptions on SFEE we get

$$\dot{Q} - \dot{W} = \dot{m}\left[h_2 - h_1 + \frac{V_2{}^2 - V_1{}^2}{2} + g(Z_2 - Z_1)\right]$$

$$\dot{Q} - \dot{W} = \dot{m}\left[h_1 - h_2 + \frac{V_1{}^2 - V_2{}^2}{2}\right]$$

$$h_1 = u + pv = 2590 + 13.8 \times 10^5 \times 0.143 = 199930\ \frac{J}{Kq}$$

$$h_2 = u + pv = 2360 + 0.35 \times 10^5 \times 4{,}37 = 155310\ \frac{J}{Kq}$$

$$\dot{W} = 250 - 0.38\left[155310 - 199930 + \frac{90^2 - 30^2}{2}\right] = 15837.6\ W = 1.58376\ KW$$