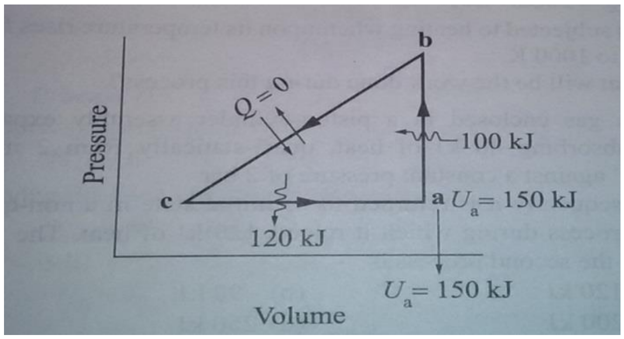
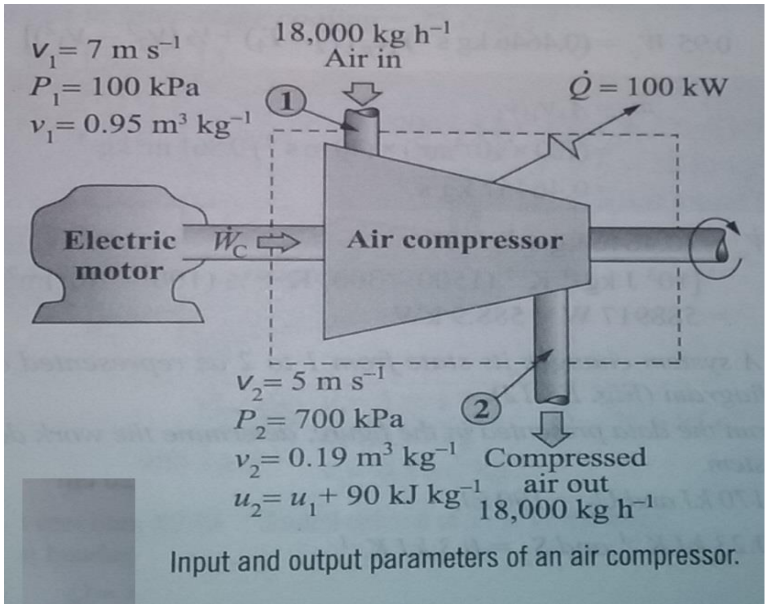
T&HT: Tutorial sheet no.1

1. A gas in a closed system is taken through a cyclic process. First it is heated isochorically ($\Delta V=0$) from state **a** to state **b** whereupon its pressure increases from P_a to P_b (in fig.). Then it is compressed adiabatically (process **bc**) to its initial pressure P_a. Finally it is allowed to expand isobarically from state **c** to state **a**.
   Process **ab**: heat absorption of 100kJ
   Process **bc** : work done on the gas = 70kJ
   Process **ca** : heat rejection of 120 kJ
   U_a= 150kJ
   Determine: (1) U_b (2) U_c (3)W_{ca}

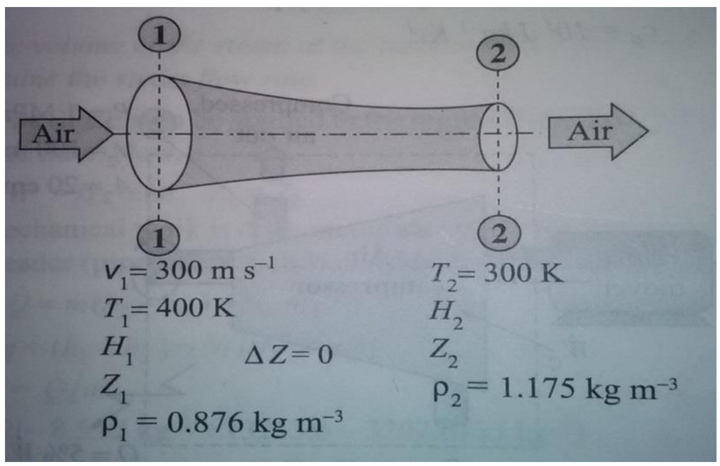


2. An air compressor compresses air from 100kPa to 700 kPa whereupon the internal energy of air is increased by 90kJkg^{-1}. The jacket cooling water extract s 100kW of heat developed due to the compression (fig.)
   Determine
   i. The rate of the shaft work input to the compressor
   ii. The ratio of the inlet to outlet diameter
   Given:
   Air flow rate = 18000 kg h^{-1}
   Air velocity at the inlet = 7 m s^{-1}
   Air velocity at the outlet=5 m s^{-1}
   Specific volume of the air at inlet = 0.95m^{3}kg^{-1}
   Specific volume of the air at outlet= 0.19m^{3}kg^{-1}



Input and output parameters of an air compressor.

3. Air at the rate of 3600 kg h^{-1} is flowing through a converging nozzle(fig.)



Air temperature at inlet = 400 K

Air temperature at outlet = 300 K

Air velocity at the nozzle inlet = 300 m s^{-1}

Specific heat of air at constant pressure = 1kJ kg^{-1} K^{-1}

Determine

i. The exit velocity of the air

ii. Rate of the inlet to exit flow area of the nozzle

4. Air (288K/100kPa) enters the diffuser blades of a jet engine with a velocity of 200 m s^{-1}. Determine

i. The mass flow rate of the air

ii. Temperature of the diffuser-exit air

Given: the diffuser inlet area = 0.4 m^2

Ignore the exit velocity of air with respect to its velocity at the diffuser inlet.

5. A heat engine, a heat pump, and a refrigerator receive 500kJ of heat each. But they reject 250kJ, 600 kJ, and 700 kJ of heat, respectively.

Determine

  i. The efficiency of the heat engine
  ii. The Cop of the heat pump
  iii. The Cop of the refrigerator

6. The Carnot heat engine and a refrigerator are embedded between the same two TERs (i.e., they operate between the same two temperature limits). The efficiency of the heat engine is 50%. Find the COP of the refrigerator.
7. A reversible heat engine receives 50% of its intake heat from a thermal reservoir at 1000 K, 25% of intake heat from the reservoir at 750 K. and the balance amount from another reservoir at 500 k. it discharges 40% of its rejected heat to a sink at 275 K and the balance amount to another sink at 250 K. determine the maximum possible efficiency this heat engine may register.
8. Equal quantities of the same gas enclosed in an adiabatic container are separated by a partition wall. They are at different temperatures T_1 and T_2, respectively ($T_1>T_2$). The partition is suddenly removed and the system is allowed to attain equilibrium. show that $1/2\,(T_1+T_2) > T_1T_2$
9. There is a heat source at 1000 K. it loses 2 MJ of heat to a sink at (a) 500 K (b) 750 K
   Determine
   i. Which heat transfer process is more irreversible
   ii. Entropy generation in each case.
10. Steam at 5 MPa/450°C enters a steam turbine, expands over the blades, and then leaves as turbine exhaust at 1.4 MPa. Determine the work output of the turbine per unit mass of steam assuming the system is adiabatic and internally reversible.
11. A reversible heat engine is embedded into the two heat sources –one is a finite body at 900 K and the other is a heat reservoir at 300 K. the HE operates in a cycle and produces a mechanical work output of 200 kJ kg^{-1}.
   The heat capacity of the body = 1.048 kJ kg^{-1} K^{-1}
   Determine
   i. Δs_{body}
   ii. Δs_{HE}
   iii. Δs_{TER}
   iv. The maximum work that can be available from the heat engine

   Comment : whether the process is reversible or irreversible