2NE3 October 18 Quiz 5 solution.

1. [12 marks] A well-insulated large steam turbine receives steam at 4.5MPa and 400 C and the exit condition is measured to be 20 C with quality of 0.9.
2. Indicate the specific work output of the turbine [kJ/kg]
3. Indicate the specific work if the inlet condition was 4.5MPa and 400 C but the outlet condition was changed to be 20 C with quality 1.0. [kJ/kg]
4. Indicate the specific work if the inlet condition was 4.5MPa and 500 C but the outlet condition was changed to be 20 C with quality 1.0. [kJ/kg]
5. Plot all of the above processes on a P-v diagram (you can use dotted lines to indicate the processes between the state points).
6. [12 marks] A well-insulated compressor used as part of an oxygen purification process for a medical supply company takes 0.1kg/s of oxygen from 20C and 100kPa and compresses it to 500kPa and 190C. (You may assume constant specific heats and R = 0.2598 kJ/kgK, Cp=0.918 kJ/kgK and Cv=0.658 kJ/kgK.)
7. Calculate the power in kW needed for the compression of the ideal gas.
8. Calculate the power in kW needed if the exit pressure with 1000kPa at 190C.
9. Sketch the above processes on a P-v diagram (use a dotted line to indicate the process between the state-points).

Solution:

|  |  |
| --- | --- |
| 1. Point 1a – p1a = 4.5 MPa, t1a = 400 ℃, from table A6 h1a=3205.7 kJ/kg   Point 2a – t2a = 20 ℃, x2a = 0.9, from table A4 h2a= hf + x2a×hfg = 83.915 + 0.9 × 2453.5 = 2292.065 kJ/kg  Point 2b – t2b = 20 ℃, x2b = 1.0, from table A4 h2b= hg = 2537.4 kJ/kg  Point 1c – p1c = 4.5 MPa, t1c = 500 ℃, from table A6 h1c=3440.4 kJ/kg   1. For process 1a 🡪 2a: W = h1a - h2a = 3205.7 - 2292.065 = 913.635 kJ/kg 2. For process 1a 🡪 2b: W = h1a - h2b = 3205.7 – 2537.4 = 668.3 kJ/kg 3. For process 1c 🡪 2b: W = h1c - h2b = 3440.4– 2537.4 = 903.0 kJ/kg | 1. Point 1 – t1 = 20 ℃, p1 = 100 kPa   Point 2 – t2 = 190 ℃, p2 = 500 kPa  Point 3 – t3 = 190 ℃, p2 = 1000 kPa  Q – W = m(Δh + Δpe + Δve), where Q = 0, Δpe + Δve = 0  -W = mΔh = mcp(ΔT) 🡪 W = mcp(T1 – T2)   1. For process 1🡪2:   W1-2 = 0.1 × 0.918 × (20 – 190) = -15.606 kW  V2 = RT2 / p2 = 0.2598 × (190 + 273.15) / 500 = 0.24065 m3/kg   1. For process 1🡪3:   Pressure does not effect power out. W1-3 = -15.606 kW  V3 = RT3 / p3 = 0.2598 × (190 + 273.15) / 1000 = 0.12033 m3/kg |