Name:_____

ENGG 311 (Fall 2016)
QUIZ 4

ID:_____

Time Allowed: 30 minutes — 14th November 2016

Steam at 500 lbf in^{-2} and 700°F flows through a pressure reducing valve and steam turbine operating in series. At the valve outlet (corresponding to the turbine inlet) the pressure is 400 lbf in^{-2}, and at the turbine outlet the pressure is 7 lbf in^{-2}. At a steam flow rate of 1 lb/s, the work developed by the turbine is 400 hp, and the heat transfer rates from the valve and turbine are 20 Btu/s and 50 Btu/s respectively. The process is operating at steady state and kinetic and potential energy effects are negligible. Determine:

a) the specific enthalpy of the steam at the valve outlet (Btu/lb),
b) the temperature at the valve outlet (°F),
c) the specific enthalpy of the steam at the turbine outlet (Btu/lb),
and d) the state of the steam at the turbine outlet: if it is superheated determine its temperature (°F), if it is a vapour-liquid mixture determine its temperature (°F) and quality.

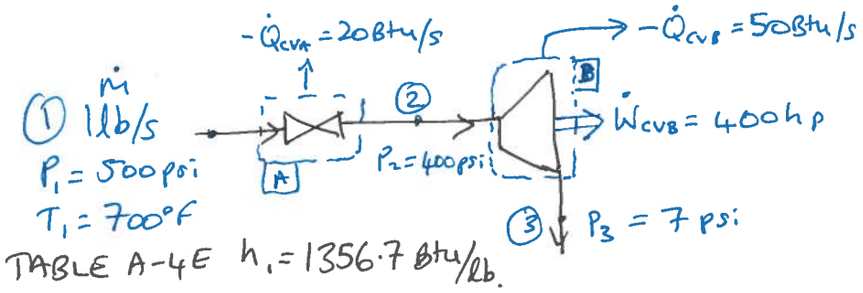

TABLE A-4E $h_1 = 1356.7$ Btu/lb.

(a) 1st LAW, CV A, Steady State KE + PE negligible.

$$\dot{Q}_{CVA} = \dot{m}(h_2 - h_1) \quad \therefore \quad h_2 = h_1 + \frac{\dot{Q}_{CVA}}{\dot{m}}$$

$$h_2 = 1356.7 \frac{\text{Btu}}{\text{lb}} + \frac{-20}{1} \frac{\text{Btu.s}}{\text{s.lb}} = 1336.7 \frac{\text{Btu}}{\text{lb}}$$

(b) TABLE A-4E $P_2 = 400$ psi $\quad T = 600$°F $\; h = 1306.6$ Btu/lb
$T = 700$°F $\; h = 1362.5$ Btu/lb

Interpolation

$$T_2 = \left[600 + \left(\frac{1336.7 - 1306.6}{1362.5 - 1306.6}\right).100\right]°F = 653.8°F$$

(c) 1st LAW C.V. B

$$\dot{Q}_{CVB} - \dot{W}_{CVB} = \dot{m}(h_3 - h_2)$$

$$\therefore h_3 = h_2 + \frac{(\dot{Q}_{CVB} - \dot{W}_{CVB})}{\dot{m}}$$

$$\dot{W}_{CVB} = 400\,\text{hp} \cdot \frac{2545}{1\,\text{hp}} \frac{\text{Btu}}{\text{h}} \cdot \frac{1\,\text{h}}{3600\,\text{s}} = 287.78 \text{ Btu/s.}$$

$$\therefore h_3 = \left[1336.7 + \frac{(-50 - 287.78)}{1}\right] \frac{\text{Btu}}{\text{lb}}$$

$$\therefore h_3 = 1003.92 \frac{\text{Btu}}{\text{lb.}}$$

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(d) State (3) $P_3 = 7$ psi $h_3 = 1003.92$ Btu/lb.

TABLE A-3E 7 psi: $h_f = 144.8 \frac{Btu}{lb}$ $h_g = 1136.9$ Btu/lb.

∴ Vapour - Liquid mixture. at $T_{sat} = T_3 = 176.82°F$.

$$x_3 = \frac{h_3 - h_f}{h_{fg}} = \left(\frac{1003.92 - 144.8}{992.1}\right) = 0.8660$$

or 86.6%