ANNOUNCED QUIZ #5 – ME 3030 — Section 001 – Fall 2025

NAME: SOLUTION

This is an open book quiz. You may use a four function calculator. An unsigned honors pledge will result in a zero.

1. A flow of steam enters a compressor as a saturated vapor at 1.5 bar and has its pressure increased to 10 bar. If the compressor is adiabatic and operates in steady-state, determine the minimum power input required to compress the steam in units of kJ per kg of steam flowing, and the exit temperature. You may assume kinetic and potential energy effects are negligible.

GIVEN: H_2O, P_i, P_e, $\dot{Q}=0$, S.S.

FIND: $(\dot{W}/\dot{m})_{min} = ?$; $T_e = ?$

ASSUME: No KE or PE effects

ANALYSIS: C.O.E. for a C.V.

$$\frac{dE}{dt} = \dot{Q} - \dot{W} + \sum_i \dot{m}_i\left(h_i + \frac{V_i^2}{2} + gz_i\right) - \sum_e \dot{m}_e\left(h_e + \frac{V_e^2}{2} + gz_e\right)$$

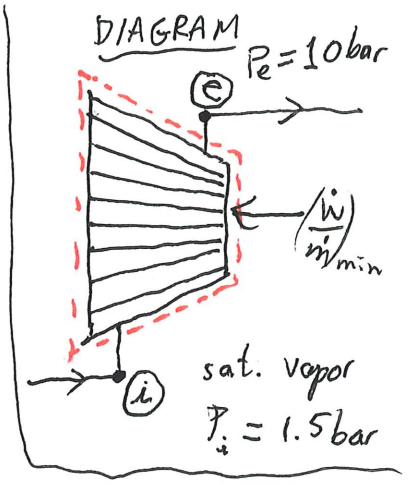
S.S.; adiabatic; No KE or PE effects

$$\dot{m}_i = \dot{m}_e = \dot{m}$$

$$\frac{\dot{W}}{\dot{m}} = h_i - h_e$$

$$h_i = h_g(1.5\,bar) = 2693.6\ kJ/kg$$

DIAGRAM



Entropy balance for a C.V.

$$\frac{dS}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \sum_i \dot{m}_i s_i - \sum_e \dot{m}_e s_e + \dot{\sigma}$$

S.S.; adiabatic; $\dot{\sigma} \to 0$ b/c minimum power will occur for the perfect case, i.e. no irreversibilities.

$$\hookrightarrow s_i = s_e$$

$$s_i = s_g(1.5\,bar) = 7.2233\ \frac{kJ}{kg\cdot K}$$

$$s_e = 7.2233\ \frac{kJ}{kg\cdot K}$$

$$h_e = h(10\,bar,\ 7.2233\ kJ/kg\cdot K)$$

P = 10 bar		
T (°C)	h (kJ/kg)	s (kJ/kg·K)
320	3093.9	7.1962
Te	he	(7.2233)
360	3178.9	7.3349

Interpolating

$$\frac{(7.3349-7.1962)\ kJ/kg\cdot K}{(3178.9-3093.9)\ kJ/kg} = \frac{(7.2233-7.1962)\ kJ/kg\cdot K}{(h_e-3093.9)\ kJ/kg} \rightarrow h_e = 3110.51\ kJ/kg$$

$$\frac{(7.3349-7.1962)\ kJ/kg\cdot K}{(360-320)\ °C} = \frac{(7.2233-7.1962)\ kJ/kg\cdot K}{T_e - 320\,°C} \rightarrow T_e = 328\,°C$$

$T_e = 328\,°C$ ← ANS

$$\frac{\dot{W}}{\dot{m}} = 2693.6\ \frac{kJ}{kg} - 3110.51\ \frac{kJ}{kg}$$

$$\frac{\dot{W}}{\dot{m}} = -416.\ \frac{kJ}{kg}$$

← ANS

I HAVE NEITHER PROVIDED OR RECEIVED HELP DURING THIS QUIZ.

_____

SIGNATURE