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MET 440

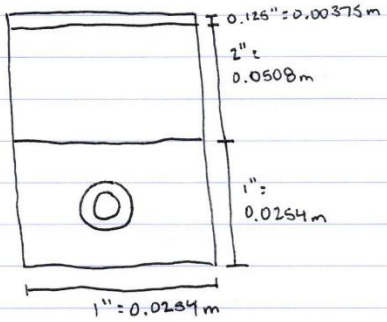
EXAM 1

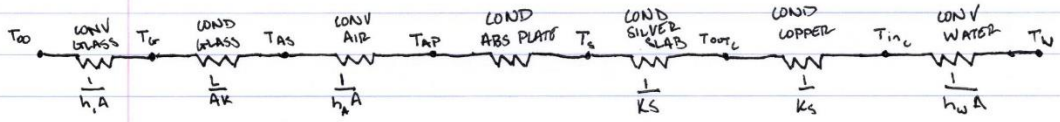
1) PURPOSE: DETERMINE AMOUNT OF HEAT COLLECTED BY WATER IN ONE TUBE, AIR SPACE TEMPERATURE, FLOW RATE, AND COLLECTOR EFFICIENCY

SOURCES: - BAYAZITOGLU, Y., OZISIK, N., "A TEXTBOOK FOR HEAT TRANSFER FUNDAMENTALS, BEGEL HOUSE, INC. (2012)

- CLASS NOTES

DRAWINGS + DIAGRAMS:





DESIGN CONSIDERATION:

- STEADY STATE
- CONSTANT PROPERTIES
- L OF PIPES IS SAME AS SOLAR COLLECTOR
  - ↳ L = 12" OR 0.3048 m
- A IS ASSUMED TO BE $1\ m^2$
- RADIATION PASSES THROUGH TO THE SILVER SLAB

DATA & VARIABLES:

$T_{\infty} = 25°C$

$h_w = 1000\ W/m^2 \cdot K$

$h_a = 10\ W/m^2 \cdot K$

$h_i = 50\ W/m^2 \cdot K$

FROM TABLE APPENDIX

$K_{SILVER} = 418.7\ W/m^2 \cdot °C$

$K_{COPPER} = 387.6\ W/m^2 \cdot °C$

$K_{WATER\ @20°C} = 0.597\ W/m^2 \cdot °C$

$K_{GLASS\ AVG} = 0.78\ W/m^2 \cdot °C$

FROM PROBLEM GIVEN

$C_p = 4179\ J/K_g \cdot °K$

$T_w = 20°C$

$T_o = 45°C$

$\rho_{WATER\ @40°C} = 997\ K_g/m^3$

PROCEDURE:

- FIND SHAPE FACTOR OF SILVER SLAB & COPPER TUBE
- FIND THERMAL RESISTANCES
- FIND TEMPERATURE OF SILVER SLAB
- FIND q_{WATER}
- FIND TEMPERATURE OF AIR SPACE
- FIND FLOW RATE
- FIND COLLECTOR EFFICIENCY

CALCULATIONS:

SILVER SLAB

CASE 6 SHAPE FACTOR (FROM TABLE IN LECTURE NOTES)

$$S = \frac{2\pi L}{\ln(1.08\,w/D)}$$

$$= \frac{2\pi(1)}{\ln(1.08(0.0254)/(0.016875))}$$

$$= 11.4874$$

RESISTANCE OF SILVER SLAB

$$R_{SIL} = \frac{1}{KS}$$

$$= \frac{1}{(11.4874)(418.7)}$$

$$= 0.000208$$

COPPER TUBE

CASE 2 (TABLE 4.2)

$$S = \frac{2\pi H}{\ln(r_0/r_i)}$$

$r_0 = 0.007938\ m$

$r_i = 0.006706\ m$

$$= \frac{2\pi(1)}{\ln(0.007938/0.006706)}$$

$$= 37.2538$$

RESISTANCE OF COPPER TUBE

$$R_{COP} = \frac{1}{KS}$$

$$= \frac{1}{(387.6)(37.2538)}$$

$$= 0.000069$$

RESISTANCE OF GLASS

CONVECTION = $\frac{1}{h_1 A}$

$R_{CONV} = \frac{1}{50(1)} = 0.02$

CONDUCTION = $\frac{L}{KA}$

$R_{COND} = \frac{0.003178}{1(0.78)} = 0.004071$

RESISTANCE OF AIR SPACE

$R_A = \frac{1}{h_2 A}$

$= \frac{1}{10(1)} = 0.1$

RESISTANCE OF WATER

$R_W = \frac{1}{h_w A}$

$= \frac{1}{1000(1)} = 0.001$

90% OF q_T ENTERING SYSTEM = 630 W/m^2

$q_T = q_{WATER} + q_{AIR}$

SOLVING TO FIND TEMPERATURE OF SILVER

$$\frac{T_{SIL} - T_{\infty}}{R_{CONV} + R_{COND} + R_A + R_{SIL}} + \frac{T_{SIL} - T_W}{R_{SIL} + R_{LOP} + R_W} = q_T$$

$$\frac{T_{SIL} - 25}{0.02 + 0.004071 + 0.1 + 0.000208} + \frac{T_{SIL} - 20}{0.000208 + 0.000069 + 0.02575} = 630$$

$T_{SIL} = 33.4948°C$

FIND q_{WATER}

$$q_{WATER} = \frac{T_{SIL} - T_W}{R_{SIL} + R_{COP} + R_W}$$

$$= \frac{33.9948 - 20}{0.000208 + 0.000069 + 0.02375}$$

$$\boxed{q_{WATER} = 561.65 \ W/m^2}$$

FIND TEMPERATURE OF AIR SPACE

$$q_{air} = \frac{T_A - T_\infty}{R_{CONV} + R_{COND} + R_A}$$

$$68.3496 = \frac{T_A - 25}{0.02 + 0.004071 + 0.1}$$

$$\boxed{T_A = 33.5°C}$$

FIND FLOW RATE

$$q = h / (\rho C \Delta T)$$

$$= 1000 / (4179(1000.52)(45-20))$$

$$= \boxed{0.00001 \ m^3/s}$$

COLLECTOR EFFICIENCY

$$\eta = q_{abs} / q_{AVAIL}$$

$$\eta = 561.65 / 700$$

$$= \boxed{80\%}$$

SUMMARY:

$q_{WATER} = 561.65\ W/m^2$

$T_A = 33.5°C$

$Q = 0.00001\ m^3/s$

$\eta = 80\ \%$

ANALYSIS

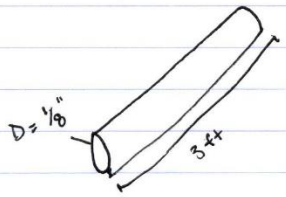
THE HEAT COLLECTED BY THE WATER IS ABOUT 80% OF THE ORIGINAL RADIATION ENTERING THE SYSTEM. THIS IS TRUE AS THE SYSTEM IS A MULTILAYERED SYSTEM. THE AIR SPACE TEMPERATURE IS GREATER THAN THE AMBIENT AS THE SYSTEM REFLECTS 10% OF THE RADIATION.

2)

PURPOSE: DETERMINE CONDUCTIVITY OF BRAZING MATERIAL IF DISTANCE IS 1 FT + TEMPERATURE IS 100°F

SOURCES: BAYAZITOGLU, Y., OZISIK, N., "A TEXTBOOK FOR HEAT TRANSFER FUNDAMENTALS," BETEL HOUSE, INC. (202)

DRAWINGS & DIAGRAMS



DESIGN CONSIDERATION

- STEADY STATE
- CONSTANT PROPERTIES

DATA & VARIABLES

$T_\infty = 80°F = 539.67°R$

$h = 0.9\ BTU/(hr.ft^2.°R)$

$T_o = 1600°F = 2059.67°R$

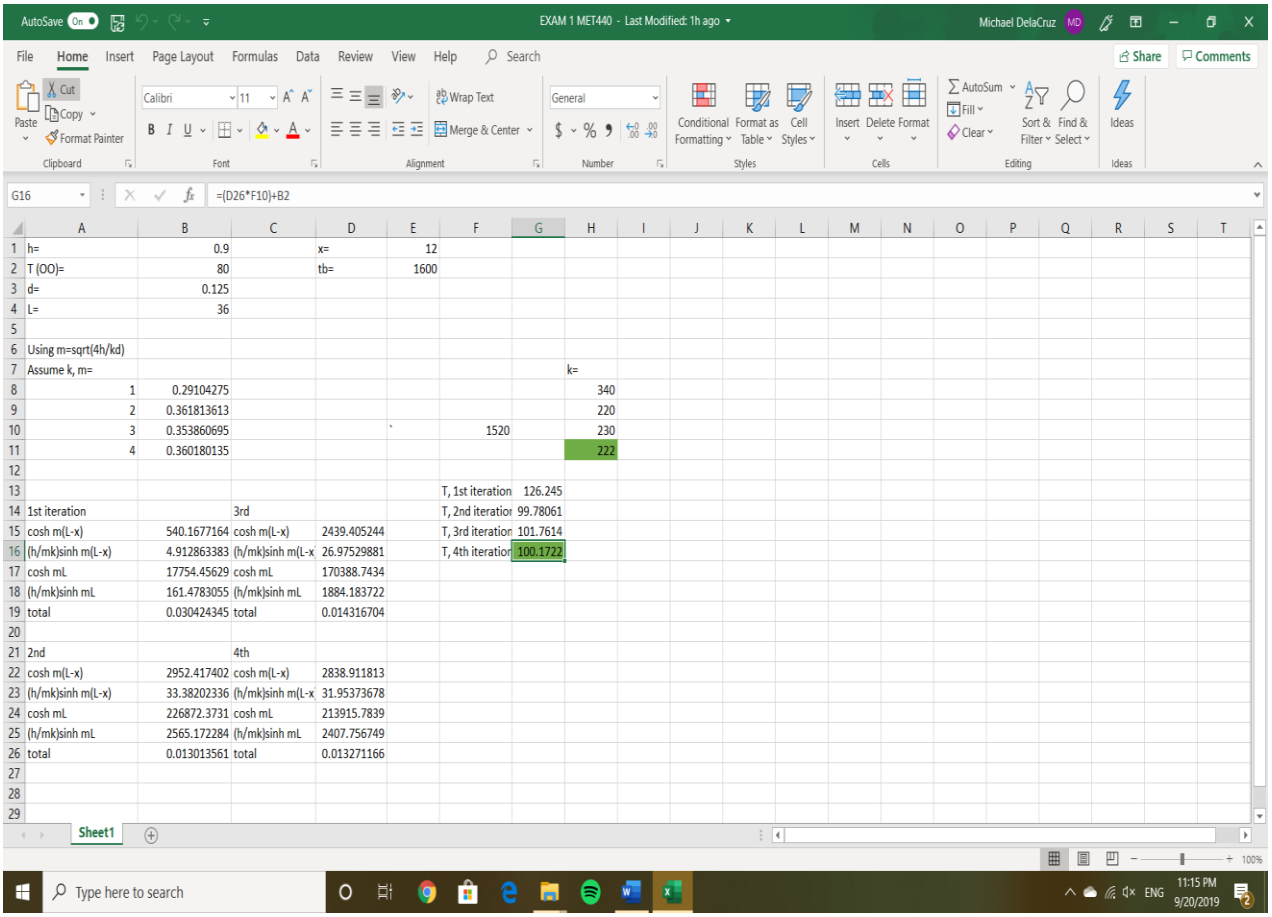
PROCEDURE:

: ASSUME A K VALUE
- USE EQUATION FOR TEMP. DISTRIBUTION CASE A
- ITERATE UNTIL VALUE IS WITHIN 10% OF DESIRED VALUE

CALCULATIONS: DONE ON EXCEL

$\frac{T - T_\infty}{T_o - T_\infty}$ = CASE A EQUATION FOR TEMP. DISTRIBUTION

$\frac{T - 80}{1600 - 80} =$



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	h=	0.9		x=	12															
2	T (OO)=	80		tb=	1600															
3	d=	0.125																		
4	L=	36																		
5																				
6	Using m=sqrt(4h/kd)																			
7	Assume k, m=							k=												
8	1	0.29104275						340												
9	2	0.361813613						220												
10	3	0.353860695				1520		230												
11	4	0.360180135						222												
12																				
13						T, 1st iteration	126.245													
14	1st iteration		3rd			T, 2nd iteratio	99.78061													
15	cosh m(L-x)	540.1677164	cosh m(L-x)	2439.405244		T, 3rd iteration	101.7614													
16	(h/mk)sinh m(L-x)	4.912863383	(h/mk)sinh m(L-x	26.97529881		T, 4th iteration	100.1722													
17	cosh mL	17754.45629	cosh mL	170388.7434																
18	(h/mk)sinh mL	161.4783055	(h/mk)sinh mL	1884.183722																
19	total	0.030424345	total	0.014316704																
20																				
21	2nd		4th																	
22	cosh m(L-x)	2952.417402	cosh m(L-x)	2838.911813																
23	(h/mk)sinh m(L-x)	33.38202336	(h/mk)sinh m(L-x	31.95373678																
24	cosh mL	226872.3731	cosh mL	213915.7839																
25	(h/mk)sinh mL	2565.172284	(h/mk)sinh mL	2407.756749																
26	total	0.013013561	total	0.013271166																
27																				
28																				
29																				

SUMMARY:

$K = 222\ BTU/(hr \cdot ft^2 \cdot °R)$
$= 31.99\ W/m \cdot K$

ANALYSIS:

THE K VALUE FOUND IN THE ITERATIONS FALL IN LINE WITH THE VALUES IN THE BOOK FOR COPPER ALLOY. A HIGH K VALUE MAKES SENSE AS COPPER IS A GOOD CONDUCTOR OF HEAT.