CM3215

Fundamentals of Chemical Engineering Laboratory

Overall Heat Transfer Coefficient for Double-Pipe Heat Exchanger

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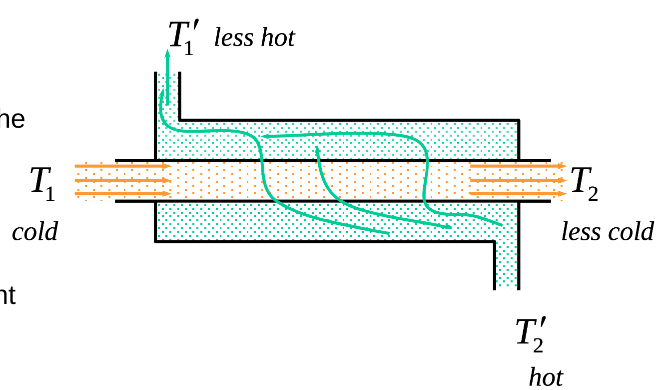
Double-Pipe Heat Exchangers

- Simplest type of heat exchanger
- Total heat transferred proportional to the log-mean temperature difference
- Counter-current shown; co-current also possible



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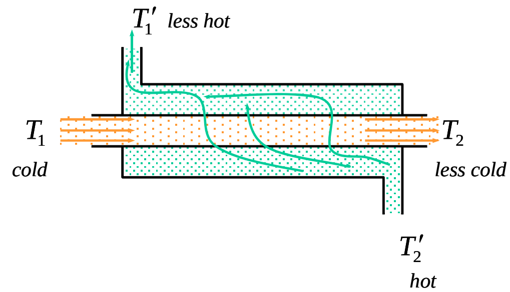
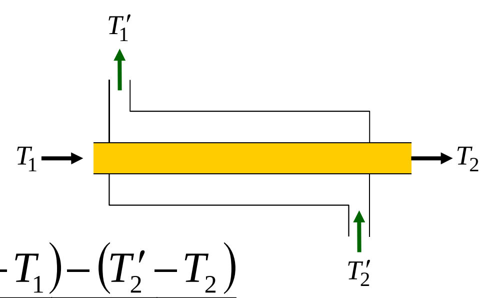
Double-Pipe Heat Exchangers



Steady state macroscopic energy balance on:

- Inside
- Outside
- Overall



Total Heat Transferred given by:

$$Q = U\underbrace{(2\pi RL)}_{\boldsymbol{A}}\underbrace{\frac{(T_1'-T_1)-(T_2'-T_2)}{\ln\dfrac{(T_1'-T_1)}{(T_2'-T_2)}}}_{\equiv \Delta T_{lm}}$$

=log-mean temperature difference

$$U \equiv \frac{Q}{A\Delta T_{lm}}$$

Driving temperature difference at the left side of heat exchanger

Driving temperature difference at the right side of heat exchanger

$$\Delta T_{lm} \equiv \frac{\left(T_1' - T_1\right) - \left(T_2' - T_2\right)}{\ln \dfrac{\left(T_1' - T_1\right)}{\left(T_2' - T_2\right)}}$$

Note: the log-mean average temperature driving force will be a number between these two ΔT's

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From the Equipment Schedule (see website):

8/17/2001
DWC

Department of Chemical Engineering
Michigan Tech University

Equipment Schedule for Fundamentals of CM Laboratory Apparatus

Tag	Location of Device	Comments	Product	Flowrate	Specific Gravity	Temp., deg. F
E-01	Above branched piping circuit	Double-pipe Heat Exchanger, Shell-2"Sched. 40 C.S. pipe, Tube-3/8" o.d. type L copper tubing, 48" long.	City Water/ Steam	5.12 GPM	1	55
P-01	Below bench	3 gpm@71 ft. head, 1 1/4"x1", 120/240 VAC, 1ph., 1/2 hp open drip-proof motor	City Water	5 GPM	1	55
T-01	Below W007 outlet	Tank, 10 gallon, heavy wall PE, 18 3/4"h x 13" o.d.	City Water	5 GPM	1	55
T-02	Below W008 outlet	Tank, 10 gallon, heavy wall PE, 18 3/4"h x 13" o.d.	City Water	5 GPM	1	55

Key to Miscellaneous Identifiers	
PT-##	Pressure Tap
T#	Steam Trap

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We will record data (and first calculations) on the white board in class – be prepared to do so

- Temperatures
- ΔT_{lm}
- Heat flow (steam side)
- Heat flow (water side)
- $U\left(\frac{W}{m^2K}\right)$, water side
- $U\left(\frac{W}{m^2K}\right)$, steam side

Answer the SurveyMonkey to submit your data – be prompt!

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Report 6: Overall Heat Transfer Coefficient for Double-Pipe Heat Exchanger

- Pump water through inner pipe of double-pipe heat exchanger
- Flow steam through outer pipe of double-pipe heat exchanger
- Allow to come to steady state (monitor; prove steady state)
- Measure appropriate temperatures, flow rates and replicates
- Share raw data with classmates; use all data from your lab station
- Calculate and report overall heat transfer coefficient; use two different methods
- Report the process of achieving steady state
- Address all objectives in assignment memo

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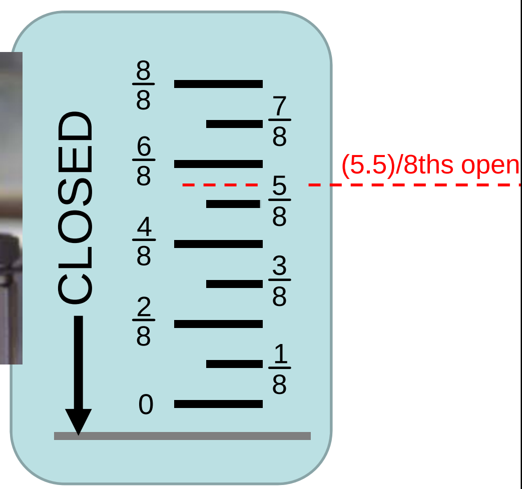
Pneumatic Valve Position

Note: The position of the valve stem is read from a set of notches based on 1/8th distance per notch:

(compare to a 12 inch ruler)

x= fraction open



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Prelab Assignment:

- Review the following: concept of the double-pipe heat exchanger, the overall heat transfer coefficient, logarithmic mean temperature difference and purpose and operation of steam traps.
- Calculate the heat transfer area of the double pipe heat exchanger in the lab. Base your calculation on the outside area of the inside pipe.
- Fit the latent heat of vaporization of steam to a function
- Be prepared to make some trial calculations
- Prepare a safety section