CM3215

Fundamentals of Chemical Engineering Laboratory

Overall Heat Transfer Coefficient for Double-Pipe Heat Exchanger

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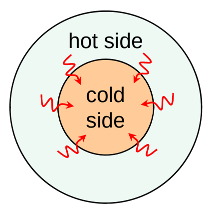
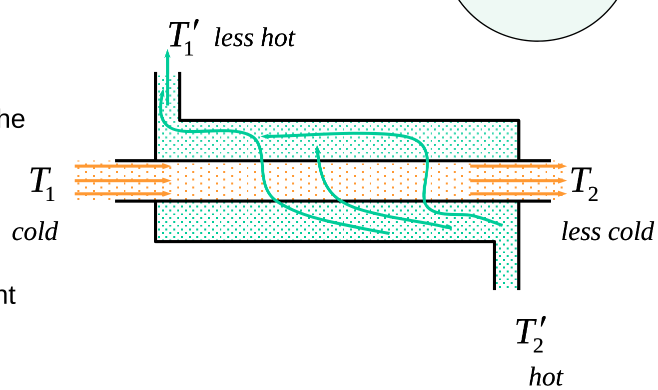
Double-Pipe Heat Exchangers



- 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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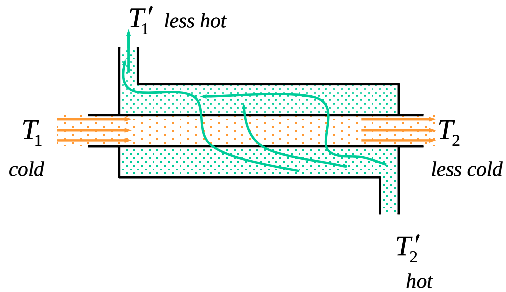
Double-Pipe Heat Exchangers

Steady state macroscopic energy balance on:

- Inside
- Outside
- Overall



Covered in CM3110 Transport Processes I

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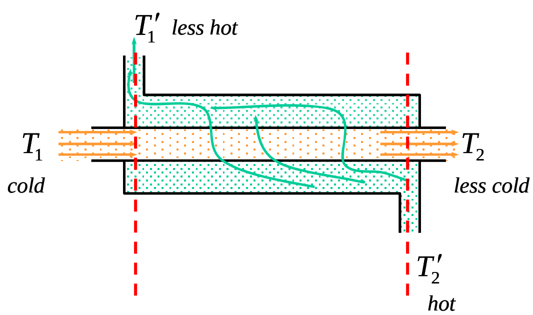
Double-Pipe Heat Exchangers



$\Delta T_{left} = (T_1' - T_1)$

$\Delta T_{right} = (T_2' - T_2)$

- ΔT = ***driving force for heat transfer***
- ΔT **varies down the length** of the heat exchanger (HE)
- Amount of heat transferred varies down the length of the HE

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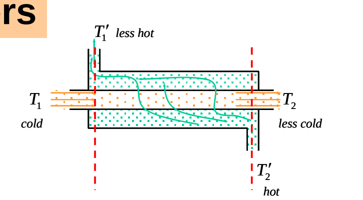

$\Delta T_{left} = (T_1' - T_1)$

$\Delta T_{right} = (T_2' - T_2)$

The **overall heat transferred Q** is governed by the average driving force, $\Delta T_{average}$

The **correct average** driving force (as we show in CM3110) is the **log mean ΔT**

Comes from considering the energy balances)

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Log Mean ΔT Driving Force

The overall heat transferred is governed by **the log mean driving force**

Driving temperature difference at the left side of heat exchanger

Driving temperature difference at the right side of heat exchanger

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

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

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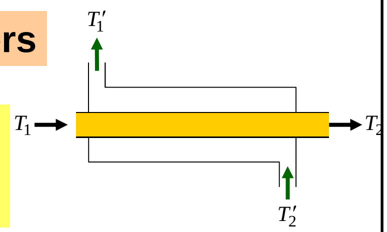
Double-Pipe Heat Exchangers

- **Total Heat Transferred given by Q**
- **The HE is characterized by its overall heat transfer coefficient, U**



$$Q = UA\Delta T_{lm}$$

$$= U(2\pi R_{outer}L)\Delta T_{lm}$$

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

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Where do we get A?

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 (or Google forms) to submit your data – be prompt!

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How do we measure Q?

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

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

Two ways:

- Water side
- Steam side
- Perform *Macroscopic Energy Balances* to obtain Q

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Macro-E-Balance comes from CM2110 and CM2120;

see our handout page for Dr. Morrison's E- Balance Notes: www.chem.mtu.edu/~fmorriso/cm310/Energy_Balance_Notes_2008.pdf

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

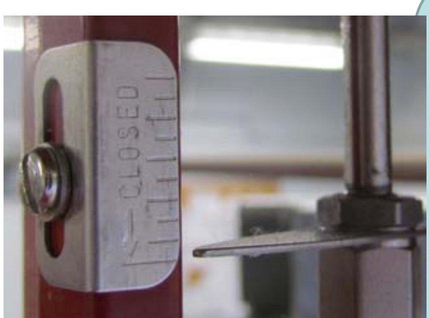
- Pump water through inner pipe of double-pipe heat exchanger
- Flow steam through outer pipe of double-pipe heat exchanger
- Allow to come to steady state (monitor; prove steady state)
- Measure appropriate temperatures, flow rates and replicates
- Share raw data with classmates; use all data from your lab station across 5 lab sections
- Calculate and report **overall heat transfer coefficient**; use two different methods
- Report the process of achieving steady state
- Address all objectives in assignment memo

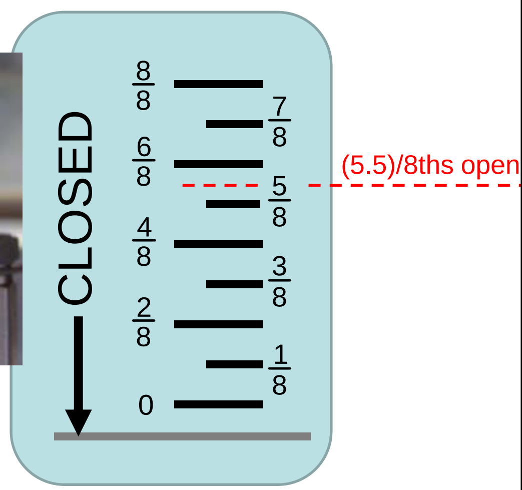
Pneumatic Valve Position

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 over a reasonable temperature range (near atmospheric pressure) to an empirical function
- Be prepared to make some trial calculations
- Prepare a safety section