Mixing
& heat transfer lab

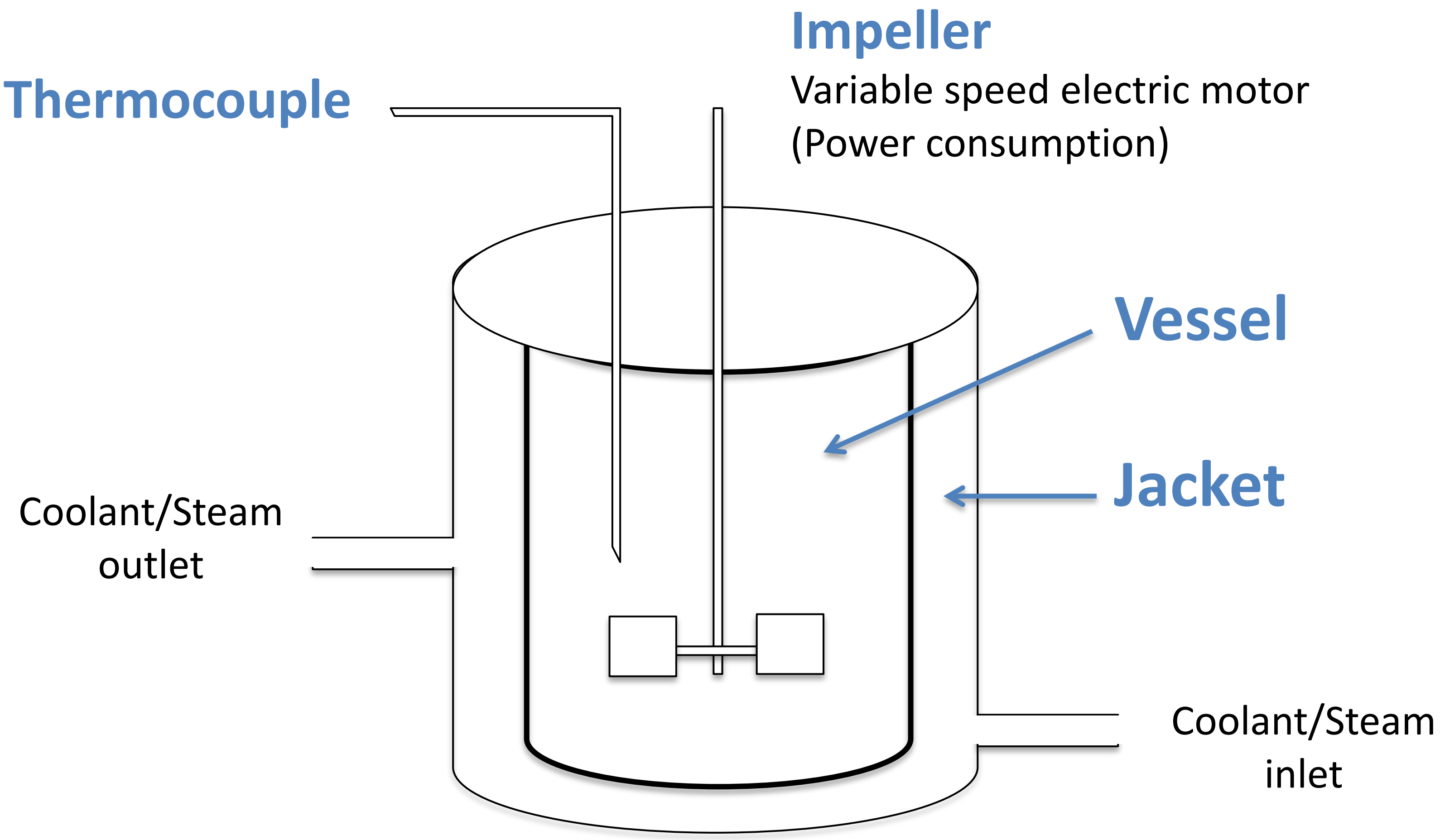
Mixing: Power consumption and Mixing Time

Heat transfer: Come up with your own heat transfer correlation (for your geometry and for your fluid)

Experimental Design

- Find:
  - the Power Consumption, Mixing Time and governing Heat Transfer Equation for heating a non-Newtonian fluid (CMC) using a steam jacketed kettle.
- Vary:
  - Kettle Type
  - Agitator Speed
- Measure:
  - Power (P), Temp vs time, Tank/Impeller Dimensions, Impellor rpm's (N)
- Outside data:
  - basic rheology data determine fluid properties for your non-Newtonian fluid at different temperatures and agitation speeds.
- Learn & Communicate:
  - how mixing time, power consumption, heat transfer depend on the agitator and fluid properties.

Batch Process



Solution: Xanthan Gum 0.5% (non – Newtonian, shear thickening)

Procedure

1. Hook up a Power meter (measure power)
2. Set up a Tachometer (measure rpm)
3. Fill Vessel with xanthan gum solution
4. Set up Thermometer (measure temp)
5. Heat from 30° C – 80°C under agitation
    1. Variables by team. Kettle Type. Agitation Speed.
    2. Measure: Temp vs. time, P, N

-Measure Power consumption:

Different agitation velocities: Different power consumption

Measure: Watts. 1 W = 1 J/s

Energy per unit time

Use energy to obtain Power number

-Measure Agitation speed (rpm) using a Tachometer

http://www.amazon.com/gp/product/B001JHGY2Q/ref=s9_simh_gw_p236_d0_i1?pf_rd_m=ATVPDKIKX0DER&pf_rd_s=center-2&pf_rd_r=1SHA6TVYPZY7XD18EWX8&pf_rd_t=101&pf_rd_p=1688200382

- Overall Heat Transfer

In mind for the prelab

Combined convection and conduction

$q_{overall} = UA\,(T_s - T_f)$

U Accounts for all resistances to transfer

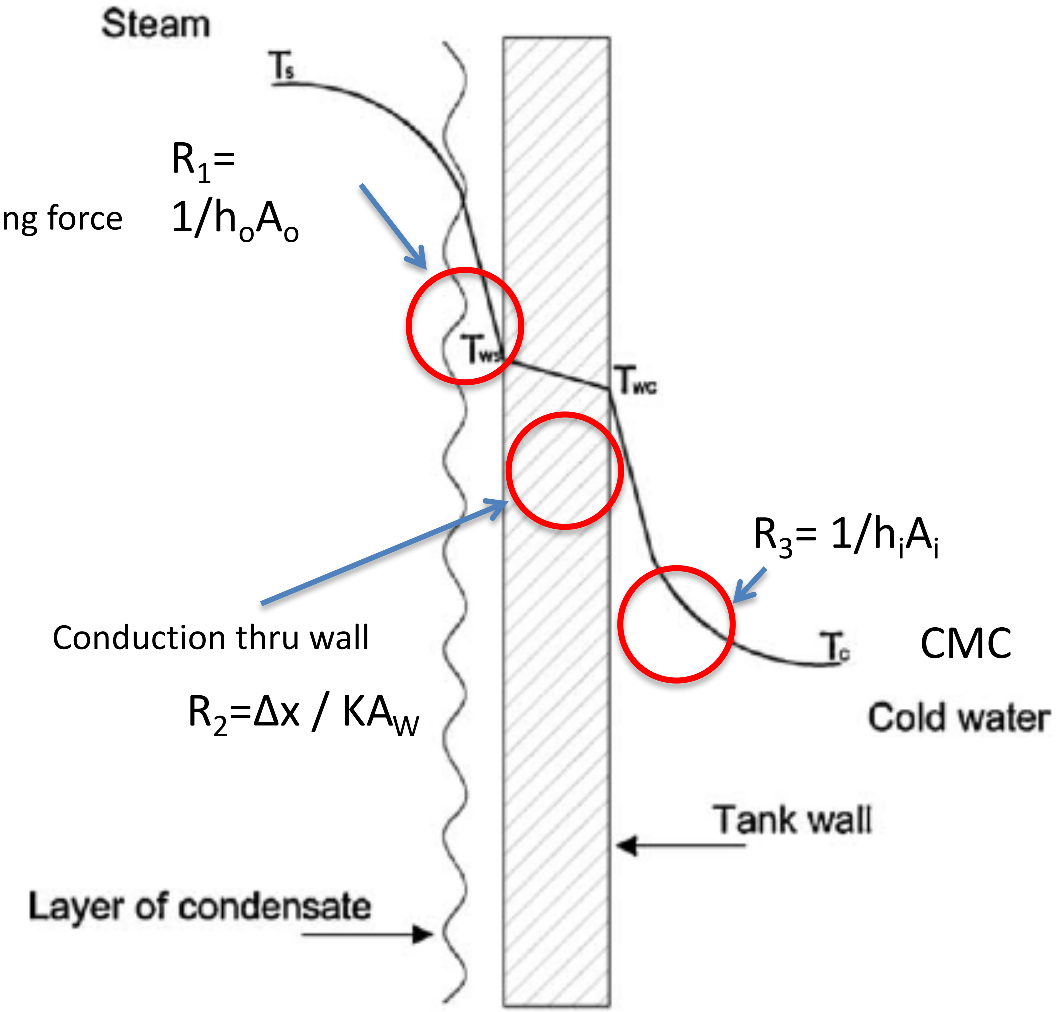
Temp diff = driving force

U: overall heat transfer coefficient

$$\frac{1}{UA} = R_1 + R_2 + R_3$$

3 resistances in our system

- R1 → resistance across steam
- R2 → conduction thru wall
- R3 → resistance across CMC



$R_1 = 1/h_oA_o$

Conduction thru wall

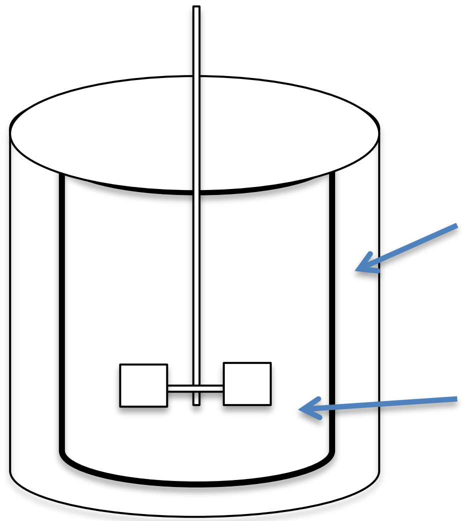
$R_2 = \Delta x / KA_W$

$R_3 = 1/h_iA_i$

CMC

We will ignore conduction through the wall. Assume : thin wall $\Delta x = 0$; $R_2 \rightarrow$

- Heat Transfer



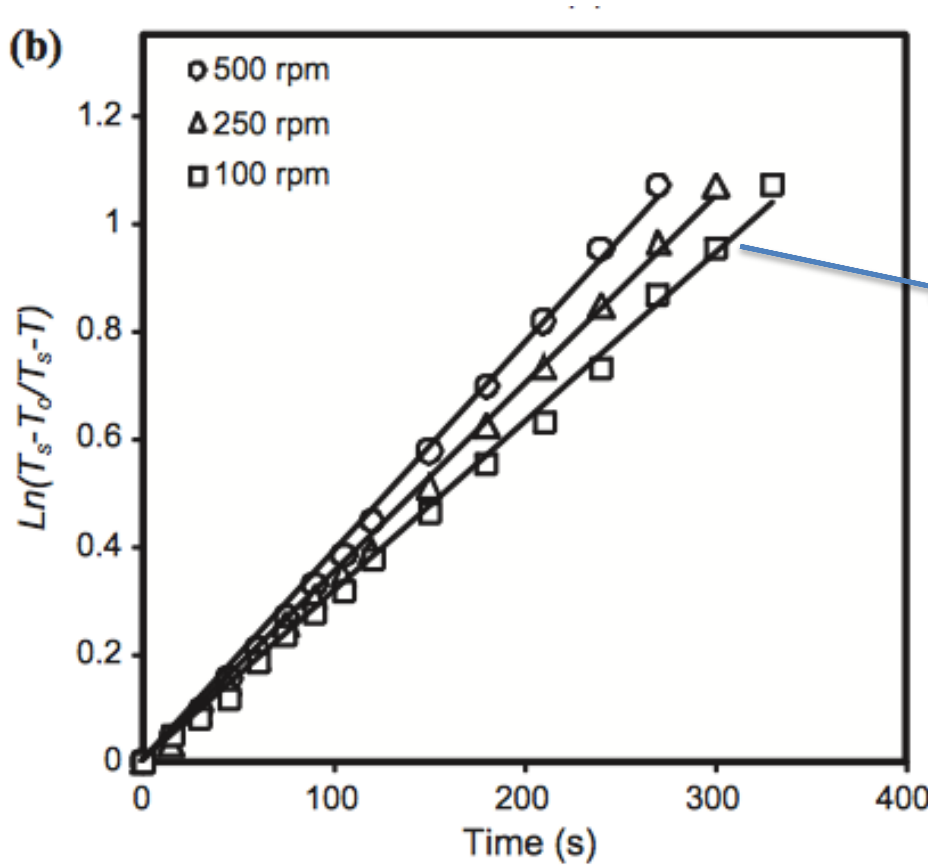
Ts: Saturated steam constant pressure (known T)

Tf: Temperature of the fluid, variable (function of time)

Agitation Speed (rpm)	
Power Consumption (W)	
HEATING	
Steam Pressure	
Temperature (°C)	Time (min:sec)
20	0:00
30	1:20
-	-
80	15:30

5 Different agitation speeds

You will measure T_{fluid} for various time
T_{steam} is known from the measured pressure (20 psi, saturated steam)
T_o is and defined



calculate U from slope:

- Different rpm, give different U

FINALLY,

Come up with your own heat transfer correlation

$$Nu = a * \mathrm{Re}^{b} * \mathrm{Pr}^{c} * Vi^{d}$$

$$\frac{hD}{k} = a * \left(\frac{D_a^2 N \rho}{\mu_a}\right)^{b} * \left(\frac{C_p \mu}{k}\right)^{c} * \left(\frac{\mu}{\mu_o}\right)^{d}$$

c=1/3 and d=0.21

Plot the different h and N, to fit the relationship above and find a and b

WEEK OF Jan 22

VESSEL 1	VESSEL 2
Group 3	Group 4

Prelab due by 5 PM on 01/21

WEEK OF Jan 29

VESSEL 1	VESSEL 2
Group 1	Group 2

Prelab due by 5 PM on 01/28

Same distribution for Monday and Wednesday

Food Science Pilot Plant

NLSN 1135 (rear right of food science building)