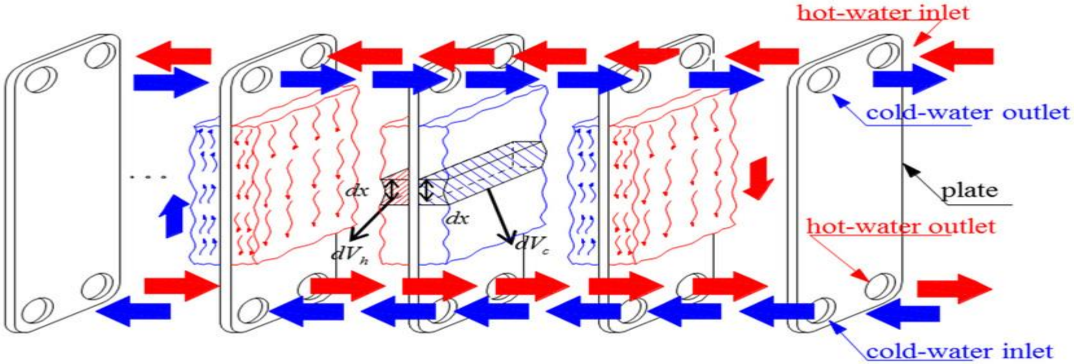
Characterization of a Plate Heat Exchanger



https://www.researchgate.net/figure/Heat-transfer-process-of-the-plate-heat-exchanger-PHE_fig1_319695150

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June 6, 2024

https://wcruk.com/what-is-a-plate-heat-exchanger/

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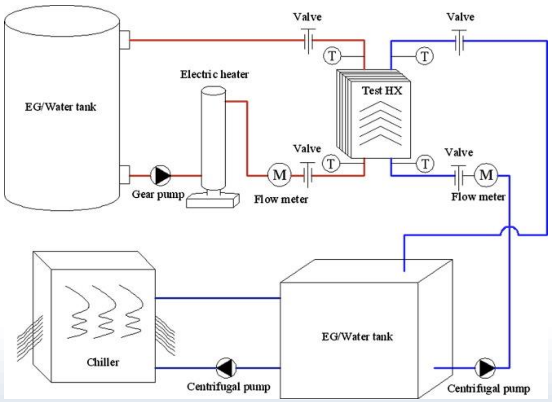
This presentation focuses on characterizing a plate heat exchanger and comparing it to theory

$$Nu = C_1 Re^{C_2} Pr^{\frac{1}{3}} \qquad U_{meas} = \frac{Q}{A_{proj}\Delta T_{LMTD}}$$

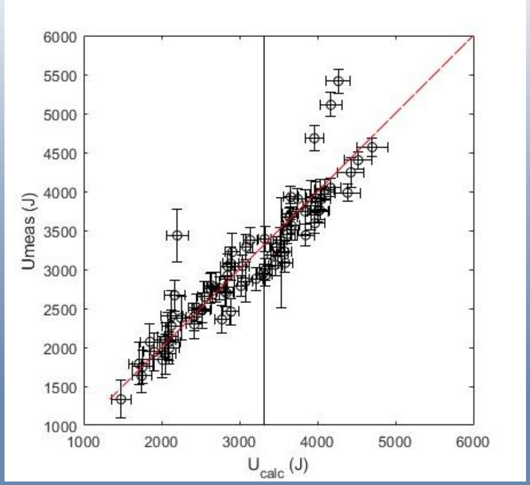
$$Q = \frac{m_h c_h (T_{h,i} - T_{h,o}) - m_c c_c (T_{c,i} - T_{c,o})}{2}$$

$$\frac{1}{A_{proj} h_h} = \frac{1}{A_{proj} U_{calc}} - \frac{t}{A_{proj} k_w} - \frac{1}{A_{proj} h_c}$$

Note relevant heat transfer equations



Record steady state data



Compare real characteristics to theoretical

The Nusselt number characterizes heat transfer of the system

$$experimentally\ found\ (same\ for\ hot\ and\ cold\ fluid)$$

$$Nu = C_1 Re^{C_2} Pr^{\frac{1}{3}}$$

$$\frac{convective\ heat\ transfer}{conductive\ heat\ transfer} = \frac{hL}{k}$$

$$\frac{Momentum\ Diffusivity}{Heat\ Diffusivity} = \frac{C_p \mu}{k}$$

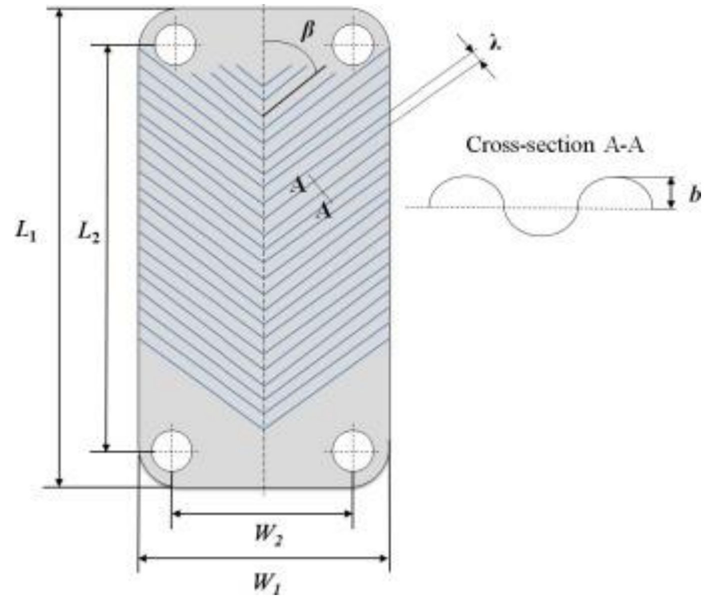
$$\frac{inertial\ forces}{viscous\ forces} = \frac{\rho v L}{\mu}$$

Theoretical and measured overall heat transfer coefficients can be found and compared

Theoretical

$$\frac{1}{A_{proj}h_h} = \frac{1}{A_{proj}U_{calc}} - \frac{t}{A_{proj}k_w} - \frac{1}{A_{proj}h_c}$$

$$A_{proj} = L_2 \times W_1$$



https://doi.org/10.1016/j.applthermaleng.2016.10.147

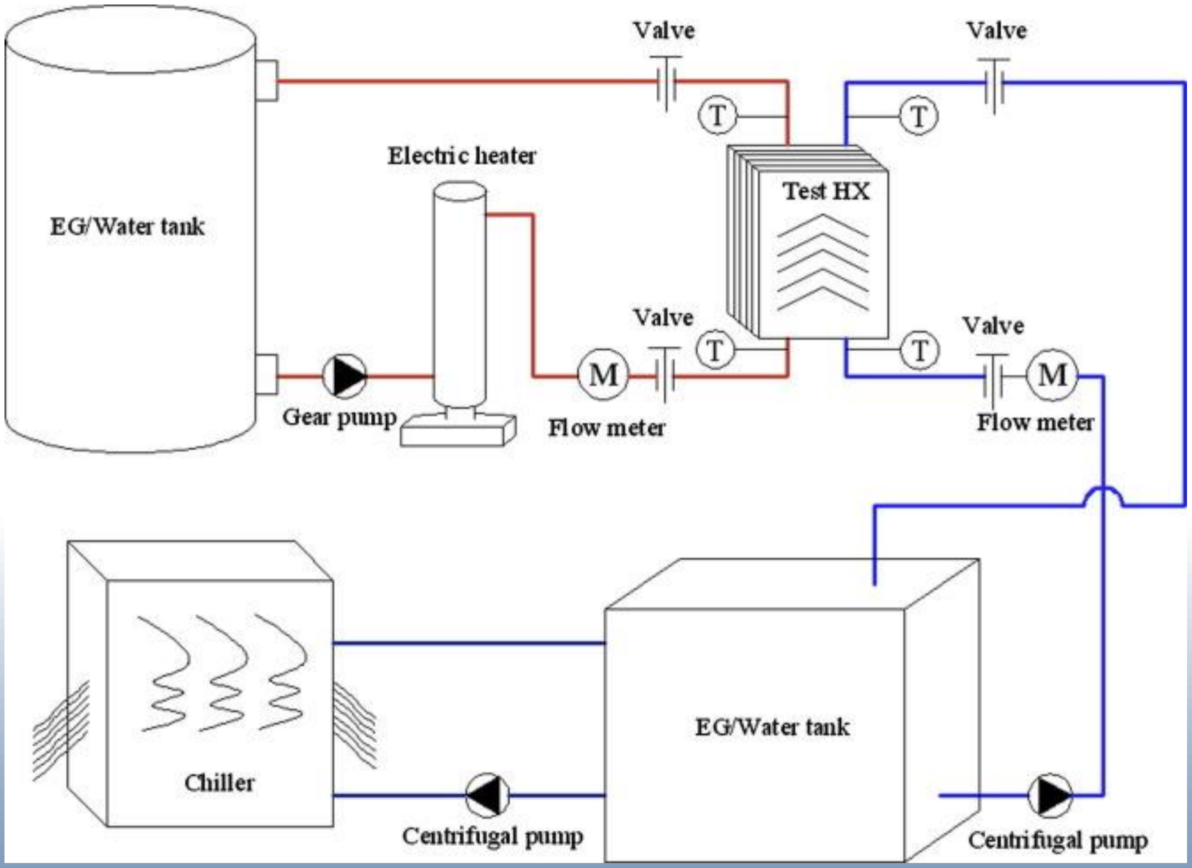
Measured

$$U_{meas} = \frac{Q}{A_{proj}\Delta T_{LMTD}}$$

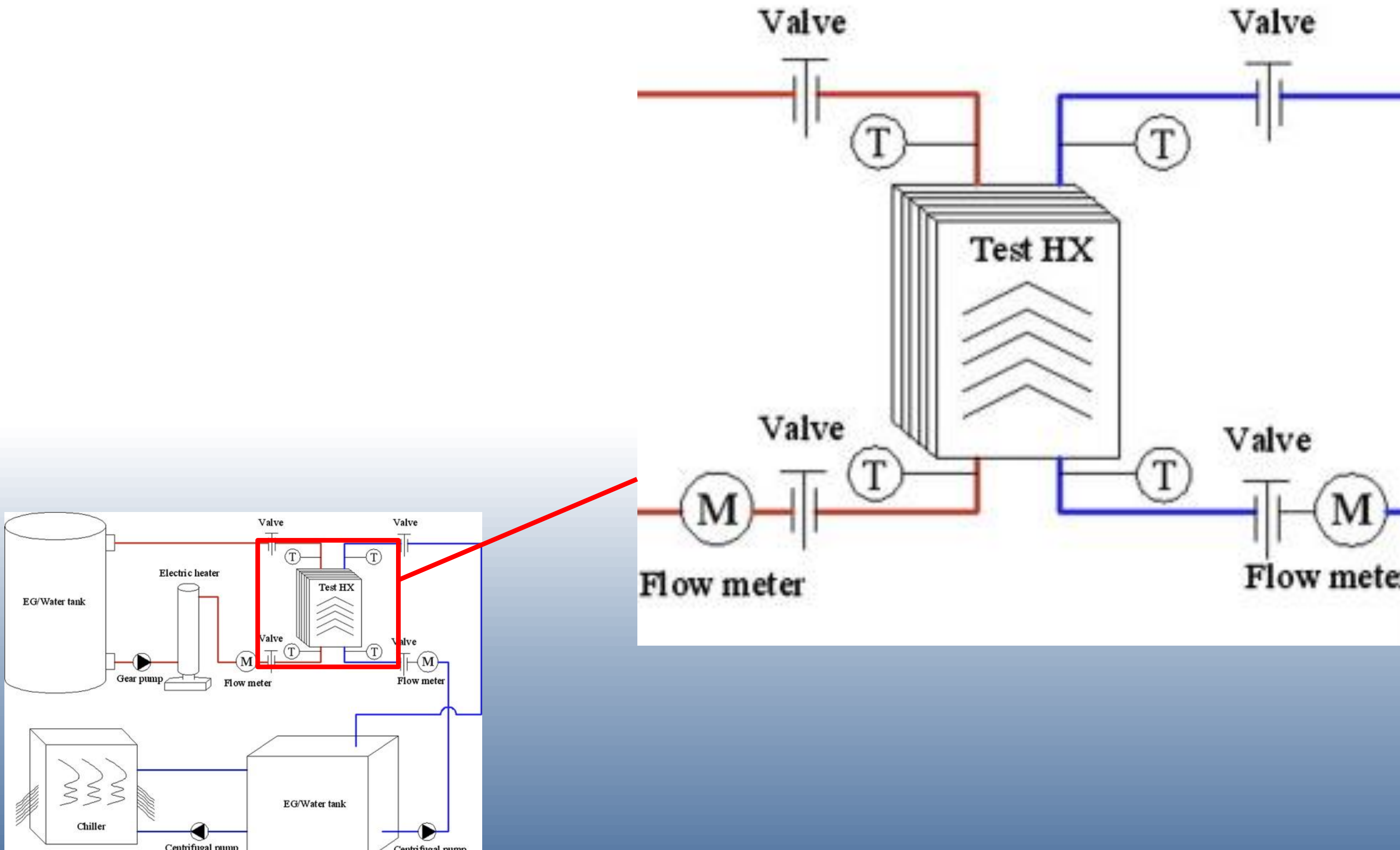
$$Q = \frac{m_h c_h (T_{h,i} - T_{h,o}) - m_c c_c (T_{c,i} - T_{c,o})}{2}$$

$$\Delta T_{LMTD} = \frac{\Delta T_{in} - \Delta T_{out}}{ln\frac{\Delta T_{in}}{\Delta T_{out}}}$$

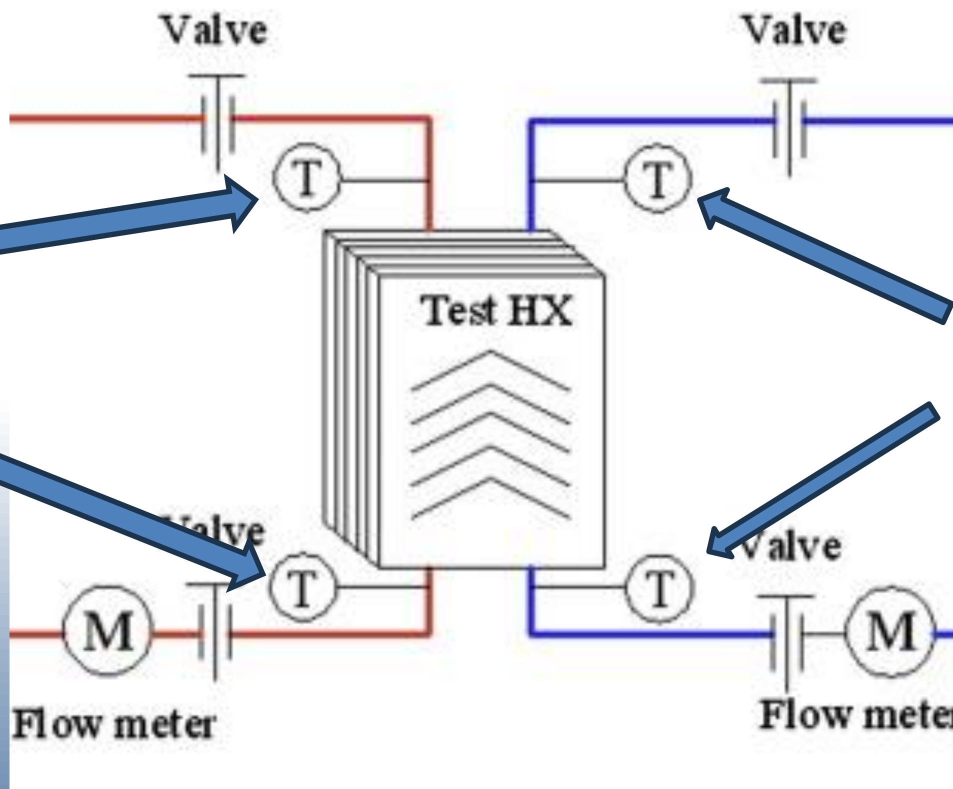
Temperature and flow rates should be collected and plugged into the previous equation



Temperature and flow rates should be collected and plugged into the previous equation



Temperature and flow rates should be collected and plugged into the previous equation



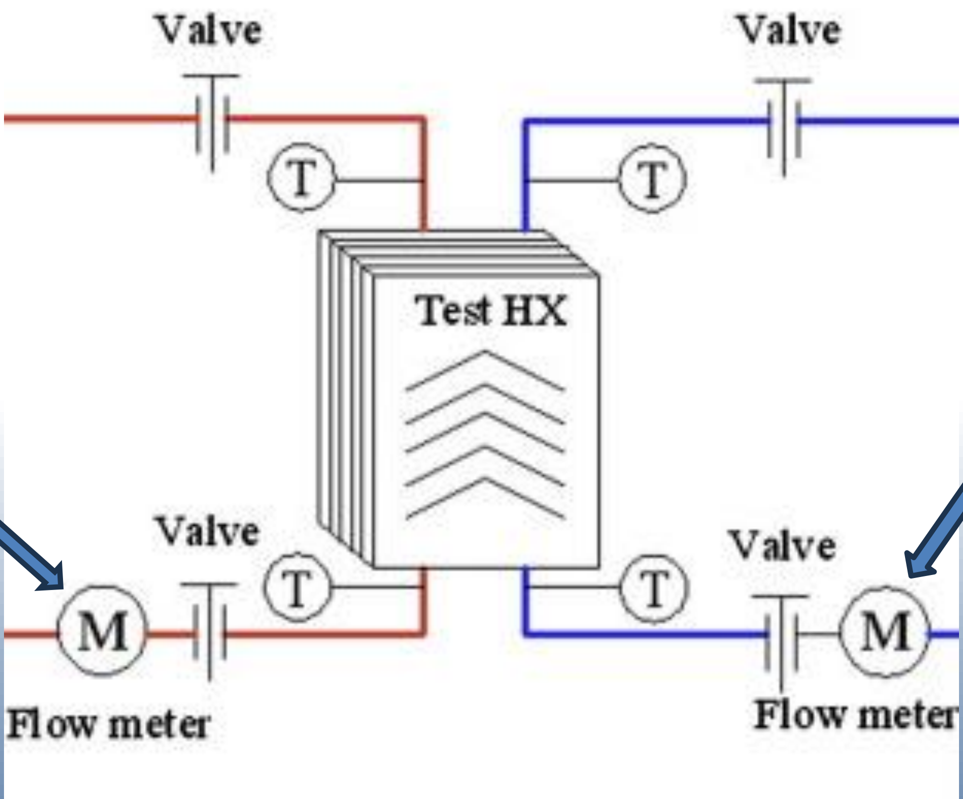
Hot inlet and outlet thermocouples

Cold inlet and outlet thermocouples

Temperature and flow rates should be collected and plugged into the previous equation

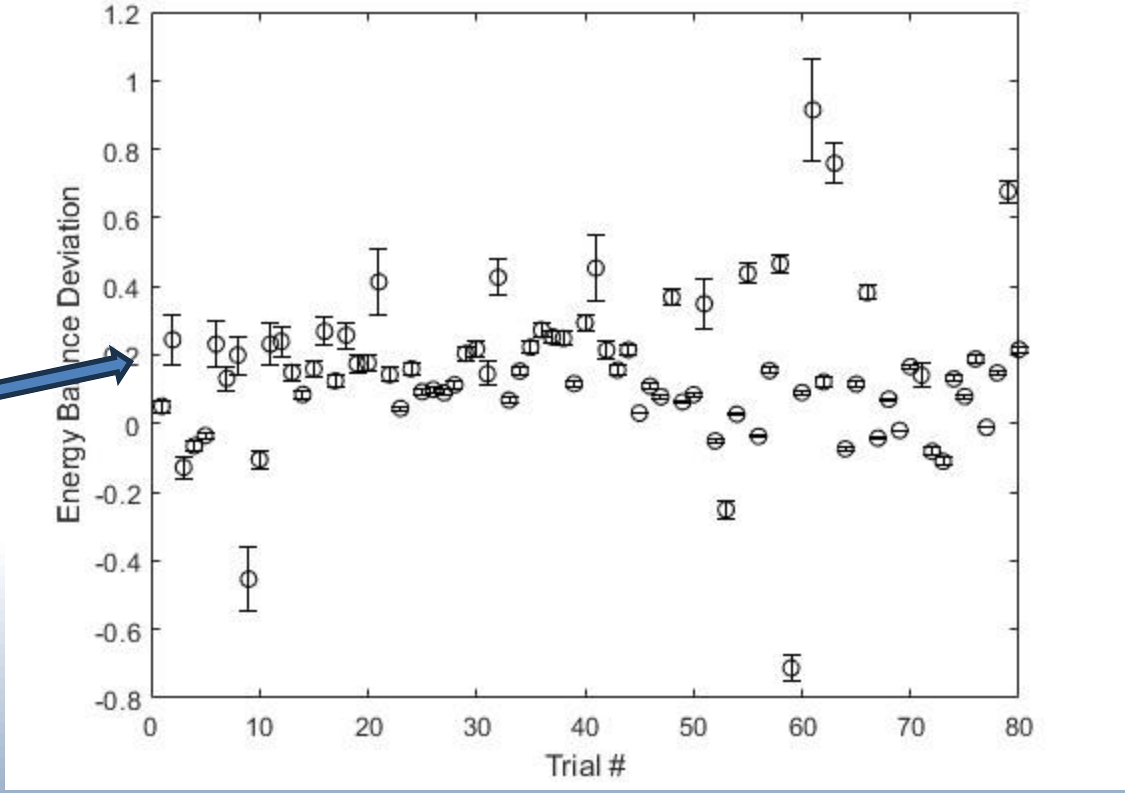
Hot inlet flowmeter

Cold inlet flowmeter



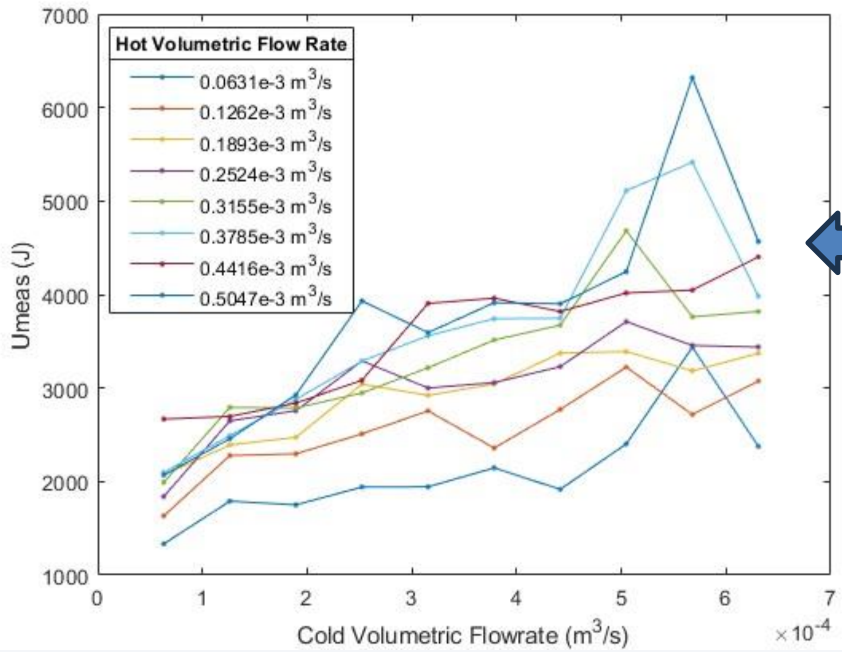
Heat losses seen through deviations in energy balance

% of heat lost



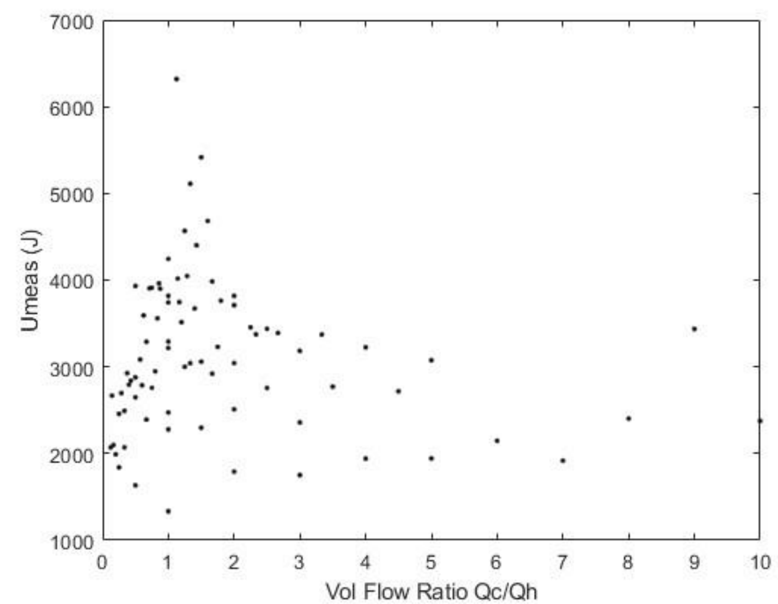
Mostly positive deviations

Effects of changing the hot and cold flowrates

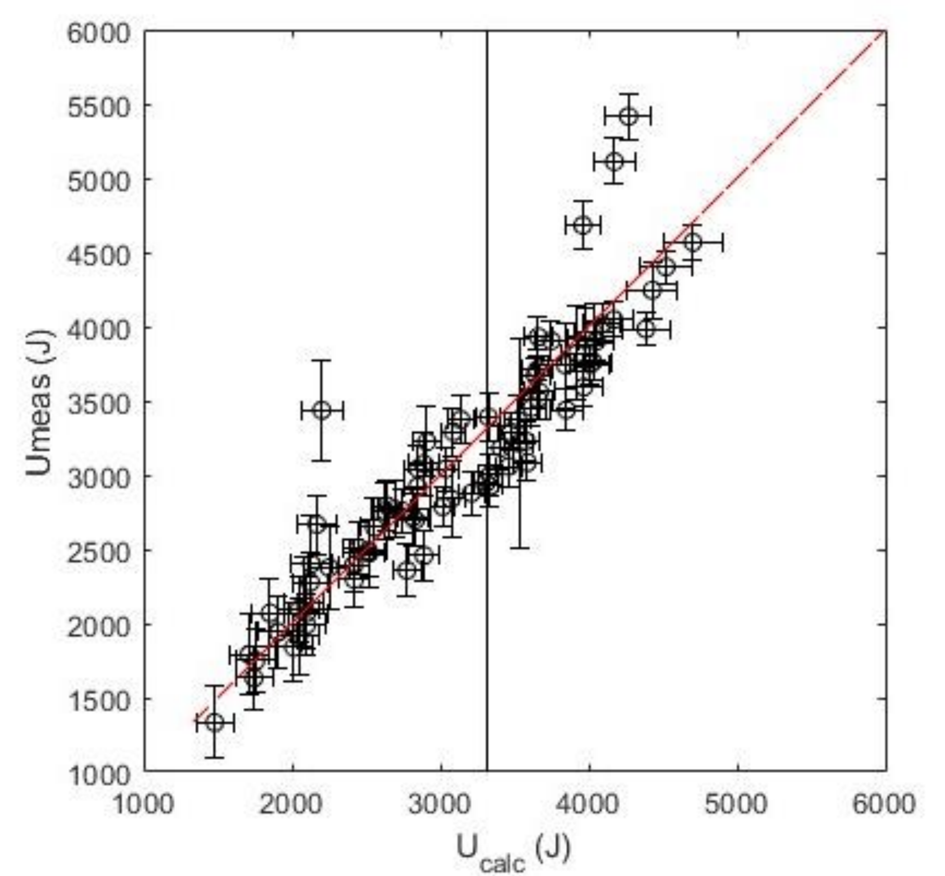


Increasing the flow rates improves heat transfer

Heat transfer is better at 1:1 hot and cold flow rates



Theoretical and measured data confirm accurate data and low inefficiencies



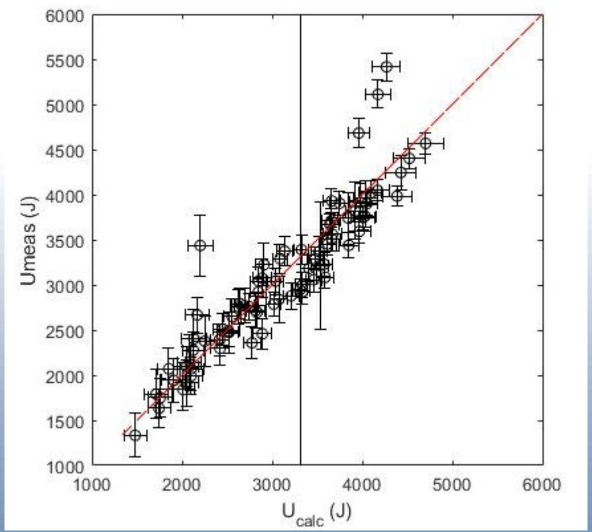
In conclusion, a reliable correlation was drawn between the Nusselt number, Reynolds number, and Prandtl number.

The correlation is as follows:

$$Nu = 0.4Re^{0.60}Pr^{\frac{1}{3}}$$

Coefficients
$C_1 = 0.4 \pm 0.2$
$C_2 = 0.60 \pm 0.06$

which is confirmed by the correlation between measured and calculated overall heat coefficients



Questions?

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