Unit Operations and Chemical Engineering Laboratory: *London Recap Lecture*

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Plan for today

- 1 slide for each experiment
- A few more comments


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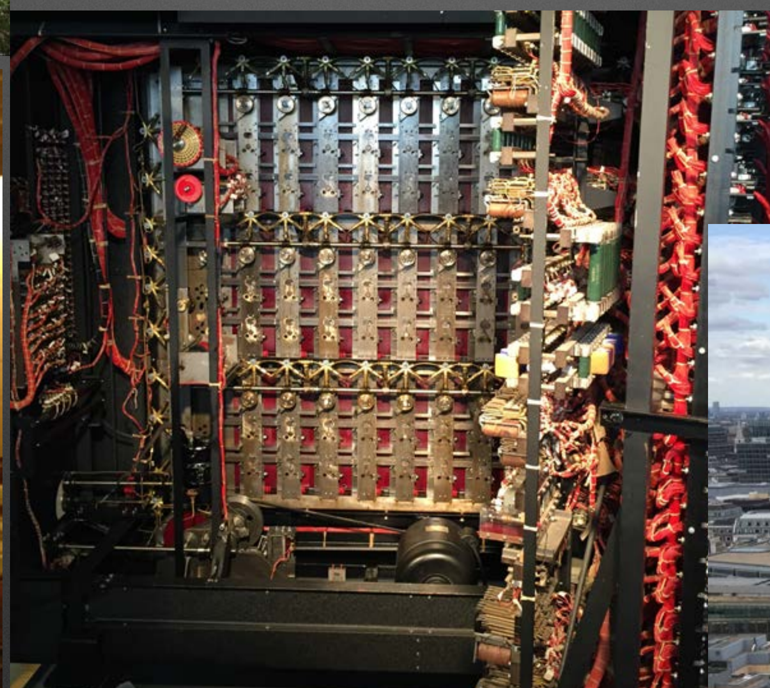
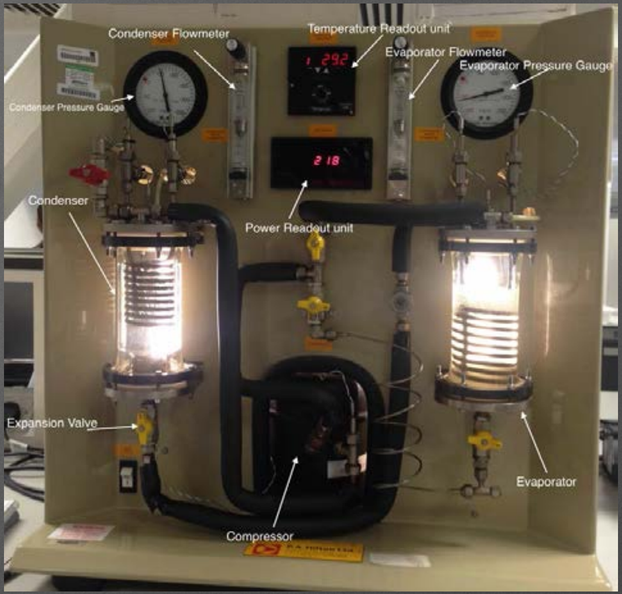


Pilot Plant

- Device: Remove CO_2 from a gas mixture
- ~15 wt% MEA in water is the working fluid; chemically enhanced absorption (about 2 orders of magnitude greater than physical solubility, >3 OoM than N_2) recycle by heating and contact with CC “steam/MEA” flow in packed tower. Recycle everything
- You measure: gas composition at 6 points along absorber, many temperatures, pressures,
- You can vary gas and liquid flows, steam flow to reboiler, etc.
- Verification of process, learning operating procedures, running process are critical outcomes
- Main results:
  - You determine mass transfer coefficients in absorber, heat transfer coefficients in C100 and C200 and verify pump performance

Refrigeration cycle experiment



- Device: Cool something!
- Standard vapor-compression cycle pumping heat from cold heat exchanger to a hot heat exchanger
- You measure: electric power input, temperatures and pressures of working fluid
- You can vary water flows to both heat exchangers and measure “Watts” for each
- Compressor runs at constant speed (you can *estimate* the mass flow)
  - not likely to be very efficient if heat exchangers limit performance
- Main results: the p-H diagram with statepoints, Carnot COP, COP for ideal cycle, real cycle and in terms of electric power input, careful error analysis for heating/cooling load

"Pipe flow" experiment

- Device: Transport a liquid without leaking!
- Water or a light HC oil is pumped in circular pipes (and packed bed, etc.) of different sizes
- You measure: pressure change over fixed distances, read/calibrate flow rates
- You can vary: Flow rates and can select different pipes
- Main results: f-Re diagram (all data on one or two plots, with error bars), compared to expected theory/correlation; determination of scaling of "losses" for some fittings, viscosity of the oil (if we can't get a separate measurement of this

Laboratory Gas Absorber

- Device: Remove CO2 from a gas mixture
- Water is the working fluid, physical absorption, recycle by heating and spraying to strip CO2
- You measure: gas composition at 3 points along absorber, temperatures, maybe some pressure changes
- You can vary gas and water flows and in principle, the compositions
- Need to cool the water feed to encourage absorption
- Analysis follows the formalism of $Z = H_{OG}*N_{OG}$ (integral of the concentration driving force along column)
    - You get H_{OG} and then calculate “k a” (mass transfer coefficient times contacting area)
- Main results: the “k a” values and some assessment of performance as gas/liquid flows are varied. location of operation conditions on the standard plot for “flooding” for a packed bed.

Rankine Cycle

- Device: Convert chemical energy into “work” (a.k.a. correlated motion, but specifically electricity)
- Miniaturized, (modified: drop P to “superheat”) Rankine cycle.
- You measure: propane flow rate, state points around cycle, power output, steam flow
- Main results: performances of each component in cycle and overall efficiency.

Heat Exchanger

- Device: “Exchanges Heat!”
- “double pipe” and (maybe) shell and tube heat exchangers that contact hot and cold water in separate streams
- You measure: temperatures in/out/middle, (maybe pipe wall), flow rates
- You can vary flow rates and some temperatures
- “First” law analysis (+ error analysis)
  - Determine degree of heat “losses”. Determine power load in terms of flow rates and temperatures
- Use “greatest of all equations” to get either overall or specific location heat transfer coefficients.
  - “Log mean” comes from integration of the driving force along the device when temperatures of both streams are changing

Safety

- Humans are not Grizzly or even Black Bears
- Know where the thin ice is
- A quick look could inform all
- There is a time and place for even Mozart
- Better to test the speed of a first rather than a zero order reaction!
- Step up when it is your turn to “look out for the peeps”

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It takes a Team!

- The Great Escape