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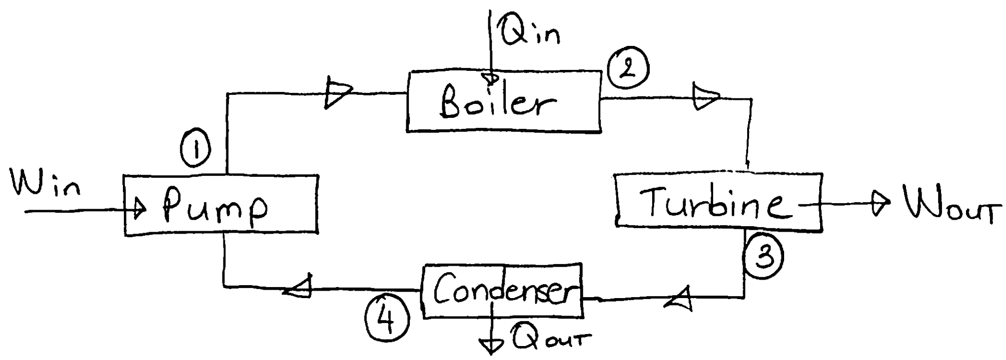
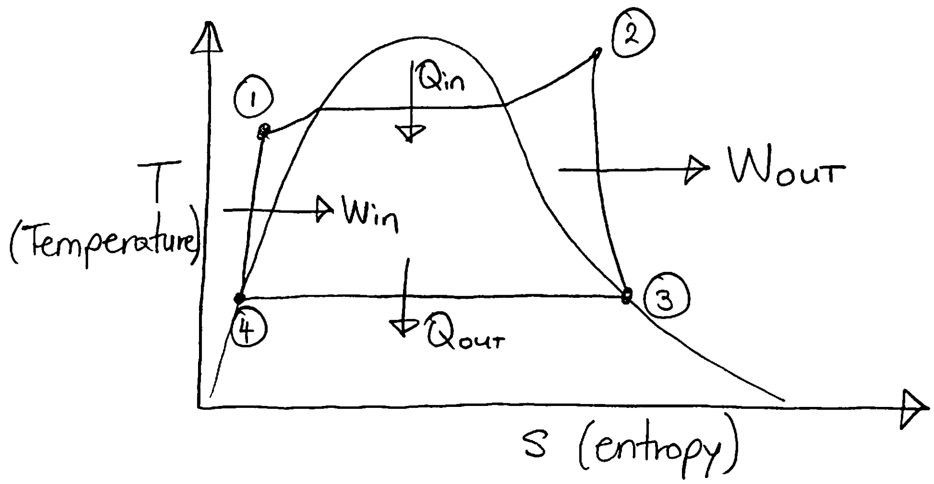
ME 320 - Heat Transfer

Why is heat transfer important and what is it?

A good example is power generation (from thermo)





What parts of this thermodynamic cycle (Rankine) involve heat transfer? ⇒ ALL of Them!

Pump: Friction Losses generate heat ⇒ needs to be dissipated to keep pump cool.
Boiler: Boiling process adds heat to the working fluid
Turbine: Friction losses & conduction losses result in heat loss to the surroundings ⇒ S increases
Condenser: Condensation process removes heat from working fluid.

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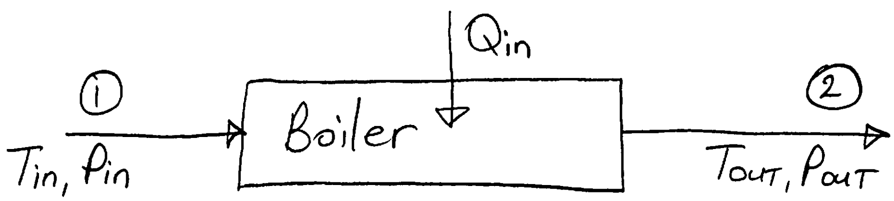
In general, thermodynamics is a <u>state approach</u>. Heat transfer tells you the details of what is in between each state & how it happens. Allows us to develop tools to help design real life thermodynamic components.

For example:

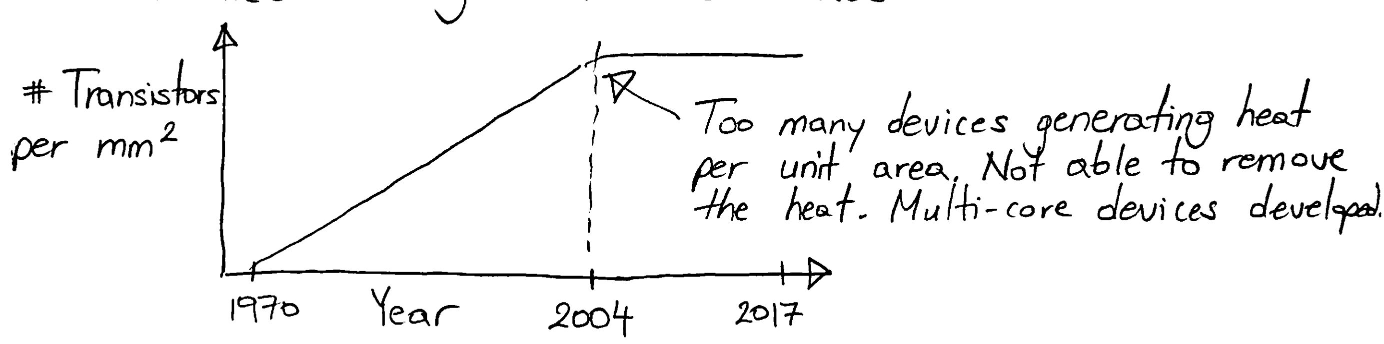


From enthalpy tables, you can determine T_{out}, P_{out} if given T_{in}, P_{in} & Q_{in}. However, as an engineer, what size should your boiler be to obtain the Q_{in} required? How is the fluid obtaining the heat in the boiler? How do we make this process most efficient?

These are all questions you will be able to answer by the end of ME320.

Other important applications:

- Electronics Cooling ⇒ Moore's Law



- Biology ⇒ Human Body ⇒ Sweating, Blood flow

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Tools we Need:

1. Conservation of mass
2. Conservation of momentum
3. Conservation of energy * (most important one)
4. Entropy ⇒ Heat always flows from T_{high} to T_{low} (naturally)

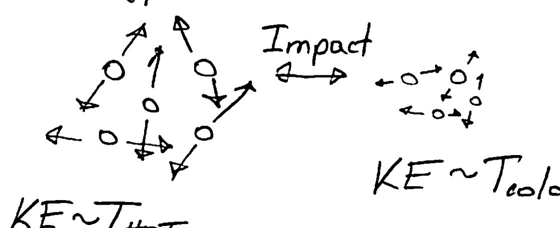
Some Basics:

What are the important paramaters in heat transfer:

- T ⇒ [°C or K] ⇒ Temperature = average kinetic energy in random directions.
- Q ⇒ [W or J/s] ⇒ Heat transfer rate
- q'' ⇒ [W/m²] ⇒ Heat flux
- C_p ⇒ [J/kg·K] ⇒ Specific heat ⇒ how much energy it takes to raise the temperature of 1 kg of a material by 1°C or 1K.
- k ⇒ [W/m·K] ⇒ thermal conductivity ⇒ more on this later

Modes of Heat Transfer

Conduction: ⇒ Energy transfer via direct molecular contact (called diffusion)



⇒ Molecular collisions transfer kinetic energy & transfer heat.

$$KE_{Avg} = \left[\overline{\tfrac{1}{2} m v^2}\right] = \frac{3}{2} k_B T \quad \Rightarrow \text{ME 420}$$

Examples: 1) Heat transfer in a solid object heated on one end
2) When you touch something hot

Convection: ⇒ Conduction with fluid flow
Examples: 1) Boiling, pipe flow, ocean currents, blood flow