Heat Transfer Coefficient In Liquid Metal Reactors

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What is Heat Transfer???

- The heat transferred, q (Btu/hr), between the coolant and a surface
- Newtons Law of Cooling:

$$q = hA(t_w - t_f)$$

h = coefficient of heat transfer

A= area

t_w , t_f = wall-surface bulk-temperatures

h= is a function of coolant physical properties

- Thermal conductivity
  - The ability of a material to conduct heat
- Specific heat
  - Heat required to change a unit of mass of a substance by one degree
- Viscosity
  - Resistance of a liquid or gas flow
- Operating conditions
  - Speed
  - Pressure
  - Flow Channel geometry

Why do we want effective heat transfer???

- Large amounts of heat can be transferred at high temperatures with low temperature difference between the wall and the surface

Coolant	h, (Btu/hr)	W/q
Light and heavy water	5000-8000	1
Organic liquids (polyphenyls, etc.)	2000-3000	4 to 10
Liquid metals (sodium, sodium-potassium alloys, etc.)	4000-10000	3 to 7
Gases (He, CO2, N2, air, etc.)	10-100	around 100

Make-up of NaK

- NaK (78% K, 22% Na)
- Reacts explosively with air & water
- High purity, non-corrosive to metal
- The ability to cool high heat fluxes
- The possibility to use pumps without moving parts
  - Great for space applications

Heat transfer with change in phase

- Local boiling may be allowed at high loads to increase heat transfer.
  - Heat is transferred in the nucleate boiling region and by boiling with bubble formation from nucleation sites.
- When the coolant acts as a moderator bubbles accompanying the phase change reduces moderating power.

Processes of phase change

- Evaporation:
  - Liquid into vapor
- Boiling:
  - Process in which vapor forms into a continuous phase
- Two-phase flow:
  - The case where both liquid and vapor move together in a channel
- Condensation:
  - Conversion of vapor back into a liquid

Nucleate Boiling in Microgravity

- Ultimate goal is to improve the understanding
- Nucleate Boiling is different on Earth than on the Moon
  - New modeling must be established
  - No constants can be used
- Boiling Process
  - Nucleation
  - Growth
  - Motion
  - Collapse

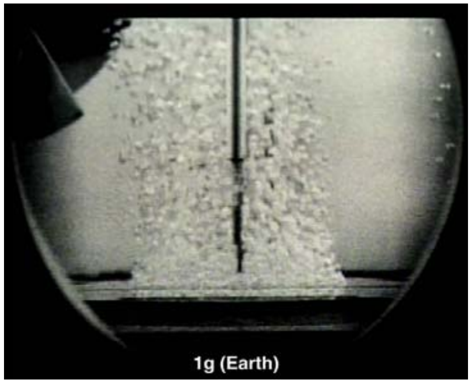
Two-phase flow

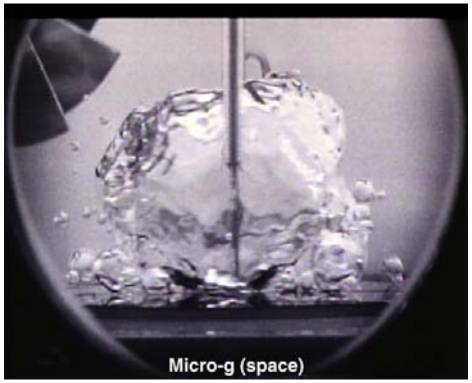
- What is two phase flow???
- Classified as diabatic or adiabatic
  - Boiling may or may not take place
- Single component: (water, steam)
- Two component: (water,air)
- In all cases vapor rises faster than the liquid

Critical Heat Flux (CHF)

- CHF or dry-out temperatures are reduced considerably in microgravity
- Pool boiling process is enhanced
- The unknown:
  - The upper heat flux
  - Try to get as close as possible to CHF without dry-out

Boiling Experiment





The 1-g boiling action of buoyancy allows the bubbles to overcome surface tension. In micro-g the buoyancy force is very weak. Consequently, the bubbles remain attached to the surface heater because of surface tension and become large as more vapor is produced due to the continuous input energy from the heater.

My Progress

- Learn new terms and ideas
- Research material compilation
- Redundant papers and articles
- Comparing experiments
- Results compilation of different liquid metals

Thank You