Institute of Refractories Engineers

Heat Flow and Thermal Expansion

Training Day 2016

Sheffield
13 October 2016

Course Aim

- To give an appreciation of how heat flows through a lining and how thermal gradients are calculated and used
- To give an appreciation of thermal expansion and how thermal expansion allowances can be made.

Contents

- Introduction
- Thermal conductivity
- Coffee
- Thermal Gradient Calculations
- Exercise
- Lunch
- Thermal Expansion
- Exercise
- Transient Conditions

Why Consider Heat Flow?

Temperature Gradient
- Shell temperature
  - Max design temperature
  - Acid dewpoint
  - Hand safe
- Refractory Service
  - Material melting
  - Slag Penetration
  - Maximum Service Temperature
  - THERMAL EXPANSION

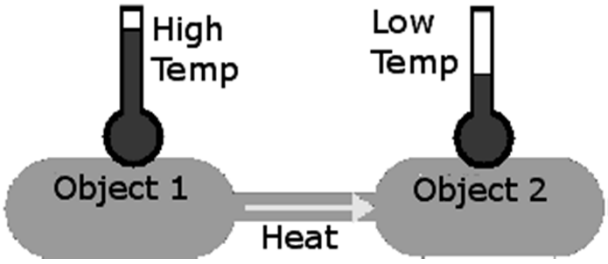
Heat Flow
- Skull stability
- Energy loss
- Heating and cooling rates
  - Turnaround time

What is Heat

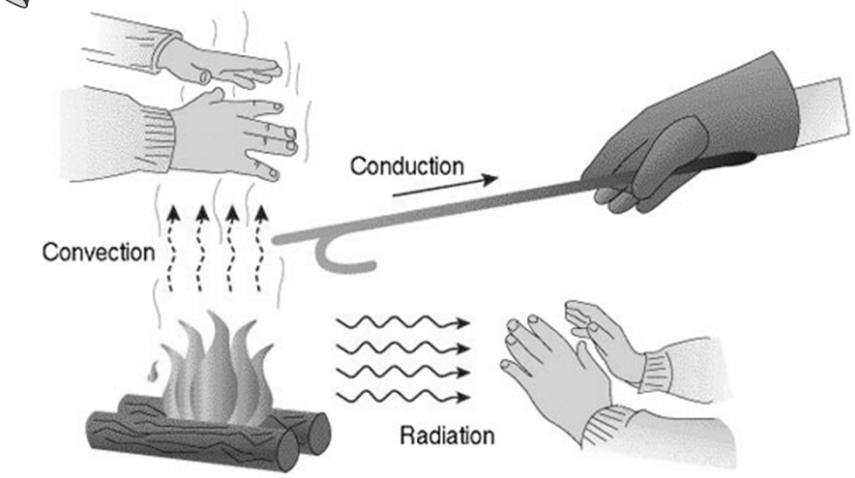
Heat is a form of ENERGY

Temperature is a measure of thermal state
As a material cools it looses heat (thermal energy)

Heat Energy flows in one diection



How Does Heat Flow

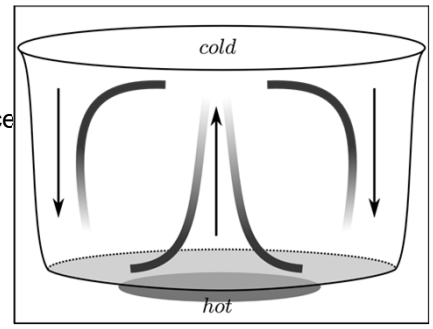


Convection

Convection is when heat energy is moved by a movement of a fluid (mass flow)

Natural Convection

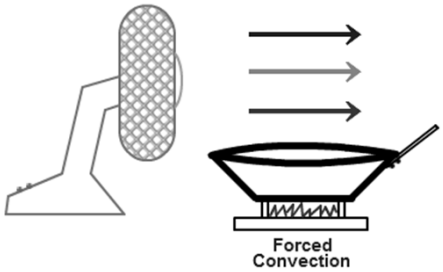
- Fluid near hot object is heated
- Thermal expansion of heated fluid
  - Decrease in density
  - Low density fluid rises,
  - High density fluid sinks
- Cool fluid into contact with heat source
- Cycle continues



Forced Convection

Heat (energy) transfer caused by mass transfer
Mass transfer caused by externally driven fluid flow

- Cooling fans
- Water cooling circuits
  - Car engine cooling
  - Blast furnace cooling
  - Domestic boiler



Radiation

Heat Transfer by Electromagnetic Radiation,

- IR wavelengths
- Can pass through transparent materials and space
- Stopped by opaque materials
- Amount of energy transfer depends stronglt on temperature

Thermal Expansion

Refractories expand when heated up

The steel shell constrains the expansion and leads to stresses

The stresses can be very high

Damage to lining

Damage to shell

Loss of containment

Correct understanding of expansion and how to allow for it is essential