Training Day 2022

Exercise – Heat Flow and Heat Loss

PROBLEM

A hot gas duct in a chemical plant is currently lined with single layer of alumina brick. 125mm thick).
The hot face temperature is 1200℃.

Assume a wind speed of 5m/s and an ambient temperature of 0℃. Assume the shell is unpainted steel with an emissivity of 0.8

What is the shell temperature?
What is the heat loss per sq.m from the shell?

The plant need to reduce the shell temperature to <60℃ to make the plant “hand safe”. The overall lining thickness cannot be increased. How might you achieve this?
NOTE – the gas in the duct contains an abrasive dust.

What is the heat loss per sq m at a shell temperature of 60℃?

The thermal conductivity of different materials (assume constant over temperature range

Alumina Brick	2W/mK
Insulating Castable	0.5W/mK
Insulating Firebrick	0.25W/mK
Fibre Board	0.1W/mK
Microporous Panel	0.05W/mK

Shell Temperature Calculation Method

1. Collect Data IN SAME UNITS
    - Hot Face (°C)
    - Ambient (°C)
    - Lining Thickness (m)
    - Lining conductivity over range of temperatures (W/mK)
    - Surface Emissivity (no unit)
    - Wind Speed (m/s)
2. First Estimate of Shell Temp – Guess
3. Find Surface Heat Transfer per sq m from graph
    - For Radiation
    - For Convection
    - Add together for Total
4. Calculate temp drop across lining from
   $W = k A \Delta T/\Delta x$
   W from step 3
   k is given above
   ΔT is (Hot Face-Shell)
   Δx is thickness (in m not mm)
5. Calculate Shell Temp from Hot Face – ΔT
   If this is larger than estimate, your estimate is too small, try again for a larger shell temp
   If this is smaller than estimate. Your estimate is too small, try again for a smaller shell temp
6. Repeat from Step 3 until step size of change is small