Item { On Conduction in liquids and gases → Senior two }

A Chemical engineer designs a heat exchanger to transfer heat from a hot gas to a cold liquid.

Hint: Assume a flat plate heat exchanger with surface area (A) and temperature difference (ΔT) between the hot gas (T_g) and cold liquid (T_l).

Given values: $K_g = 0.05\ W/mk$ (thermal conductivity of the hot gas)

$K_l = 0.5\ W/mk$ (thermal conductivity of the cold liquid)

$A = 1\ m^2$ (surface area of the heat exchanger)

$\Delta T = 100^{\circ}c$ (temperature difference between the hot gas and cold liquid)

$L = 0.1\ m$ (thickness of the heat exchanger material.

Task: Having studied Physics; help the engineer to understand

a) how conduction occurs in both the gas and liquid. → (06 scores)

b) how to Calculate the heat transfer rate (Q) → (04 scores)

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Expected Responses

a) • Conduction in the hot gas:

- The hot gas molecules have kinetic energy, causing them to vibrate and collide frequently.
- During collisions, energy is transferred from the faster-moving molecules to the slower-moving ones, spreading heat throughout the gas.
- The thermal conductivity of the gas (k_g) determines the rate at which heat is conducted.

• Conduction in the cold liquid:

- The cold liquid molecules have lower kinetic energy, but still collide and transfer energy.
- As heat is transferred from the gas, the liquid molecules gain energy and their temperature increases.
- The thermal conductivity of the liquid (k_l) determines the rate at which heat is conducted.

(b) From $\dot{Q} = \frac{k_g A \Delta T}{L} + \frac{k_l A \Delta T}{L}$

$= \left(\frac{0.05 \times 1 \times 100}{0.1}\right) + \left(\frac{0.5 \times 1 \times 100}{0.1}\right)$

$= 50 + 500$

$\dot{Q} = 550\ W$ ✓

Note that, we only score the correctness of the learners responses ✓