Under steady-state conditions, the rate of heat conduction through the wall must perfectly equal the total rate of heat dissipated from the outer surface to the surroundings via simultaneous convection and radiation ($Q_{total} = Q_{cov} + Q_{rad}$). Because the problem explicitly specifies the outer surface temperature (130°C), we can completely bypass the internal conduction calculations.

Step 1: Analyze the Convective Heat Transfer

Convection occurs due to the energy transfer between the solid outer brick wall surface and the moving ambient air molecules. This is governed by Newton's Law of Cooling.

- **Surface Temperature (T_s):** 130°C
- **Ambient Fluid Temperature (T_{∞}):** 30°C
- **Surface Area (A):** 25m^2
- **Convective Film Coefficient (h):** 18 W/m^2-K

$$Q_{conv} = \left(18\frac{W}{m^2-K}\right)\left(25\ m^2\right)(130\ -\ 30)\ \ ^oC\ =\ 45,000W$$

Step 2: Analyze the Radiative Heat Transfer

Radiation heat transfer depends on the absolute temperatures of the interacting surfaces and is governed by the Stefan-Boltzmann law. The handwritten material utilizes an older engineering reference metric where the Stefan-Boltzmann constant is pre-converted into thermal energy per hour (J/hr).

- **Absolute Surface Temperature ($T_{s,K}$):** 130 + 273 = 403 K
- **Absolute Surrounding Temperature ($T_{\infty, K}$):** 30 + 273 = 303 K
- **Emissivity (ϵ):** 0.85
- **Radiation Constant (in J/hr):** 20408.4 x 10^{-8} J/hr-m^2-K^4

$$Q_{rad} = \left(20,408\ x\ 10^{-8}\ \frac{J}{hr-m^2-K^4}\right)\epsilon A\left(T_{s,K}^{\ 4} - T_{\infty,K}^{\ 4}\right)$$

$$Q_{rad} = \left(20,408\ x\ 10^{-8}\ \frac{J}{hr-m^2-K^4}\right)(0.85)(25\ m^2)\left(403^4 - 303^4\right)K^4$$

$$Q_{rad} = \left(77,835,709.92\ \frac{J}{hr}\right)\left(\frac{1\ hr}{3600\ sec}\right) =\ 21,621.03\ W$$

Step 3: Compute Total Transmitted Heat

Summing both independent parallel modes of heat dissipation yields the total thermal energy escaping the furnace wall:

$$Q_{total} = Q_{conv} + Q_{rad} =\ (45,000\ W\ +\ 21,621.03\ W)\ =\ 66,621.03\ W$$

$$Q_{total} =\ 66.62\ kW$$

In mechanical and thermal engineering board examinations, problems are frequently designed to test not only your computational accuracy but also your conceptual discernment. This specific problem presents a classic "examiner's trap" by including redundant information—namely, the brick wall thickness (130 mm) and its thermal conductivity (1.33 W/m-K).

Notice that radiation accounts for roughly 32.5% (21.6 kW out of 66.6 kW) of the total heat loss. Because radiation scales to the *fourth power* of absolute temperature (T^4), its contribution increases exponentially as equipment surfaces get hotter. Engineers designing furnace hulls or boiler casings cannot rely on simple convection coefficients alone; high-emissivity surfaces drastically change insulation requirements.