1)Heat loss through a composite wall

A 3 m high and 5 m wide wall consists of long 32 cm 22 cm cross section horizontal bricks (k =0.72 W/m ·°C) separated by 3 cm thick plaster layers (k =0.22 W/m ·°C).There are also 2 cm thick plaster layers on each side of the brick and a 3-cm-thick rigid foam (k0.026 W/m ·°C) on the inner side of the wall. The indoor and the outdoor temperatures are20°C and 10°C, and the convection heat transfer coefficients on the inner and the outer sides areh1=10W/m2 ·°C andh2 =25 W/m2 ·°C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

The answer:

$A = (0.015 + 0.22 + 0.015) * 1 = 0.25m2$

$R1, conv. = \frac{1}{h1 * A1 - dimen} = \frac{1}{10 * 0.25} = 0.4\ \frac{C}{W}$

$Rfoam = \frac{\text{Lfoam}}{Kfoam * A1 - dimen} = \frac{0.03}{0.026 * 0.25} = 4.615 \frac{C}{W}$

$Rplaster.up = Rplaster.down = \frac{\text{Lfp. up or down}}{Kp * Ap.up\ or\ down} = \frac{0.32}{0.22 * 0.15 * 1} = 96.97\ \frac{C}{W}$

$Rbrick = \frac{\text{Lbrick}}{Kbrick * Abrick} = \frac{0.32}{0.72 * 0.22 * 1} = 2.02\ \frac{C}{W}$

$\frac{1}{Rtotal.parallel} = \frac{1}{96.97} + \frac{1}{2.02} + \frac{1}{96.97} = 0.516\ \frac{C}{W}$

$R\ total.parallel = \frac{1}{0.516} = 1.94\ \frac{C}{W}$

$Rplaster.left = Rplaster.right = \frac{\text{Lp. lft or right}}{Kp * Ap.lt\ or\ rt} = \frac{0.02}{0.22 * 0.25 * 1} = 0.363\ \frac{C}{W}$

$R2, conv. = \frac{1}{h2 * A1 - dimen} = \frac{1}{40 * 0.25} = 0.1\ \frac{C}{W}$

R wall.total =0.4+4.615+0.363+1.94+0.363+0.1=7.781 $\frac{C}{W}$

The rate of heat transfer loss:

$\dot{Q} = \frac{\text{T1} - \text{T}\infty}{Rwall.total} = \frac{20 - (-10)}{7.781} = 3.86\ W$

AND

R wall.total *Thickness of brick=16 mm*

=6.81 $\frac{C}{W}$

***SO**, the heat transfer rate is*:

$\dot{Q} = \frac{\text{T1} - \text{T}\infty}{Rwall.total} = \frac{20 - (-10)}{6.81} = 4.41\ W$

By comparing the two results, we found that: double the thickness of a brick inside a composite wall doesn't significantly increase the thermal resistance of a whole wall, so the rate of heat transfer doesn't significantly decrease.