Week 4

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Task 1: Complete the modified example of simplified wall calculations and find the total heat transfer through wall

Wood frame: built around 38mm 90mm wood studs with a center-to-center distance of 400mm.

Urethane rigif foam insulation: fill the 90mm wide cavity between the studs

Inside: filled with 13mm gypsum wallboard and outside with 13mm polywood and 13mm 200mm wood bevel lapped siding.

(75% of area is insulation and 25% can be considered wood)

Answer:

	Wood	Insulation
Outside Air	0.03	0.03
Wood Bevel (13mm*200mm)	0.14	0.14
Polywood(13mm)	0.11	0.11
Urethane Rigif Foam Ins.(90mm)	NO	3.528
Wood Studs(90mm)	0.63	NO
Gypsum Board(13mm)	0.079	0.079
Inside Surface	0.12	0.12
R_{total}	1.109 m^2 ℃$/W$	4.007 m^2 ℃$/W$

Because R'_{wood} = 1.109 $m^2℃/W$, $R'_{insulation}$ = 4.007 $m^2℃/W$

So $U_{wood} = \frac{1}{R'wood} \approx 0.9017\ W/m^2℃$, $U_{insulation} = \frac{1}{R'insulation} \approx 0.2496\ W/m^2℃$

$$\frac{1}{R'total} = \frac{1}{R'wood} + \frac{1}{R'insulation}$$

$$\frac{1}{R} = \frac{A}{R'}$$

So $\frac{Atotal}{R'total} = \frac{Awood}{R'wood} + \frac{Ainsulation}{R'insulation}$

And $U = \frac{1}{R}$

$A_{total}*U_{total} = A_{wood}*U_{wood} + A_{insulation}*U_{insulation}$

$U_{total} = U_{wood}* \frac{Awood}{Atotal} + U_{insulation}* \frac{Ainsulation}{Atotal} = U_{wood} * (21\%+4\%) + U_{insulation}*75\% \approx 0.4126\ W/m^2℃$

$R_{value} = \frac{1}{Utotal} \approx 2.4237\ m^2℃/W$

$Q_{total} = U_{total} * A_{total} * T$ = 0.4126 * 50 * 2.5 * (1-20%) * 22 – (-2) = 990.24W

Task 2 Summary about Radiation and Radiative Heat Transfer

Summary

About **Radiation**:

Radiation refers to the part made by source of electromagnetic energy from the source to the distant spread, and then the phenomenon of no longer return to the source, the energy in the form of electromagnetic waves or particles spread outward. Radiation is one of the modes of heat transmission. All objects in nature, as long as the temperature is above the absolute temperature of zero degrees Celsius (-273.15 ℃), constantly transmit heat outward in the form of electromagnetic waves and particles. And the higher the temperature, the shorter the wavelength of electromagnetic wave emitted. This transfer of energy is called Radiation, which is emitted in a straight line from the heat source.

Electromagnetic radiation is oscillated in the same phase and mutually perpendicular to the electric and magnetic fields in space as a wave movement, transfer energy and momentum. The amplitude changes periodically along the vertical direction of the propagation direction. The greater the amplitude, the greater the intensity. The magnetic field, electric field and direction of electromagnetic wave are perpendicular to each other.

The relationship between the speed of the electromagnetic wave which equal to the speed of light c (3×10^8m/s), and the wavelength λ and frequency (the number of electromagnetic changes per second) f can be expressed in a formula:

$$c=\lambda f$$

When these waves are arranged in order of wavelength or frequency, they are called electromagnetic spectrum. If the frequencies of each band are arranged in order from low to high, they are power electromagnetic waves, radio waves (classified as long, medium, short and microwave), infrared, visible light, ultraviolet, X-ray and γ-ray. Cosmic rays (x-rays, γ-rays, and shorter wavelengths) have the shortest wavelengths.

About **Radiative Heat Transfer**:

Radiative heat transfer is the heat transfer method that the body sends out the heat energy outwardly in the form of electromagnetic radiation. It does not depend on any external conditions and is one of the three main ways of heat conduction.

As any object emits radiant energy, and also absorbs it from surroundings. The difference between the energy a body radiates and the energy it absorbs is the net energy it transmits. The higher the energy per unit time, the stronger the radiation capability.

The thermal effect occurs when radiant energy is absorbed by an object. Therefore, radiation is an important way of converting energy into heat. Radiation heat transfer is a process of heat transfer between hot and cold objects based on electromagnetic radiation. It is a kind of non-contact heat transfer, which can also be carried out in vacuum.

When an object is exposed to radiation (energy Q) from other objects, it produces three phenomena: absorption, reflection and penetration. If we regard the total energy as Q, then the relationship between these parts and the total energy as shown in the following equation:

$$Q=Q_A+Q_R+Q_D$$

if we regard $A=Q_A/Q$ as absorption rate, $R=Q_R/Q$ as reflection rate, $D=Q_D/Q$ as penetration rate, $A+R+D=1$

if $A=1$, $R=D=0$, that is, the energy of thermal radiation reaching the surface of the object is completely absorbed, the object is called absolute black body, short for black body.

In fact, there is no absolute black body, only some objects are close to absolute black body.

The hotter the black body, the more light it emits. Moreover, the luminous color of the black body only depends on the heating temperature, which is equivalent to the spectral energy distribution of the absolute black body radiation, and the amount of spectral energy after heating is only related to its temperature. Given a certain heating temperature for the black body, there is only a certain color of light or only a certain relative spectral energy distribution corresponding to it.