Week 4

Tuesday, October 29, 2019 10:50 PM

PILAPIL, Nina Camille D.
10695066

TASK 1. Simplified Wall Calculation

Determine the overall unit thermal resistance **(R-value)** and the overall heat transfer coefficient **(U-factor)** of a wood frame wall that is built around **38mm x 90mm wood studs** with a center-to-center distance of 400mm. The 90mm wide cavity between the studs is filled with **urethane rigid foam insulation**. The inside is finished with **13mm gypsum wallboard** and the outside with **13mm plywood** and **13mm x 200mm wood bevel lapped siding**.

The insulated cavity constitutes 75% of the heat transmission area while the studs, plates, and sills constitute 21%. The headers constitute 4% of the area, and they can be treated as studs (this means 75% of area is insulation and 25% can be considered wood)

Also, determine the **rate of heat loss through the walls** of a house whose perimeter is **50m** and wall height is **2.5m** in Las Vegas, Nevada, whose winter design temperature is **-2°C**. Take the indoor design temperature to be **22°C** and assume 20% of the wall area is occupied by glazing.

Unit thermal resistance (the *R*-value) of common components used in buildings

Component	*R*-Value m² · °C/W	*R*-Value ft² · h · °F/Btu	Component	*R*-Value m² · °C/W	*R*-Value ft² · h · °F/Btu
Outside surface (winter)	0.030	0.17	Wood stud, nominal 2 in × 6 in (5.5 in or 140 mm wide)	0.98	5.56
Outside surface (summer)	0.044	0.25	Clay tile, 100 mm (4 in)	0.18	1.01
Inside surface, still air	0.12	0.68	Acoustic tile	0.32	1.79
Plane air space, vertical, ordinary surfaces (ε_{eff} = 0.82):			Asphalt shingle roofing	0.077	0.44
			Building paper	0.011	0.06
13 mm ($\frac{1}{2}$ in)	0.16	0.90	Concrete block, 100 mm (4 in):		
20 mm ($\frac{3}{4}$ in)	0.17	0.94	Lightweight	0.27	1.51
40 mm (1.5 in)	0.16	0.90	Heavyweight	0.13	0.71
90 mm (3.5 in)	0.16	0.91	Plaster or gypsum board,		
Insulation, 25 mm (1 in)			13 mm ($\frac{1}{2}$ in)	0.079	0.45
Glass fiber	0.70	4.00	Wood fiberboard, 13 mm ($\frac{1}{2}$ in)	0.23	1.31
Mineral fiber batt	0.66	3.73	Plywood, 13 mm ($\frac{1}{2}$ in)	0.11	0.62
Urethane rigid foam	0.98	5.56	Concrete, 200 mm (8 in)		
Stucco, 25 mm (1 in)	0.037	0.21	Lightweight	1.17	6.67
Face brick, 100 mm (4 in)	0.075	0.43	Heavyweight	0.12	0.67
Common brick, 100 mm (4 in)	0.12	0.79	Cement mortar, 13 mm (1/2 in)	0.018	0.10
Steel siding	0.00	0.00	Wood bevel lapped siding, 13 mm × 200 mm (1/2 in × 8 in)	0.14	0.81
Slag, 13 mm ($\frac{1}{2}$ in)	0.067	0.38			
Wood, 25 mm (1 in)	0.22	1.25			
Wood stud, nominal 2 in × 4 in (3.5 in or 90 mm wide)	0.63	3.58			

	Wood Unit: $\frac{m^2C}{W}$	**Insulation** Unit: $\frac{m^2C}{W}$
Outside Surface (winter)	0.03	0.03
Wood Bevel Lapped Siding (13mm x 200mm)	0.14	0.14
Plywood (13mm)	0.11	0.11
Urethane Rigid Foam Insulation (90mm)	-	$\frac{(0.98)(90)}{25} = 3.528$
Wood Studs (38mm x 90mm)	0.63	-
Gypsum Board (13mm)	0.079	0.079
Inside Air	0.12	0.12

Unit Thermal Resistance (R-values)

$$R'_{wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109\ \frac{m^2C}{W}$$

$$R'_{ins} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007\ \frac{m^2C}{W}$$

Overall Heat Transfer Coefficient (U-factor)

Using given formulas, $\frac{1}{R'} = U \rightarrow U_{total} = 0.25\ U_{wood} + 0.75\ U_{insulation}$

$$U_{wood} = \frac{1}{R'_{wood}} = \frac{1}{1.109} = 0.9017\ \frac{W}{m^2C}$$

$$U_{ins} = \frac{1}{R'_{ins}} = \frac{1}{4.007} = 0.2496\ \frac{W}{m^2C}$$

$$U_{wall} = 0.25\ U_{wood} + 0.75\ U_{insulation} = (0.25)(0.9017) + (0.75)(0.2496) = 0.4126\frac{m^2C}{W}$$

Rate of Heat Loss Through the Wall (Q_{wall})

$$Q_{total} = U_{total} * A_{total} * \Delta T$$

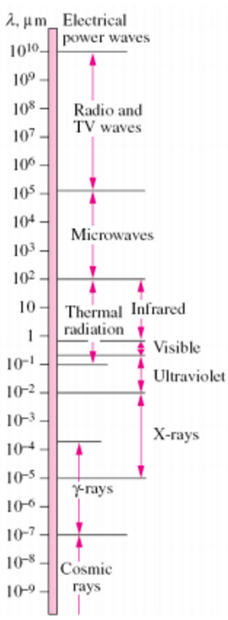
$$A_{total} = 50m * 2.5m * 0.8 = 100m^2$$

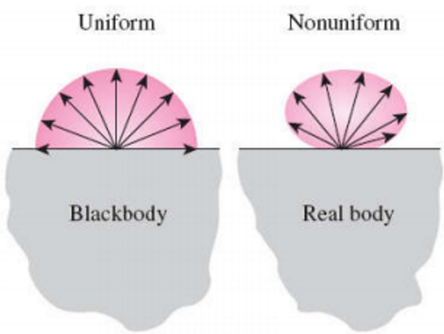
$$\Delta T = 22°C - (-2°C) = 24°C$$

$$Q_{total} = 0.4126\frac{m^2C}{W} * 100m^2 * 24°C = 990.24W$$

TASK 2. Write a summary in your own words of what you have learned about radiation and radiative heat transfer.

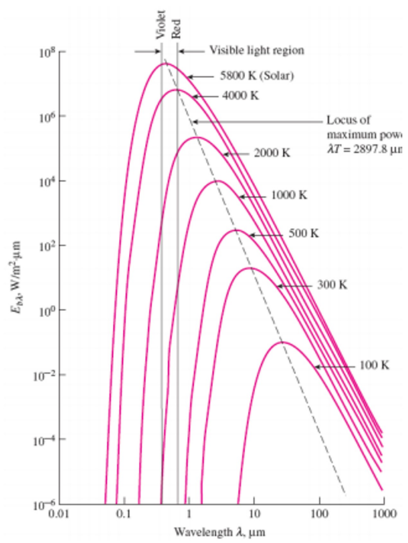
Radiation is a kind of heat transfer by which objects reach thermal equilibrium with its surroundings. It does not require the presence of a material unlike conduction and convection. Because of this, it is the only way to transfer heat in a vacuum. It occurs in solids, liquids, and gases.

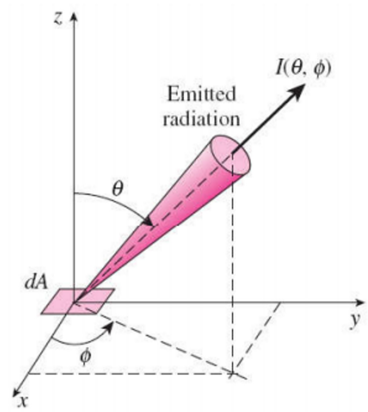




Thermal radiation occurs as a result of energy transitions of molecules, atoms, and electrons of an object. The rate of thermal radiation is dependent solely on one factor: temperature. Temperature is the measure of strength of energy transitions at the microscopic level and thermal radiation is continuously emitted by all objects whose temperature is above absolute zero.

The electromagnetic wave spectrum delineates the different types of waves according to wavelengths. Light is simply the portion of the spectrum (0.40-0.76 µm) that is visible to the human eye. This also determines the colors that we see reflected from objects of different wavelengths. Ultraviolet radiation occurs at the lower end of the visible spectrum between wavelengths of 0.01-0.40µm and can be dangerous to humans. Radiation emitted at wavelengths beyond the visible spectrum at 0.76-100µm are classified as infrared.





Different objects may emit and absorb different amounts of radiation per unit of surface area. A blackbody is a perfect emitter and absorber of radiation. It absorbs all incident radiation regardless of wavelength and direction. The emitted radiation is a continuous function of radiation and at any specified temperature, it increases proportionally with wavelength, reaches a peak, and then begins decreasing inversely with wavelength. The point at which it reaches the peak is given by Wein's displacement law. As temperature increases, the curves showing the emissive power shift to the left to the shorter wavelength region. This means that a larger range of the emitted radiation occurs at the shorter wavelengths.