Cooling Load problem

A small Company Contains two rooms, each room $(4 * 10 * 4)\ m^3$, the walls made from three layers, (Concrete, Brick red and Concrete). the first room has a glass window $(1.25 \times 1.5)\ m^2$. the Second room has a glass window $(1.5 \times 2)\ m^2$. The first room Contains three office workers and one waiter. The second room Contains two office workers, one head office and two cleaners. the first room Contains three Computers, one Coffee machine and eight lamps. the second room Contains three Computers, one microwave and ten lamps. Calculate the Cooling load of the Company. take in account:

- The average heat of person 200 watt.
- power of computer 250 watt, $\eta = 90\%$.
- power of Coffe machine 100 watt, $\eta = 85\%$
- Power of Microwave 450 watt, $\eta = 95\%$.
- power of lamp 60 watt.
- the mass flow rate of the ventilated air 0.2 Kg/sec.
- Neglect the effect of humidity in ventilation
- out side temperature 38°C, Required inside 24°C

* Cooling load calculations:

تنقسم الاحمال الحرارية الى نوعين ، داخلي وخارجي.

1- Internal load: الاحمال الداخلية

a) light: من الإضاءة

$$Q = A \cdot q \cdot n \quad (watt)$$

- n ← عدد اللمبات
- q ← lamp power (watt/m²)
- A ← مساحة الغرفة (m²)

ملاحظة: تهمل المساحة في حالة اعطاء الـ(q) بالـwatt.

b) Equipments: الاجهزة والمعدات

$$Q = (1-\eta)\,E \quad (watt)$$

- E ← power of equ.
- η ← efficiency

c) Persons: الاشخاص

$$Q = n \cdot q/person \quad (watt)$$

- n ← عدد الاشخاص
- $q/person$ ← متوسط كمية الحرارة لكل شخص

d) ventilation: التهوية

$$Q_{vs} = \dot{m}_v \cdot c_p \cdot (t_o - t_i) \quad (watt)$$

- Q_{vs} ← كمية الحرارة من الهواء الجاف
- $\dot{m}_v$ ← معدل تدفق الهواء Kg/sec
- c_p ← الحرارة النوعية = 1.005 KJ/Kg.°C
- t_o ← درجة الحرارة بالخارج °C
- t_i ← درجة الحرارة بالداخل °C

$$Q_{V.L} = \dot{m}_v \, [H_o - H_i] \quad \text{(Watt)}$$

- $Q_{V.L}$ ← كمية الحرارة من الهواء الرطب
- $\dot{m}_v$ ← معدل تدفق الهواء kg/sec
- H_o ← الطاقة الكلية طبقاً لنسبة الرطوبة بالخارج
- H_i ← الطاقة الكلية طبقاً لنسبة الرطوبة بالداخل.

2 - External load : الاحمال الخارجية

a) Heat transimition through walls & windows: انتقال الحرارة من الخارج الى الداخل

$$Q = U \cdot A \cdot (t_o - t_i) \quad \text{(watt)}$$

- U ← معامل انتقال الحرارة $(W/m^2\,^{\circ}C)$
- A ← مساحة الحوائط (m^2)
- t_o ← درجة الحرارة الخارجية $^{\circ}C$
- t_i ← درجة الحرارة الداخلية $^{\circ}C$

$$U = \frac{1}{h_o} + \frac{1}{h_i} + \frac{L}{K} + \cdots$$

- L ← سمك الحائط او الشباك (m)
- h_o ← معامل انتقال الحرارة عن طريق الحمل بالخارج (معطى)
- h_i ← معامل انتقال الحرارة عن طريق الحمل بالداخل (معطى)
- K ← معامل انتقال الحرارة عن طريق التوصيل خلال الحائط او الشباك (من الجداول)

Given:

$h_o = 25 \ W/m^2K$

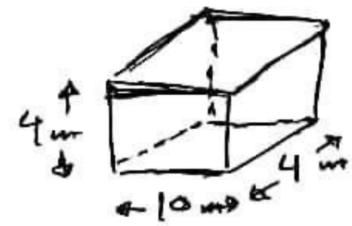
$h_i = 30 \ W/m^2C$

$L_{concrete\, o,i} = 5 \ mm$ سُمك الحجر للعمارة بالداخل والخارج

$L_{Brick,\, red} = 10 \ Cm$ سُمك الطوب الاحمر

$L_{glass} = 5 \ mm$ سُمك الزجاج

For room number one:



***Internal load:**

a) light : $Q = q \cdot n$

$Q = 60 * 8$

$= 480$ watt # 1

b) Equipments: $Q = (1-\eta) E$

$Q_{computers} = (1-0.9) * 250 * 3$

$= 75$ watt # 2

$Q_{coffee machine} = (1-0.85) * 100$

$= 15$ watt # 3

c) persons: $Q = n \cdot q/person$

$= 4 * 200 = 800$ watt # 4

d) ventilation: $Q_{v,s} = \dot{m}_v \cdot c_p \cdot (t_o - t_i)$

$Q_{v,s} = 0.2 * 1.005 * 10^3 * (38-24)$

$= 2814$ watt # 5

$Q_{v,L} = \dot{m}_v [H_o - H_i]$ neglect.

* ملحوظة: في حالة عدم اعطاء ال $\dot{m}_v$ نهمل حساب كمية الحرارة عن طريق ال ventilation.

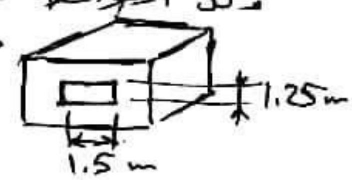
***External load:**

a) Heat transmitted through walls:

* نفرض ان الحائط الاكبر به الشباك مثل الحوائط معرضة لإنتقال الحرارة ماعدا الارضي و السقف.

$Q = U \cdot A \cdot (t_o - t_i)$

$U = \frac{1}{h_o} + \frac{L_{Co}}{K_c} + \frac{L_{Br}}{K_{Br}} + \frac{L_{Ci}}{K_c} + \frac{1}{h_i}$



* الحائط يتكون من ثلاث طبقات:

6) Heat transmitted through window :

$$Q_{window} = U \cdot A \cdot \Delta T$$

$U = 0.08 \ w/m^2 \cdot C$ نفس القيم السابقة

$$Q_{wind.} = 0.08 \times (1.5 \times 2) \times (38 - 24)$$

$$= \underline{3.36 \text{ watt}} \quad \# 7$$

* The cooling load of room number two :

$$Q_{C,2} = 600 + 75 + 22.5 + 2814 + 1000 + \text{Zero} + 385.31 + 3.36 = \boxed{4900.17 \text{ watt}}$$

* The total cooling load of Company :

$$Q_{C,T} = Q_{C,1} + Q_{C,2}$$

$$= 4575.39 + 4900.17$$

$$= \boxed{9475.56 \text{ watt}}$$

من ال watt لـ ton ref. نقسم

على 3516 .

$$Q_{C,T} = \boxed{2.7 \text{ ton ref.}}$$

من الجداول :

$K_C = 0.8 \ w/mK$

$K_{B,r} = 0.6 \ w/mK$

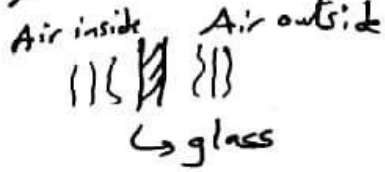
$$U = \frac{1}{25} + \frac{5\times10^{-3}}{0.8} + \frac{10\times10^{-2}}{0.6} + \frac{5\times10^{-3}}{0.8} + \frac{1}{30} = 0.2525 \ w/m^2.C$$

$$Q_{wall} = 0.2525 * [2(4*4) + (4\times10) + ((4\times10)-(1.5*1.25))] * (38-24)$$
$$= 389.29 \text{ watt} \quad \#6$$

b) Heat transimitted through window :

الشباك مكون من طبقة واحدة

$$Q_{window} = U.A.(t_o - t_i)$$



$$U = \frac{1}{h_o} + \frac{L_g}{K_g} + \frac{1}{h_i}$$

$K_g = 0.8 \ w/mK$: من الجداول

$$U = \frac{1}{25} + \frac{5\times10^{-3}}{0.8} + \frac{1}{30} = 0.08 \ w/m^2 K$$

$$Q_{window} = 0.08 * (1.5 * 1.25) * (38-24)$$
$$= 2.1 \text{ watt} \quad \#7$$

* the Cooling load of room number one :

$$Q_{C,1} = Q_{Lights} + Q_{Computers} + Q_{Coffee\ machine} + Q_{persons} + Q_{V,S} + Q_{V,L} + Q_{walls} + Q_{windows}$$

($Q_{V,L}$ → 0)

$$480 + 75 + 15 + 800 + 2814 + \text{zero} + 389.29 + 2.1 = \boxed{4575.39 \text{ watt}}$$

For room number two:

* Internal load:

a) light: $Q = q \cdot n$

$= 60 \times 10 = 600$ watt #1

b) Equipments: $Q = (1-\eta)E$

$Q_{comp.} = (1-0.9) \times 250 \times 3$

$= 75$ watt #2

$Q_{Micro} = (1-0.95) \times 450$

$= 22.5$ watt #3

c) persons: $Q = n \cdot q/person$

$= 5 \times 200 = 1000$ watt #4

d) ventilation: $Q_{v,s} = \dot{m}_v \cdot C_p \cdot (t_o - t_i)$

$= 0.2 \times 1.005 \times 10^3 \times (38-24)$

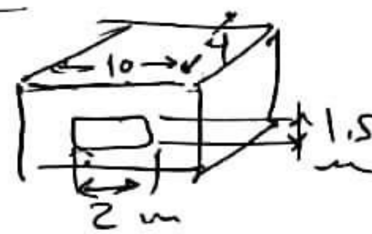
$= 2814$ watt #5

$Q_{v,L} = $ Zero (neglect)

* External load:

a) Heat transmitted through walls:

$Q_{wall} = U \cdot A \cdot (t_o - t_i)$



$U = 0.2525$ w/m²C

نفس القيم السابقة

$Q_{wall} = 0.2525 \times [2(4 \times 4) + (4 \times 10) + ((4 \times 10) - (1.5 \times 2))] \times (38-24)$

$= 385.31$ watt #6

Thermal Conductivity

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Tables

Reference Young Ch 15.

Material	Thermal conductivity (cal/sec)/(cm^2 C/cm)	Thermal conductivity (W/m K)*
Diamond	...	1000
Silver	1.01	406.0
Copper	0.99	385.0
Gold	...	314
Brass	...	109.0
Aluminum	0.50	205.0
Iron	0.163	79.5
Steel	...	50.2
Lead	0.083	34.7
Mercury	...	8.3
Ice	0.005	1.6
Glass,ordinary	0.0025	0.8
Concrete	0.002	0.8
Water at 20° C	0.0014	0.6
Asbestos	0.0004	0.08
Snow (dry)	0.00026	...
Fiberglass	0.00015	0.04
Brick,insulating	...	0.15
Brick, red	...	0.6
Cork board	0.00011	0.04
Wool felt	0.0001	0.04
Rock wool	...	0.04
Polystyrene (styrofoam)	...	0.033
Polyurethane	...	0.02
Wood	0.0001	0.12-0.04
Air at 0° C	0.000057	0.024
Helium (20°C)	...	0.138
Hydrogen(20°C)	...	0.172
Nitrogen(20°C)	...	0.0234
Oxygen(20°C)	...	0.0238
Silica aerogel	...	0.003

*Most from Young, Hugh D., University Physics, 7th Ed. Table 15-5. Values for diamond and silica aerogel from CRC Handbook of Chemistry and Physics.

Note that 1 (cal/sec)/(cm^2 C/cm) = 419 W/m K. With this in mind, the two columns above are not always consistent. All values are from published tables, but can't be taken as authoritative.

The value of 0.02 W/mK for polyurethane can be taken as a nominal figure which establishes polyurethane foam as one of the best insulators. NIST published a numerical approximation routine for calculating the thermal conductivity of polyurethane at http://cryogenics.nist.gov/NewFiles/Polyurethane.html . Their calculation for freon filled polyurethane of density 1.99 lb/ft^3 at 20°C gives a thermal conductivity of 0.022 W/mK. The calculation for CO_2 filled polyurethane of density 2.00 lb/ft^3 gives 0.035 W/mK .

Heat conduction discussion