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Heat load and Duct Design of Economical Air Duct - A Case Study at Stress Analysis Lab in Anjuman College of Engineering and Technology Nagpur

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1.1 INTRODUCTION

In today's circumstances using an air conditioner is not an optimal option as it consumes lot of electricity and we get a hefty electricity bill. For conversation of energy and to save money on electric bills opting for an air cooler ducting (HVAC) is the best option under such circumstances. As the college's is present in a hot and less humid region it justifies the use of air cooler ducting more than an air conditioner. The air cooler duct is designed on calculations referring from the ISHRAE books- Load Calculation Applications Manual and duct system and design guide.

2.1 HEAT LOAD CACULATION

I. Two types of wall area
   1. Gross wall
   2. Net wall area

Q = U x A x T

Where,

U= Overall heat Coefficient.

U= 1/ sumR

sumR = (Resistance of susbtance)

A= 34.6 x 16.2

= 560sq.ft

Δt = 106-76 = 30°F

1. Gross wall area

Q = U x A x T

A= 179 sq.ft

Δt = 30°F

ISHRAE STANDARD VALUES

SumR = $0.25 + \frac{1}{2} \times (0.12) + (8 \times 0.2) + \frac{1}{2} \times 0.12 + 0.25$

SumR = 2.2

U = $\frac{1}{SumR} = \frac{1}{2.2} = 0.45$ BTU/hr. F.Ft

$\therefore$ Q = UAΔt

Q= 0.45 x 138 x 30

Q= 1863 BTU/hr (1w = 3.14 BTU/hr)

Q= 593.31W

Q= 0.593kW

2. Roof area

Q= U x A x ΔT

U = $\frac{1}{SumR}$

U= $\frac{O}{A} \times \frac{1}{2} \times (C.P) + 8 inch\ brick + \frac{1}{2} \times (C.P) + I.A$

U= $0.25 \times \frac{1}{2} + 0.12 + 8 \times 0.08 + \frac{1}{2} \times 0.12 + 0.65$

SumR = 1.72

TAKING STANDARD ISHRAE VALUES

U =$\frac{1}{SumR} = \frac{1}{1.72} = 0.58$ BTU/hr F.ft

A = 30 x 14

A = 420sq.ft

ΔT = 106 – 76 = 30F

Q = U x A x T

Q = 0.58 x 420 x 30

Q = 7308 BTU/hr F.ft

Q = 2327.38 W

Q = 2.32 kW

Internal heat load

1. **People heat load**
2. **Lighting heat load**
3. **Electrical heat load**

1. **People heat load**

$$Q_s = \frac{\text{Sensible heat}}{people\ \times no.of\ people}$$

$$Q_l = \frac{\text{Latentheat}}{peoplw\ \times no.of\ people}$$

Ex. Lab room = 420 sq.ft = 3 people

Sensible heat (from the carts of ISHRAE)

For seated light office work = 245

Latent heat (from the carts of ISHRAE) = 155

Q_s = 245 x 3

Qs = 0.735 BTU/hr = 0.23 kW

Q_l = 0.465 BTU/hr = 0.14 kW

2. **Lightning heat load**

Q = watt/ sq.ft x 3.4

For office = 1.1 watt/sq.ft

Q = 1.1 x 420 sq.ft x 3.4

Q = 1570.8 BTU/ hr

Q = 0.50 kW

3. Electrical heat load

Q = total equipment load (watts) x 3.4

Q = 440 x 3.4

Q = 1,496 BTU/hr

Q = 438.70 w

Q = 0.45kw

TOATL HEAT =4.5KW

SINCE 3.5 KW = 1 TON OF AIR CONDITIONING

THEREFORE 4.5 KW = 1.3 TON ≈ **1.5 TON OF AIR CONDITIONIG**

A 1.5 ton air conditioner (AC) typically uses 1.2–1.5 kilowatt (KW) of electricity per hour, depending on the temperature. For example, a 5-star AC uses about 1.5 KW per hour, while a 3-star AC uses 1.6 KW per hour. If the AC is used for 7 hours a day, it might consume around 360–480 units of electricity in a month

According to Maharashtra (India) price of electricity per units = 7 rupees per unit consumed

Assuming 480 units consumed per month = 7 x 480 = **3,360 rupees per month**

Therefore going for a cooler ducting is an optimal solution to reduce the power consumption

2.2 DUCT DESIGN BY EQUAL FRACTION METHOD

M° = Q/ cp x ∆T

Where,

(M) mass flow rate = kg/s

Q(kW) heat load = 4.5 kW

Cp = Specific heat capacity (kJ/kgK)

= Cp1.026 (kJ/kgK) (standard value from ISHRAE)

∆T = temperature difference

∆T should be less than 10 °C

∆T = 8°C

M° = 4.5/1.026 X 8

M° = 0.6kg/s

M=kW/ (kJ/kgK.8K)

Density of Air = 1.2 kg/m3

Specific volume = Density-1.2-1 = 0.833 m3/kg

Formula: -

V ° = M° X v

V° = volume flow rate (m3/s)

M °= mass flow rate (kg/s)

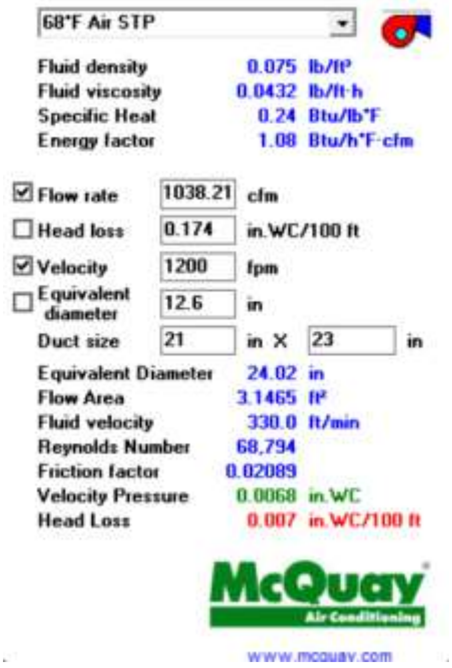
v = specific volume (m3/kg)

v = 0.6 X 0.833V=0.49 m3/s (1cubic meter/second = 2118.8 cfm)

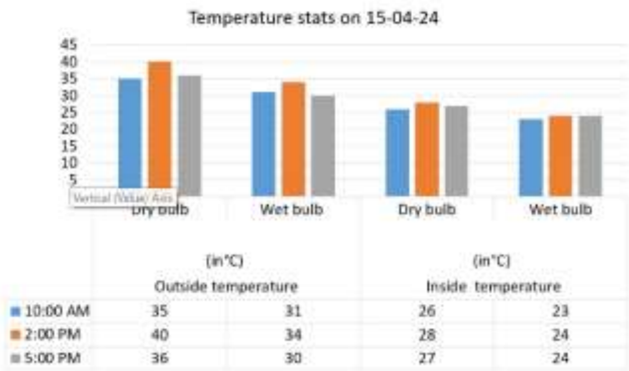
So,

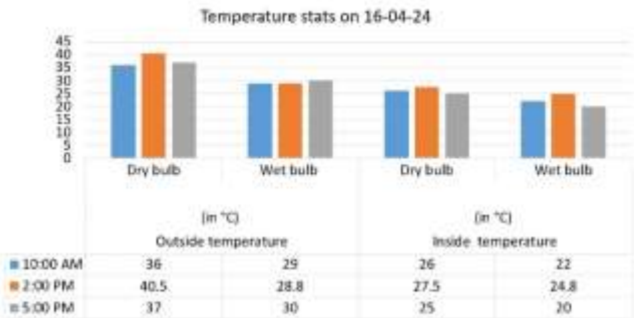
V °= 0.49 x 2118.8

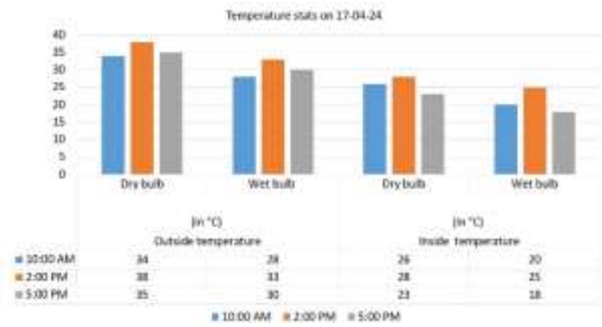
V °= 1038.21 cfm



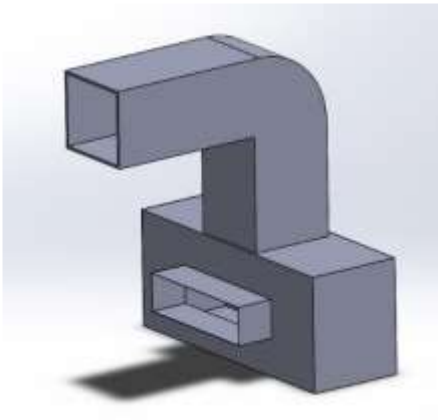
3.1 EXPERIMENTATION

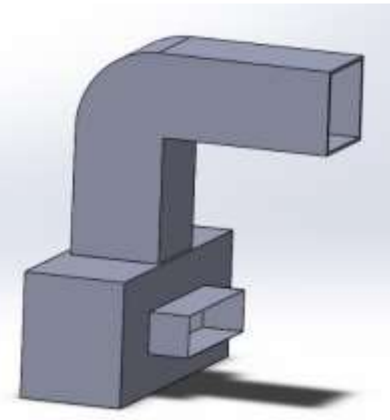






4.1 CAD MODEL OF ROOM AND 3D CAD OF DUCT





4.1 Conclusion

We were successful installing and operating our project with efficient utilization of resources. Hence we were able to provide ambient temperature, which was comfortable for teachers and students.

By taking in considering all the heat load factors while calculation of size of duct, we meet our goal to provide the necessary comfortable conditions to the students and teachers in Stress analysis lab

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