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Design and Calculations of Economical Ducting for Stress and Analysis Lab

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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.

1.1 IMPROVEMENTS

a) Compact duct = we opted for a compact duct so there will be less airflow loss and heat loss. The compact duct makes the construction and assembly cheap and easy to repair.

b) Use of wood wool = using wood wool make the construction cheap and wood wool can be replaced as it available in vast amount and is cheap so it's also user budget friendly, as wood wool don't react much on hard and soft water as compared to honeycomb pads it make wood wool a better option.

c) Insulation = insulation is an important role to avoid heat loss and to insulate the cooler air coming for the air cooler. As the duct is made from steel or aluminium it can gain the heat from the surroundings so use of an insulating is important as in this project we used cross-link 10 mm insulation.

d) Proper sealing = proper sealing have been put between the joint parts to restrict th airflow loss the the environment from the leak joints

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

∴ 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 ΔT

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)

ΔT = temperature difference

ΔT should be less than 10 °C

ΔT = 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

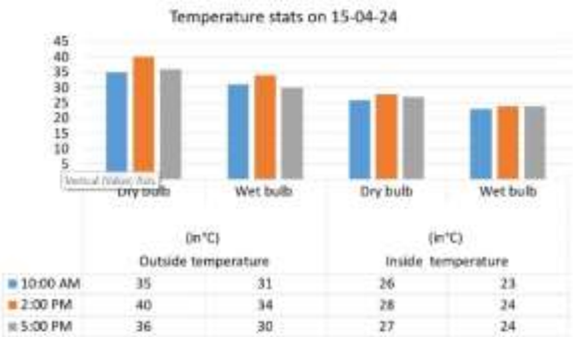
V °= 1038.21 cfm

3.1 EXPERIMENTATION

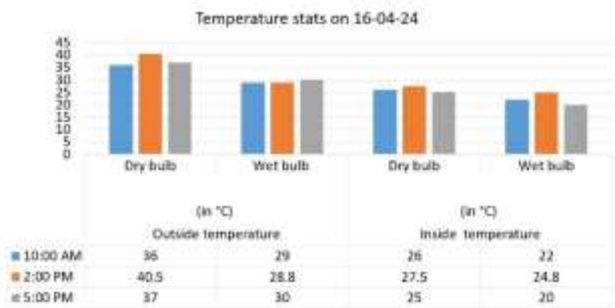
An experiment was conducted to see the effectiveness of the installed duct using scientific thermometer

Fig 1.1 – reading on thermometer

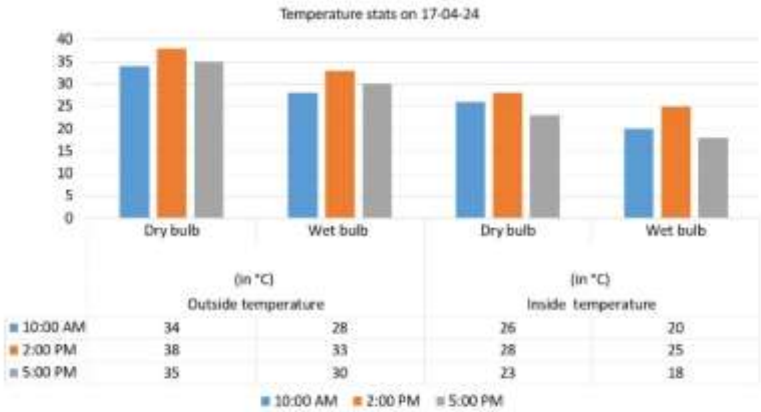
On 15th April-



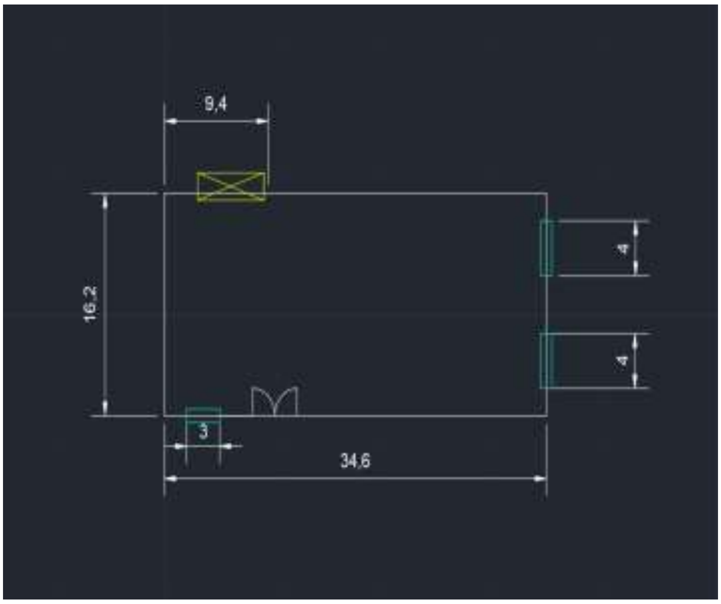
On 16th April-



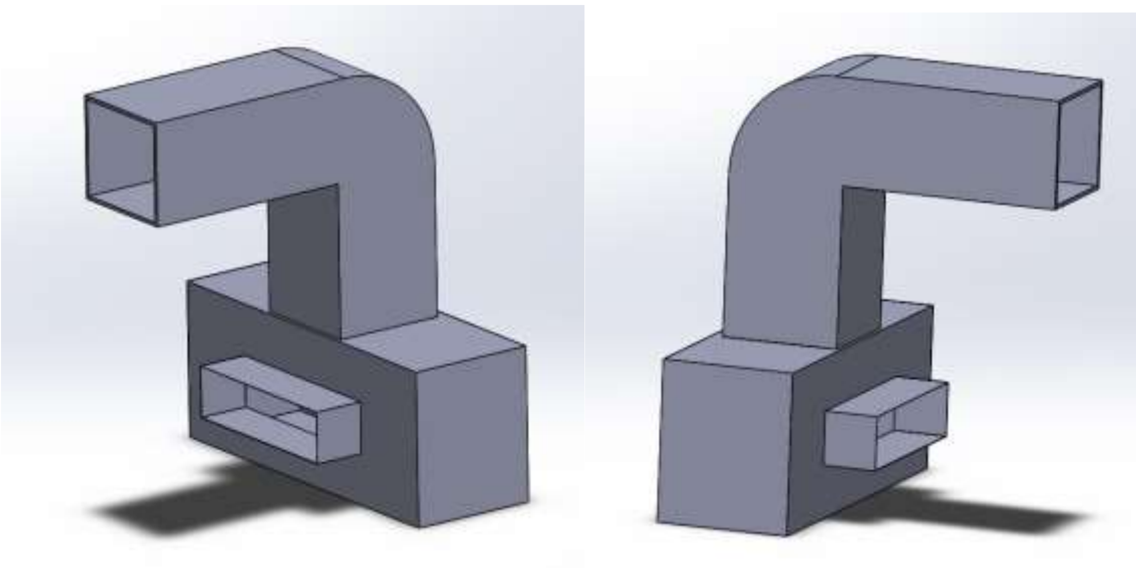
On 17th April-



3.2 CAD MODEL OF STRESS AND ANALYSIS LAB



3.3 3D MODEL OF THE DUCT



3.4 ACTUAL AIR COOLER DUCTING