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REDESIGNING AND FABRICATION OF EXISTING DUCT SYSTEM

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Abstract

Buildings' ability to maintain thermal comfort and indoor air quality depends heavily on their duct systems. However, many of the current duct systems have inadequate design and manufacture, which results in subpar performance and energy waste. The goal of this review paper is to provide an overview of recent developments in the redesign and fabrication of existing duct systems, including the use of computational fluid dynamics (CFD) simulations, sophisticated fabrication techniques, and smart materials that create a network of airflow pathways through buildings. These systems, however, may eventually become out-of-date, ineffective, and in need of revision. In this article, we evaluate current innovations in the redesign and fabrication of existing duct systems, emphasizing improvements in materials, manufacturing processes, and design methodologies.

Introduction

The aim of this research is "Redesign and Fabrication of Existing Duct System". Cooling the entire room using duct system is our overall comfort requirement. Sufficient ductwork in classroom will reduce hot and cold spots in classroom by providing consistent, even temperatures throughout classroom as well as air balancing. Under present circumstances, it becomes necessary to find a solution for effective cooling and thus a good duct and fan selection is necessary to achieve this objective. The Target of this project is to examine and analyze the factor and conditions regarding duct design and installation. Air will be cleaner with fewer dust particles, allergens, and germs floating in the air. The better the air circulates through a home, the more you filter will eliminate these hazards.

OBJECTIVE

1) To provide Air cooling with reduced power consumption
2) Create a Reliable system
3) Reduce frictional losses
4) Optimum utilization of space
5) Proper air distribution through-out classroom
6) To Reduce noise

LITERATURE SURVEY

1. Effects of wall admittance changes on duct transmission and radiation of sound by D.L. Lansing and W.E. Zorumski's

   State that how changes in the acoustic characteristics of duct walls affect sound transmission via ducts. The study explores the impact of a single modification in duct wall acoustic admittance in a rectangular infinite-length duct with airflow. The acoustic behavior and sound transmission properties of these ducts are examined by the authors.

2. Corrugated-Duct Heat Transfer, Pressure Drop, and Flow Visualization by J. E. O'Brien and E. M. Sparrow's
   State that tests done to measure the pressure drop, flow visualization, and forced convection heat-transfer coefficients in a corrugated duct. The performance of heat transmission and pressure drop characteristics of flow in a duct with corrugated walls are investigated by the authors. They also offer visualizations of the duct's flow patterns.

3. Fully Developed Pressure Drop in Triangular Shaped Ducts by L. W. Carlson and T. F. Irvine's
   State that concentrate on determining the pressure drop in a triangular-shaped duct's hydrodynamic section. The purpose of the study is to comprehend the behavior of pressure drop under fully developed flow circumstances. The authors offer insights into the flow characteristics and energy losses in triangular-shaped ducts by analyzing the pressure drop.

4. Duct Designing in AC system & its Impact on system Performance by G.S. Sharma And Brijesh Sharma
   State that theoretically it is known that the pressure drop for a typical system comprising of straight ducts, bends and diffusers is lower for a circular duct system than for a rectangular. Therefore one can very well conclude that for optimization of duct it is preferred to use circular cross section instead of rectangular duct system for the above application; great saving can be obtained in terms of operating cost.

5. Optimization of Heat Transfer through Rectangular Duct by Ravi Teja And Mandar Vahadne

State that the velocity distribution in 180 sharp corner rectangular duct shows that, at the corner points or at the sharp edged corners gives us stagnation point where the velocity at those point is zero hence the heat transfer rate at stagnation point is found to be maximum.

6. Duct Inspection And cleaning Robot by Aditya Pratap Singh And Jitin Malhotraj
   State that the ducts are the house of various impurities, dust, bacteria and fungi that reduce the air conditioning capacity and are harmful to humans. So after using this robot with cleaning brushes that clean the ducts and lead the tubes free from fungi, bacteria, and dust free ducts, we get some significant results. In this experiment, we measured the values of dust in gm/m^2. While using it with various types of the ducts, we have got the max. Improvement of 98.22%.

7. Pressure Drop In And Noise Radiation From Rectangular And Round Ducts by O.A.B. Hassan And Z. Yue
   State that Pressure loss through a rectangular duct is significantly higher than a volumetrically equal round one. In rectangular systems, the pressure loss increases with increasing aspect ratio. In rectangular ducts, it is also challenging to measure the turbulent friction factor accurately. The measurement data in the literature unmistakably demonstrate that the friction factor's prediction inaccuracy always rises as aspect ratio increases.

Specifications of the classroom

1. Sitting Capacity =80people
2. No Of Fans =4
3. No Of Light =6(3 LED & 3 CFL)
4. Projector =1
5. No Of Windows =6
6. No Of Doors = 2
7. Area Of Roof = Area Of Floor=75.80 Sq.m

Heat emitting sources in the classroom

1) Peoples sitting in classroom
2) Numbers of Lights, fans other electrical appliances in the classroom
3) Windows exposed to sun
4) Walls in direct contact with sun
5) Walls not in direct contact with sun
6) Roof
7) Floor

Duct: - A duct is a hollow conduit or passage used to transport air, gases, or fluids from one location to another. In the context of cooling systems, a duct is an enclosed pathway that distributes cooled air from a central air conditioning unit or air cooler to various areas within a building or space.

Types of duct :-

1) Circular duct
2) Rectangular duct
3) Square duct

Different methods of duct design

1) Velocity reduction method
2) Equal friction method
3) static Regain Method

DUCT DESIGN BY EQUAL FRICTION METHOD
(Design Tools Duct Sizer Version 6.4 McQuay)

M° = Q/(CP X ΔT)

where,

M° = mass flow rate kg/s
Q = (kW) heat load
Cp = Specific heat capacity (kJ/kgK)
ΔT = temperature difference
Cp = 1.026 (kJ/kgK) (standard value from ISHRAE)
ΔT = should be less than 10 °C
= 14.07 kW Total Heat Transfer
M° = 2.07 kg/s

M° = kW/(kJ/kgK.8K)
Density of Air = 1.2 kg/m3
Specific volume = Density-1
= 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 = 2.07 X 0.833
V = 1.73 m3/s (1cubic meter/second = 2118.8 cfm)

So,
v = 1.73*2118
= 3665 cfm

Considering factor of safety of 2.73
v = 3665×2.73=10,005CFM

LOSSES IN DUCTS

(A) FRICTION LOSSES:-

$$\mathbf{P_{fr1}} = \frac{\mathbf{f1l1{v_1}^2}}{\mathbf{2\times\frac{dr1}{4}}}$$

Where f_1 = C-efficient of friction
L_1 =Length of duct 1 of right branch
V_1 =Velocity of air in duct 1 of right branch
D_{r1} =Diameter of first duct

Now,

$p_f = \frac{0.3164}{R_e}$ (For turbulent flow)

$$R_e = \frac{\rho vd}{\mu}$$

$$R_e = \frac{1.13 \times 6 \times 0.67}{19.12 \times 10^{-6}}$$

$= 237.58 \times 10^3$

$$P_f = \frac{0.3164}{237 \times 10^3}$$

$= 1.33\times 10^{-6}$

$$P_{fr1} = \frac{1.33 \times 10^{-6} \times 1.524 \times 6^2}{2 \times \frac{0.68}{4}}$$

$= 2.178 \times 10^{-4}$m of air

Similarly,

$$P_{fr2} = \frac{1.59 \times 10^{-6} \times 1.524 \times 6^2}{2 \times \frac{0.55}{4}}$$

$= 3.178 \times 10^{-4}$m of air

$$P_{fr3} = \frac{2.287 \times 10^{-6} \times 1.524 \times 6^2}{2 \times \frac{0.39}{4}}$$

$= 6.436 \times 10^{-4}$ m of air

For left branch

$$P_{fr4} = \frac{2.287 \times 10^{-6} \times 1.524 \times 6^2}{2 \times \frac{0.39}{4}}$$

$=6.436 \times 10^{-4}$ m of air

Total friction loss

$P_f = P_{fr1} + P_{fr2} + P_{f3} + P_{fr4}$

$= 2.178 \times 10^{-4} + 3.178 \times 10^{-4} + 6.436 \times 10^{-4} + 6.436 \times 10^{-4}$

$= 18.228 \times 10^{-4}$m of air

(B) CONTRACTION LOSSES

$\mathbf{P_c = k_1 \times k_{r1} \times (\frac{v}{4.04})^2}$ mm of air

$=0.0267$ mm of air

(C) BENDING LOSSES

Assuming 10% loss occurs due to bends provided in our system

∴Loss of flow rate due to bend = $0.1 \times 10322\ m^3/h = 1032.2\ m^{-3}/Hr.$

Power loss due to friction and contraction is=$\rho \times g \times Q \times h_f$

Where $h_f = P_f + P_c$

$= 18.228 \times 10^{-4} + 0.0267 \times 10^{-3} = 1.85 \times 10^{-3}$ m

∴Power loss due friction and contraction= $1.13\times 9.81\times 2.87 \times 1.85 \times 10^{-3}$

=0.058 watt

Which is very small as compared to power input for 24 inch fan i.e., 500 watt as per specification.

Therefore, the major loss is due to bends.

(D)SIZE OF DUCT

We have flow rate = 2.87 m^3/sec

For left branch

Flow rate = 0.25×2.87

= 0.7175 m^3/sec

Now we have

Flow rate = area × velocity

0.7175=area ×6

Area=0.119 m^2

∴Dianeter, D_L = 0.39 m

For right branch

Flow rate = 0.71 × 2.87

= 2.1525 m^3 /sec

Now for first duct of right branch

Flow rate=area×velocity

2.1525 =area ×6

Area =0.3587 m^2

∴ D_{r1} = 0.67m

For second duct of right branch

Flow rate = area×velocity

1.435=area×6
Area =0.239 m²

D_{r2}= 0.55m

For third duct of right branch

Flow rate =area × velocity

Flow rate = 0.25 × 2.87

= 0.7175 m^3 /sec

0.7175=area ×6

Area = 0.119 m²

∴Diameter, D_{r3} =0.39 m

Rectangular equivalent for diameter

$$D = \frac{1.265(a\times b)^{0.6}}{(a+b)^{0.2}}$$

Where a and b are sides of rectangular cross section

Now for D_{r1} Rectangular cross section = 32 × 16

For D_{r2} Rectangular cross section = 26 × 16

For D_{r3} Rectangular cross section = 18 × 16

For D_L-Rectangular cross section = 18 × 14

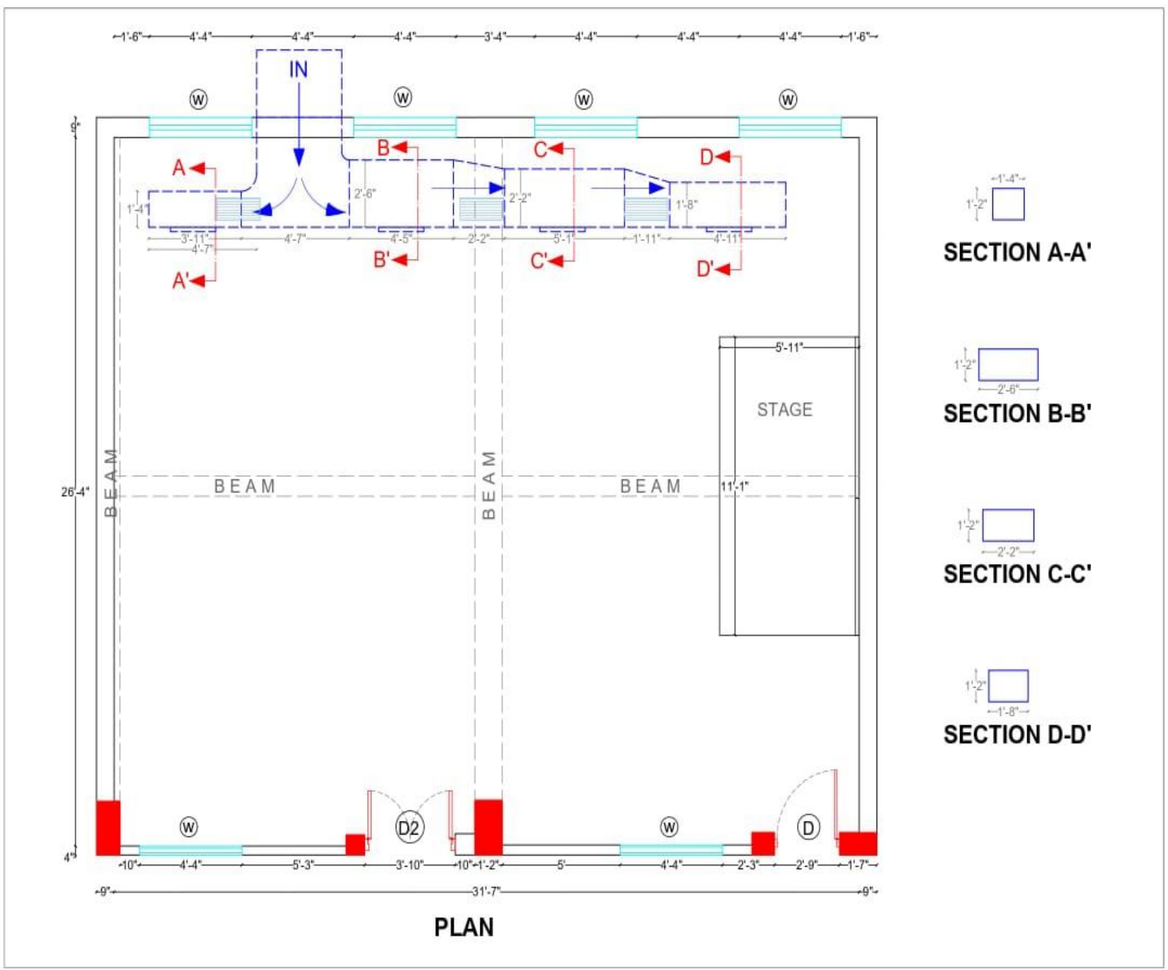
Required Specifications of duct and cooler

1) Cooler:-
   Metal body cooler
   3Wood Wool pads
   900 rpm motor
   33'' fan made of fiber
   2 water pumps

2) Duct :-

GI sheet material
Gauge:- 24
Powder coated double deflection aluminum grills

Proposed design:-



Conclusion :-

In conclusion, redesigning and fabricating current duct systems can result in considerable enhancements in indoor air quality, thermal comfort, and energy economy. CFD simulations, sophisticated fabrication methods, and intelligent materials can be used to optimize duct design, lower fabrication errors, and enhance duct performance. These improvements in duct system design and fabrication are crucial for creating green and energy-efficient structures, which also lower operating costs and enhance occupant quality of life. In the HVAC business, redesigning and fabricating existing duct systems is a significant area for research and development. Modern duct systems that can be tailored for a variety of purposes are more effective, long-lasting, and versatile thanks to advancements in materials, construction methods, and design principles. We might expect more innovation in this area as the demand for energy-efficient buildings expands, with the potential for even greater energy and operating cost savings.

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