A Review on Design of Ducting System for the Commercial Mall and Evaluating Flow Conditions by using CFD

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Abstract— This paper focuses on study of design and modifications air cooling duct using Computational Fluid Dynamics (CFD) analysis considering all air flow features relating to the duct system efficiency. HVAC system is widely used in residential, hotels, malls, hospital to provide thermal comfort and to maintain good indoor air quality. Design, optimization and numerical analysis of air flow characteristics in HVAC duct based on the optimization approach for the effective and efficient evaluation of HVAC duct layout, alternatives at the design stage to get the optimal duct layout results. Adequate tools and methods are now to design efficient air-cooling systems. Failure in correctly applying different load conditions to the structure of ducts and the layout of the ducting system leading to problems such as uneven cooling across the cooling space, greater frictional losses, steeper installation costs & increased noise and power consumption levels. The above cooling issues highlight the need for optimizing duct design especially to provide improved flow conditions. We used the soft wares like solidworks, ansys, revit to bring the positive out comes that collaboratively bring the results. It combines theoretical and software enabled tools to provide a detailed comparative analysis of the costs and benefits involved in selecting a particular shape (rectangular or circular) of duct for a prescribed situation. The focus of this paper will be on using CFD software tools to study velocity distribution of air in the duct at various sections, pressure difference at various outlets and distribution of air flow for different load conditions.

Keywords: HVAC, Duct, ASHRAE, CFD, PRESURE DROP, VELOCITY

I. INTRODUCTION

Earlier the use of air-conditioning for comfort purpose was considered a luxurious but now-a-day, it has been a necessity in extreme climatic conditions, such as extreme cold and hot in western countries. Window air conditioners are preferred for office rooms while large centralized units are installed for conditioning the auditorium, hospitals etc. The correct estimation of cooling load of large area is very complicated due to many factors such as outdoor temperature, humidity, air leakage into the conditioned space, occupants, quantity of fresh air taken in and solar load etc. The climate condition at workplace like offices, workshops is also important factor while selecting optimum design for air cooling duct, this results in efficient and comfortable working conditions. In order to achieve required cooling load, proper method is required. Proper air distribution is achieved with proper duct design which leads minimum losses in the system, suitable selection of fan with high efficiency, optimum air velocity in duct, inlet and outlet of fan. Today some software's are available to estimate cooling load, to design the duct, to select the fan etc. CFD as a analysis tool has the ability to establish firm quantitative data regarding air motion and can predict fluid characteristics and pressure differentials to a very low level that are experimentally impossible during experimentation. Analysis of airflow in duct with static pressure and velocity pressure is made easier and faster in Fluent software.

A. Duct System

Ducts are conduits or passages used in heating, ventilation, air conditioning (HVAC) to deliver and remove air. The needed air flows include, for example, supply air, return air and exhaust air. Ducts commonly also deliver ventilation air as part of the supply air.

As such, air ducts are one method of ensuring indoor air quality as well as thermal comfort. A duct system is also called as duct work. Planning (laying out), sizing, optimizing, detailing, and finding pressure losses through a duct system is called duct design.

B. HVAC Duct Design

1) Duct System

SAD = (Supply Air Duct)
It is defined as the conditioned air being supplied from the air conditioner outlet. This air is treated air & contains all the desired qualities as provided by the air conditioning system.
RAD = Return Air Duct
It is defined as the air being supplied back to the air conditioner from the air conditioned area. This air is returned back to the air conditioner after being circulated in the conditioned area.
Return air path should be 1.25 to 1.5 times the Supply air path
FAD = Fresh Air Duct
It is defined as the ambient air being supplied to the air conditioner inlet from the outside atmosphere. This air is supplied to the air conditioner inlet from the outside atmosphere after being initially treated.

2) Duct Shape

1) Rectangular duct
2) Circular duct
3) Square duct
4) Space do not require specific positive pressure.

3) Duct Materials

1) G.I (galvanized iron)
Low Cost & Easy Fabrication
2) Fiber Glass Duct
Low velocity application only otherwise heavy vibration will generate.
3) Thick Black Mid Steel
This sheet are used for exhaust duct.
4) PUF (polyurethane foam)

Duct are flexible & do not require insulation a PUF is an insulation material. But it is costly & may generate toxic gases in case of fire.

C. Classification of Ducts

1) Low Pressure Duct Work

1) Velocity <600mpm & static pressure S5cm of H20 gauge.
2) No specified requirements of class of cleanliness.

2) Medium Pressure Duct Work

1) velocity <600mpm & static pressure 5-15cm of H20 gauge.
2) No specified requirements of class of cleanliness.

3) Medium Pressure Duct Work

1) velocity <600mpm & static pressure 5-15cm of H20 gauge.
2) Specified class of cleanliness often incorporates debarring (exclude) of coil, absolute filters, supply, Return, Exhaust & Fresh air ducts.
3) Clean room application require Medium pressure duct work because heavy pressure loses take place through high efficiency filters.
4) Care to be taken to seal all duct joints to prevent leakage. Joint should be soldered or sealed with good quality sealant.

4) High Pressure Duct Work

1) Velocity >600mpm & static pressure 15cm of H20 gauge For specified class or marine applications.
2) Pressure drop in supply Air Ducting: 10-15cm of H20 gauge.
3) Pressure drop in Return Air Ducting: 5-10cm of H20 gauge.
4) circular (or) spiral ducting (machine fabricated) is recommended as the helical wound longitudinal joints provide adequate mechanical strength.

II. DUCT DESIGN METHOD

1) Velocity Reduction Method : v = (Q/A)

In this method arbitrary reduction are made in the air velocity as we go down the duct run.

2) Equal Friction Method:

The frictional pressure drop per unit length of the duct is maintained constant throughout the duct system & size is maintained accordingly.

If an equal friction design has a mixture of short & long runs of duct, the shortest duct will need a considerable amount of damping. This is a drawback of the equal friction design.

3) Static Regain Method:

The principle of the static regain method is to maintain a constant static pressure before each terminal & each branch to provide same flow. This is achieved by sizing the duct in such a manner that after each branch or outlet the static pressure gain due to reduction in velocity, exactly balance the pr. drop in the succeeding.

A. Duct System Components

Besides the ducts themselves, complete ducting systems contain many other components.

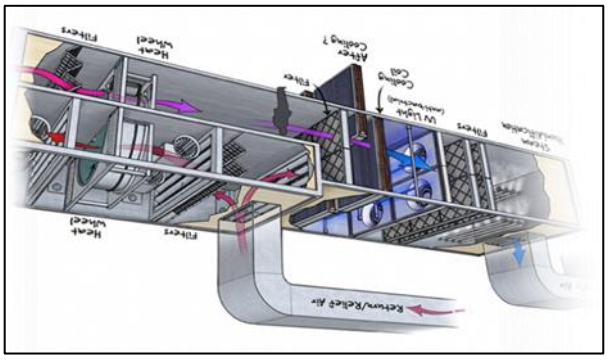

Fig. 1.5.1: Air handling unit

1) Vibration isolator

A duct system often begins at an air handler. The blowers in the air handler can create substantial vibration, and large area of the duct system Would transmit this noise and vibrations to the inhabitants of the building. To avoid this, vibration isolator (flexible) sections are normally inserted to the duct immediately before and after the air handler. The rubberised canvas-like Optimization is concerned with the minimization or maximization of the objective function depending on what someone is looking for. However, normally optimization problems are defined as minimization ‘and if a criterion is subjected to maximization then the negation of the objective function is minimized. In optimization problems, the building simulation programs are increasingly being used to evaluate the objective function. The current study is based on the minimization of the objective function in which the overall HVAC duct system model is optimization by numerical algorithm. Such an interaction provides automatic selection of optimal configuration. However, it requires suitable design optimization along with optimization variables in terms of system design and configuration parameters. The aspects of HVAC duct system configuration and sizing are strongly related with each other. The individual component models and the system of the developed overall HVAC duct system model must be accurately sized to fulfil the specified buildings load demands. However, the key difference between the configuration and the sizing issues is that the configuration of HVAC system is not predefined. Therefore, the aspect of system configuration is mainly focused on the decisions related to the type, the number, and the arrangement of the system components. Thus, after the selection of a suitable duct configuration, the sizing variables associated the particular configuration are identified. Meanwhile, the optimal configuration design is evaluated by the overall system performance.

2) Duct Design using Equal Friction Method & CFD

Cooling Load Temperature Differential (CLTD) / Cooling Load Factors (CLF) / Solar Cooling Load (SCL) is used to calculate the cooling load of an auditorium. It was an attempt to simplify two steps TFM & TETD /TA methods into a single step technique that allowed proceeding directly from raw data to cooling load. A series of factors were taken from cooling load calculation results as ‘Equivalent Temperature Difference’ for use in traditional condition (q = UA dT) equation. The conditioned air (cooled or heated) from the air conditioning equipment must be properly distributed to rooms or spaces to be conditioned in order to

provide comfort conditions. When the conditioned air cannot be supplied directly from the air conditioning equipment to the spaces to be conditioned, then the ducts are installed. The duct systems convey the conditioned air from air Duct material is usually made from galvanized iron sheet metal, Al sheet metal or black steel. But now a day, the use of non-metal ducts has increased. The resin bonded glass fiber ducts are used because they are quite strong and easy to manufacture according to desired shape and size. They are used in low velocity applications less than 600m/min and for static pressures below 5mm of water gauge.

General rules used to design air duct

1) Air should be conveyed as directly as possible to economize on power, material and space.
2) Sudden changes in direction should be avoided. When bends are essential, turning vanes should be used to minimize pressure loss.
3) Air velocities in ducts should be within permissible limits to minimize noise.
4) Diverging sections should be made gradual. The angle of divergence should not exceed 200.

III. Literature Survey

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… Then, OVERFLOW-D, an overset grid-based, Navier-Stokes CFD code is reviewed, and its adaptation … Finally, the study's conclusions are presented followed by plans for future work … These data were combined with simulation studies, S-67 test data and analyses during the trade …

IV. Conclusion

We referred several important journals for the compatible ducting system for the commercial mall and studied the ducting system methods, design softwares revit, solidworks and ansys.

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