Design of Ducting System for the Commercial Mall and Evaluating Its Flow Conditions

B. Phanindra Kumar[1] K. Raviteja[2] M. Sravankumar[3] P. Vasudev[4]
[1]Assistant Professor [2,3,4]UG Scholar
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4]Guru Nanak Institute of Technology, Rangareddy, Telangana, India

Abstract— Our project explains about the design of the ducting system and evaluating the flow conditions for a commercial mall. The design of ducting which plays a key role in the HVAC system which intern produces a superior design that facilitates the proper air distribution through the conditioned spaces based on the layout of building design. In this project calculations were done by using the Revit software. Theoretical calculations are done by use of MCquay duct sizer and thermodynamic formulae in order to extract the dimensions of the duct (length, width, height, thickness) and the parameters like Volume flow rate, Velocity, Pressure drop are determined. The design work done in SOLIDWORKS software.

Keywords: HVAC, DUCT, ASHRAE, 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.

II. 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.

A. 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.

2) 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

3) 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.

4) DUCT SHAPE

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

5) 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.

6) 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.

a) CLASIFICATION OF DUCTS

Low Pressure Duct Work

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

Medium Pressure Duct Work

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

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.

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.

III. 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.

Ductwork is found in every heating and cooling system, whether residential or commercial.

An air handler (also known as an air handler unit or abbreviated as AHU) often attaches to the duct system. The AHU is usually a large metal box containing a blower, heating or cooling elements, filter racks or chambers, sound attenuators, and dampers.

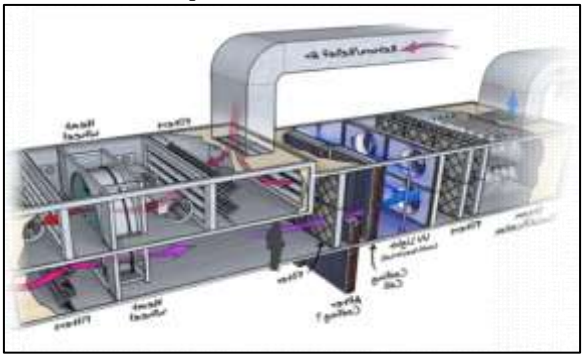


Fig. 1.5.1: Air handling unit

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.

Dampers are installed to regulate air flow. Volume Control Dampers enable the volume of air flow to be adjusted, while Combination Smoke & Fire Dampers seal off a duct when they detect smoke and fire.

Other dampers for commercial use include Air Measuring, Thermal, Backdraft, Industrial/Heavy Duty, Tunnel Transit, Marine, Balancing, Low Leakage, Relief, and Zone.

Duct fittings and configurations, including ells, tees, and reducers, are responsible for equalizing the duct pressure and balancing the airflow. For example, a reducer is a fitting that’s used when a change from one size duct to another size is needed.

Another ductwork fitting is a vent cap that provides protection for the open end of a ductwork vent stack. Each fitting and configuration helps the overall commercial ductwork performance.

The outlets, including diffusers, grilles, and registers, divide the airflow in a truck-and- branch ductwork design. For example, diffusers are used to introduce conditioned air into a space to achieve even distribution and mixing with minimum noise.

Another outlet is a register box (also known as a floor box), which is a galvanized steel grille with moving parts that’s capable of being opened and closed with the airflow directed.

Plenum is arguably the most important part of any commercial HVAC ductwork. It's an air distribution box for the central distribution and collection air flow unit of an HVAC system.

You should recognize two types of plenum: The supply plenum directs air from the central heating and cooling unit to the rooms which the system is designed to heat or cool. The return plenum carries the air from several large return grilles to a central air handler. Take-offs are round, oval, or rectangular fittings that are carefully designed to take the correct amount of airflow from the main duct into each branch duct. Vents are typically placed in the ceiling with their edges corresponding to the opening in the above duct. As warm or cool air pours through the commercial ductwork, vents allow it to disperse into the rooms below.

IV. LITERATURE REVIEW

1) SAD = Supply Air Duct, RAD = Return Air Duct, FAD = Fresh Air Duct
2) Duct materials
3) Types of ducts
4) Classification of ducts
   a) Low pressure duct work
   b) Medium pressure duct work
   c) High pressure duct work
5) Duct design methods
6) Duct design components
7) Components:
   - Duct
   - Economizer
   - Electrostatic precipitator
   - Evaporative cooler
   - Evaporator
   - Exhaust hood
   - Expansion tank
   - Fan coil unit
   - Fan filter unit
   - Fan heater
   - Fire damper
   - Fireplace
   - Fireplace insert
   - Freeze stat
   - Flue
   - Freon
   - Fume hood
   - Furnace
   - Furnace room
   - Gas compressor
   - Gas heater
   - Gasoline heater
   - Geothermal heat pump
   - Grease duct
   - Grille
   - Ground-coupled heat exchanger
   - Heat exchanger

V. METHODOLOGY

The ducting system for a commercial mall is designed on the basis of using revit software which is commonly used for the is building information modelling software for architects, landscape architects, structural engineers, mechanical, electrical, and plumbing (MEP) engineers, designers and contractors. The original software was developed by Charles River Software, founded in 1997, renamed Revit Technology Corporation in 2000, and acquired by Autodesk in 2002. The software allows users to design a building and structure and its components in 3D, annotate the model with 2D drafting elements, and access building information from the building model's database. Revit is 4D building information modeling capable with tools to plan and track various stages in the building's life cycle, from concept to construction and later maintenance and/or demolition.

A. Revit Modeling:

The Revit work environment allows users to manipulate whole buildings or assemblies (in the project environment) or individual 3D shapes (in the family editor environment). Modeling tools can be used with pre-made solid objects or imported geometric models. However, Revit is not a NURBS modeller and also lacks the ability to manipulate an object's individual polygons except on some specific object types such as roofs, slabs and terrain or in the massing environment.

1) System Families, such as walls, floors, roofs and ceilings, built inside a project.
2) Loadable families/components, which are built with primitives (extrusions, sweeps, etc.) separately from the project and loaded into a project for use.
3) In-Place Families, which are built in-situ within a project with the same tool set as loadable components.
4) An experienced user can create realistic and accurate families ranging from furniture to lighting fixtures,as well as import existing models from other programs. Revit families can be created as parametric models with dimensions and properties. This lets users modify a given component by changing predefined parameters such as height, width or number, in the case of an array. In this way a family defines a geometry that is controlled by parameters, each combination of parameters can be saved as a type, and each occurrence (instance in Revit) of a type can also contain further variations.

The architectural layout of a commercial mall

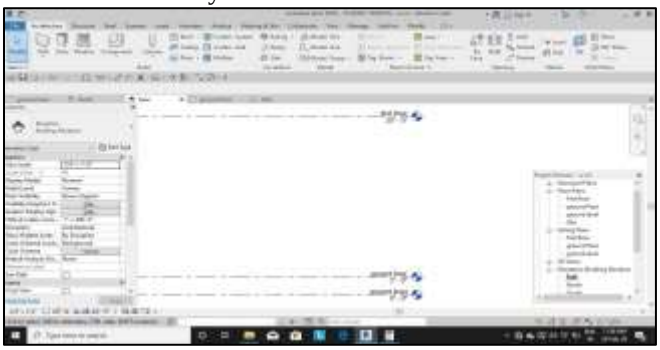


Fig. 3.1.1: The basic levels that created for commercial mall

In the above figure, the levels that created for the construction of civil plan, there are three levels that included in the civil plan, they are ground level in the level 1, ground

floor in the level 2 and first floor at level 3, with the dimensions. The height of the wall from level 1 to level 2 is 20 feet height and the overall dimensions of the building is 190 X120 square feet.

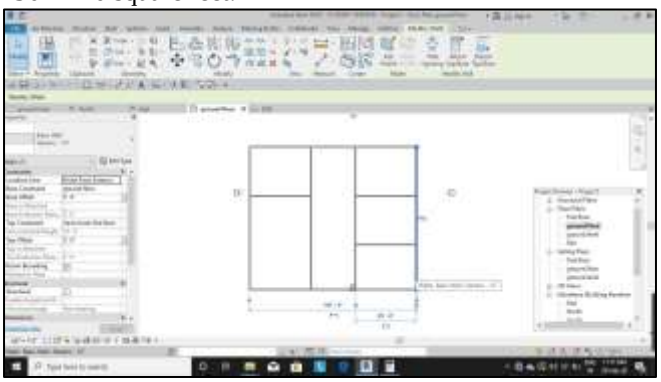
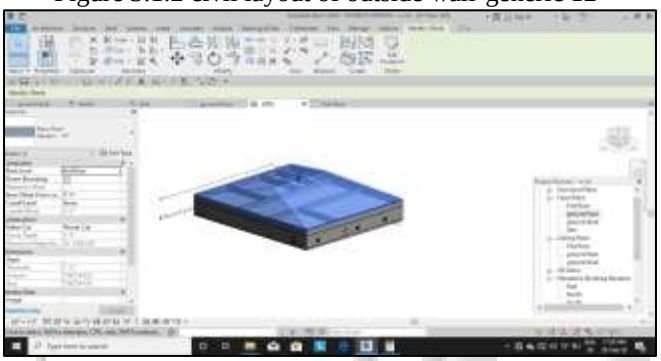


Figure 3.1.2 civil layout of outside wall-generic 12



Above Figure 3.1.4 complete architectural layout of with ceiling and roof. After the completion of architectural layout with civil plan, levels creation, flooring, ceiling and roofing everything that needed for the commercial mall. We have to analyze the building with heat and cool load calculations because we have to know conditions inside the building.

Due to high atmospheric temperature lots of heat is generated inside the room. The heat load calculations are the process of calculating the total heat generated inside the room by various sources. There are various sources of heat inside the room and all these are considered during heat load calculations.

Heat from the sun: Heat from the sun enters the room by different ways. It enters inside the room by process of conduction through the walls and roof of the rooms. It enters by convection process due to flow of the hot atmospheric air inside the room. The heat of the sun also enters the room by process of radiation via the open and closed glass windows of the room. The heat generated by the room is the major source of heat inside the room.

The total heat of the sun entering the room greatly depends on the direction or alignment of the room. The maximum heat of the sun in the morning is from the east direction it is absorbed by the walls and windows in the eastern direction. During noon and late noon maximum heat is absorbed by the walls and the windows in south and west directions respectively. The least amount of sun heat is absorbed by the walls in the north direction.

Cooling load is the rate at which sensible and latent heat must be removed from the space to maintain a constant space dry-bulb air temperature and humidity. Sensible heat into the space causes its air temperature to rise while latent heat is associated with the rise of the moisture content in the space. The building design, internal equipment, occupants, and outdoor weather conditions may affect the cooling load in a building using different heat transfer mechanisms. The SI units are watts.

Based on the heat and cool load calculations, the air flow that is obtained. By ASRAE chart and MC quay air conditioning tool, we can extract the duct sizes, then after we have to design the duct system in solid works as per the building construction and equal friction method that suitable for the building construction.

SolidWorks is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs primarily on Microsoft Windows. While it is possible to run SolidWorks on MacOS, it is not supported by SolidWorks. SolidWorks is published by Dassault Systems.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allows them to capture design intent.

Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. SolidWorks allows the user to specify that the hole is a feature on the top surface, and will then honor their design intent no matter what height they later assign to the can.

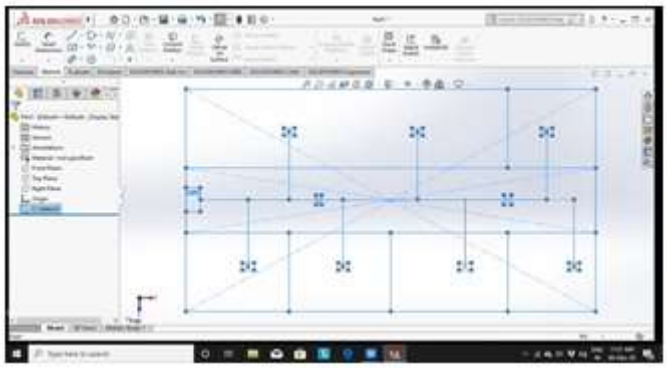


Fig. 3.2.1: layout before the duct design based on civil plan

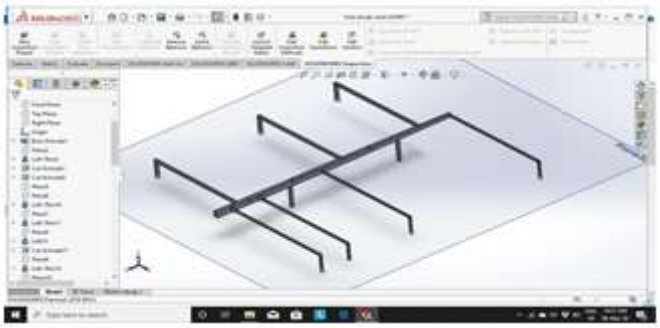


Fig. 3.2.2: design of duct system for commercial mall in solidworks

VI. RESULTS AND DISCUSSIONS

The design of ducting system has been done for the commercial mall by using the revit software, Mcquay duct sizer, Duct methods and solidworks. The method used for the duct system is based on the design layout of the building. Which gives us suitable and sustainable duct work for the air distribution. The estimated values the temperatures of different regions were find out and the project summary is provided and the temperature excel sheets and provided. In this all the parameters were taken into consideration for high accuracy and proper estimation of suitable machine. By using duct system design energy consumption of the building is reduced as possible by avoiding unnecessary loses. This is one of the most well designed and most useful method in the installations.

REFERENCES

[1] The Fundamentals volume of the ASHRAE Handbook, ASHRAE, Inc., Atlanta, GA, USA, 2005
[2] ^ HVAC Systems – Duct Design, 3rd Ed., SMACNA, 1990
[3] ^ Designer's Guide to Ceiling-Based Room Air Diffusion, Rock and Zhu, ASHRAE, Inc., Atlanta, GA, USA, 2002
[4] ^ "Should You Have the Air Ducts in Your Home Cleaned?", U.S. Environmental Protection Agency, retrieved April 17, 2008
[5] ^ Jump up to:a b NADCA (2013). "ACR, The NADCA Standard for Assessment Cleaning Restoration of HVAC Systems" (PDF). National Air Duct Cleaners Association. Archived from the original (PDF) on 11 February 2015. Retrieved 16 June 2014.
[6] ^ Jump up to:a b ANSI/ASHRAE/ACCA (2012). "Standard 180 Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems". American Society of Heating Ventilation and Air Conditioning Engineers. Retrieved 16.
[7] ^ Jump up to:a b Willis, Steve. "Verifying System Cleanliness: AGuide for CommissioningProviders" (PDF). www.commissioning.org. American Commissioning Group (ACG). Retrieved 16 June 2014.
[8] ^ AIIB/ACRA/BSOMES/HKBCxC (2004). "A Management Practice Guidance Note on Air Duct Cleaning of for Hong Kong". Asian Institute of Intelligent Buildings.
[9] ^ CIBSE (2000). "TM 26 Hygiene Maintenance of Office Ventilation Ductwork". Chartered Institute of Building Service Engineers.
[10] ^ Ductwork sealing article at Energy Star

