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# Improved Design and Simulation of Duct in HVAC Distribution Channel

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**Abstract**-In an air-conditioning system the flow of air through ducts determines the efficiency of the Heating Ventilating and air-conditioning (HVAC)system. The various factors reduce the air flow rate in the ducts that leads to poor rate of cooling in the home and industries. The ducts are of circular, square and rectangular shape which are used in everywhere in the world but all these profile have lesser amount of efficiency that leads to the low velocity and difficult in the cleaning and maintenance. In this paper, the proposed system is designed to increase the efficiency of the distribution channel by varying the profile of the ducts into the TRAPEZOIDAL shape which overcomes the existing problems. The focus of this paper will be on using flow simulation software to study the velocity of the duct.

**Index Terms**-HVAC, duct, velocity

## 1. INTRODUCTION

Currently, the production home-building industry prefers junction boxes as the primary means to Split airflow in flexible duct HVAC systems. This is largely due to the flexibility of design,

Compact size, and low cost of design.

However, implementation in the field isSubstandard, characterized by poorly performing HVAC systems and occupant complaints.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 an 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 air flow in duct with Static pressure and velocity pressure is made easier and faster in Fluent Software. The requirement of air conditioner is that it must provide Adequate cooling to the occupants in the conditioned space under A wide variety of ambient conditions. A normal healthy person feels Comfortable at 25°C DBT, the50% RH with 9 to 12m/min air velocity. Human comfort is influenced with the physiological conditions Determined by the internal heat generation.

## 2.FACTORS INFLUENCING DUCT DESIGN

2.1. Equipment Losses
2.2. Air Velocity
2.3. Duct Material
2.4. Duct Size & Shape

### 2.1. Equipment Losses

This type of loss is mainly due to components in the air distribution system and the friction loss will arise because of the improper material selection for the manufacturing of the duct. The major loss will be in the following components in the distribution system such as

1. Supply fan
2. Supply Ductwork
3. Transition fittings
4. Discharge grills
5. Return grills
6. Return ductwork

Air System Pressure Losses will arise in the grills.The air pressure losses from both the supply and return duct systems plus the loss through external a/c coil is often referred to as the external static pressure.

Manufacturers generally publish fan ratings based on external static pressure (internal losses due to coils, filters, etc. are usually accounted for in the cataloged fan ratings).

### 2.2. Air Velocity

Increasing Air Velocity Causes More Turbulence

Recommended Velocity 700-900 FPM

### 2.2. Duct Material

Duct material roughness refers to the inside surface of the duct material. The rougher the surface, the higher the friction loss. Most duct sizing tables use the roughness factor for smooth, galvanized sheet metal as the reference value.

The back side of the Duct Calculator has a conversion table for converting the material roughness from smooth sodecide which duct construction material to use.

Common choices: fiberglass duct board,**Aluminum plate**, galvanized sheet metal, “flex” vinyl coated with helical wire core.

Each material has advantages.

– First cost (price & ease of installation)

– Performance (friction loss, fan energy)

– Acoustic properties

– Thermal properties (heat gain & loss; internal/external insulation) metal to other materials.

| Material | Absolute roughness, $k_s$ (mm) | Correction factors for various pressure drop rates (Pa m$^{-1}$) 0.5 | 1.0 | 2.0 | 5.0 |
|---|---|---|---|---|---|
| Galvanised sheet steel | 0.15 | 1.0 | 1.0 | 1.0 | 1.0 |
| Galvanised steel spirally wound | 0.075 | 0.95 | 0.94 | 0.93 | 0.92 |
| Aluminium sheet | 0.05 | 0.93 | 0.91 | 0.90 | 0.88 |
| Cement render or plaster | 0.25 | 1.07 | 1.08 | 1.08 | 1.09 |
| Fair faced brick | 1.3 | 1.42 to 1.41 | 1.50 to 1.45 | 1.54 to 1.48 | 1.63 to 1.54 |
| Rough brick | 5.0 | 2.18 to 1.97 | 2.46 to 2.04 | 2.62 to 2.12 | 2.76 to 2.23 |

Table-1

### 2.4. Duct Size & Shape

The overall performance of the centralized air conditioning unit is mainly depend upon size and shape of the duct. The wide range of manufactures of the duct are in the shape of round, rectangular, square. The scope of the paper is to vary the shape of the duct and to increase the efficiency of the air-conditioning unit.

## 3. PROBLEM STATEMENT

The existing model and the design of the duct in the HVAC has certain limitations and the difficulties in the cleaning and maintenance while in the day to day usage of the customer needs.It has less rate of transferring the cooling air to the surroundings due to the loss of air inside the duct because of the low velocity. The study of this paper deals with the increasing the velocity of the duct by varying the profile by the suitable method.

## 4. EXISTING SYSTEM

Let as consider the duct as a square and the profile is made up of aluminum sheet. The flow of air inside the duct is very low since it is a cooling duct it transfer the cool air. The cold air is much denser than the hot air since the large shape of the duct is needed.

Figure-1

By implementing a model as shown in figure-1 in the Computational fluid dynamics (CFD) software like solid works the simulation and the results gives the necessary details

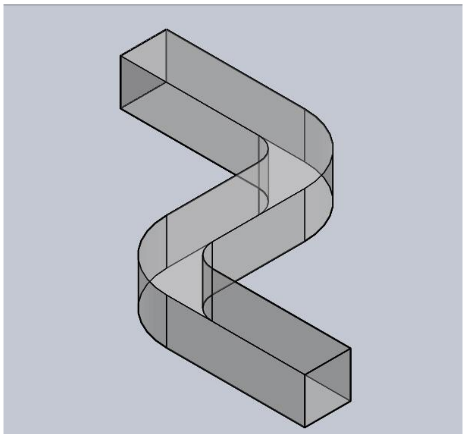

Figure-2

This is the assembly drawing of the existing system.

Upon simulating the above figure-2the solid works floXpress analysis report is generated.

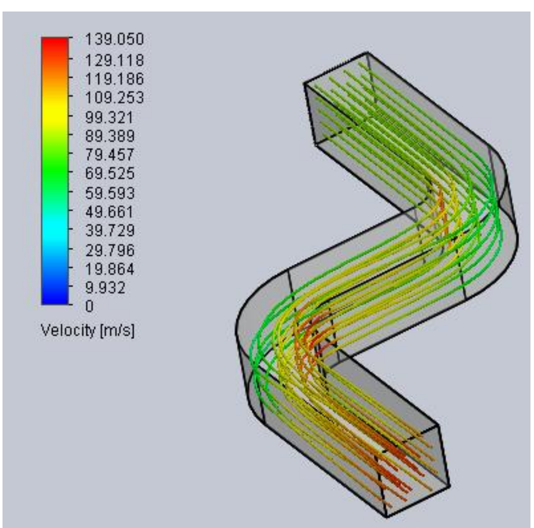


Figure-3

From the simulation analysis the graph shows that the maximum velocity experienced by the existing duct (square) is 139.050 m/s.This result can be overcome by the proposed model.

**SolidWorks FloXpress Report**

SolidWorks FloXpress is a first pass qualitative flow analysis tool which gives insight into water or air flow inside the SolidWorks model.

### Model

Model Name: F:\project details\3d diagrams\rectangle\sw\HVAC.SLDASM

### Fluid

Air

### Inlet Volume Flow 1

| | |
|---|---|
| Type | Volume Flow Rate |
| Faces | Face<1>@Part2^HVAC-1 |
| Value | Volume Flow Rate: 5.0000 m^3/s<br>Temperature: 150.00 K |

### Environment Pressure 1

| | |
|---|---|
| Type | Environment Pressure |
| Faces | Face<2>@LId1^HVAC-1 |
| Value | Environment Pressure: 101325.00 Pa<br>Temperature: 293.20 K |

### Results

| Name | Unit | Value |
|---|---|---|
| Maximum Velocity | m/s | 139.050 |

## 5. PROPOSED SYSTEM

The scope of this paper is to increase the velocity of the air which flow through the duct by varying the shape of the duct by the standard duct sizing method.

5.1 Design process

Basic sizing,

The basis of sizing: since the air flow rate (Q) is known, the cross-sectional area of the duct (A) can be established if a suitable mean velocity (V) is chosen.

$$Q= AV$$

There is no general agreement on duct system classification but low velocity systems are often regarded as those in which the maximum mean velocity is less than 10 m s -1, medium velocity as having maximum mean velocities between 10 and 15 m s -1 and high velocity systems as those with maximum mean velocities not exceeding 20 m s -1. As a general principle, velocities should be kept as low as is reasonably possible and 20 m s -1 should never be exceeded. Duct systems are classified in HVAC (1998) by pressure as well as velocity, low pressure being up to +500 Pa or down to-500 Pa, medium pressure up to + 1000 Pa or down to-750 Pa, and high pressure up to +2500 Pa or down to-750 Pa. Largenegative pressures are undesirable in comfort air conditioning systems because extract ducts with large sub-atmospheric pressures are not stable, tending to collapse if deformed.

On the other hand, large sub-atmospheric pressures are essential for industrial exhaustsystems and systems used for pneumatic conveying, but such ducts are constructed withthis in mind.

Three methods of sizing are used:

1. Velocity Method*
2. Equal pressure drop Method
3. Static regain Method

This paper deals with the increasing the velocity of the duct through the standard velocity method.

VELOCITY METHOD

The velocity method is nothing but a simple concept that introducing the nozzle in the duct that converge the air and tends to increase the velocity.

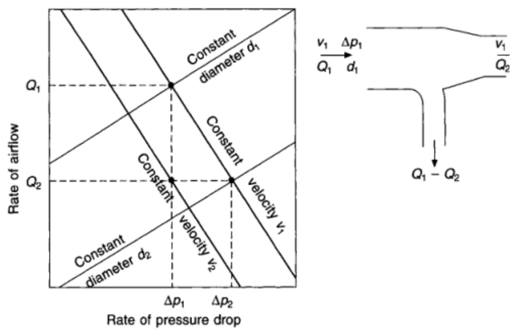


Figure-4

The figure-4 shows the variation in the velocity $V_1$ and $V_2$ also in the mass flow rate $Q_1$ and $Q_2$.Taken that the basis sizing equation

$$Q=AV\ldots\ldots\ldots\ldots\ldots \quad (1)$$

For the velocity method

$$V=Q/A\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Here from the above method it is clear that the velocity increases the air flow rate (Q) increases hereby decreasing the area (A) of the duct.

The scope of the paper represents the proposed model as designing the duct in the shape of the nozzle that is the trapezoidal profile. That maintain the velocity and the mass flow rate uniformly with higher velocity.

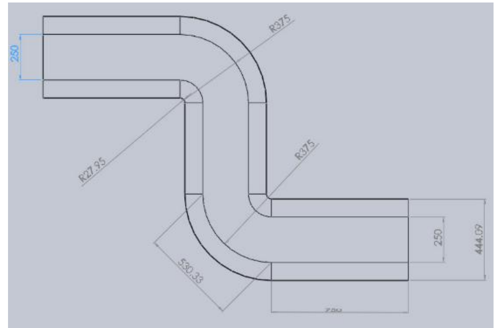

Figure-5

The above fig-5 shows the 2d diagram of the proposed model. By this type of ducts the cleaning and the maintenance of the duct is made easy and also increases the velocity.

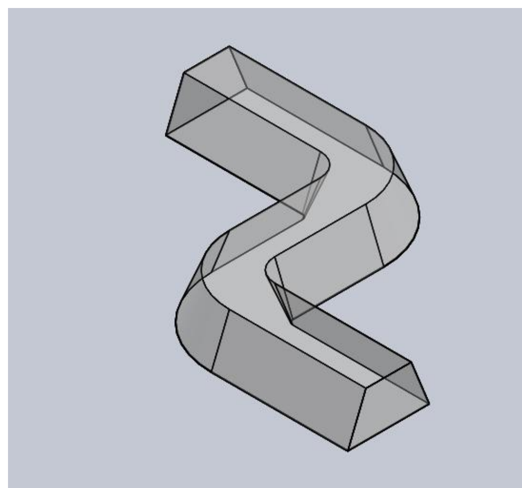

Figure-6

This is the assembly drawing of the proposed duct model. The simulation of the above model is shown in figure-7

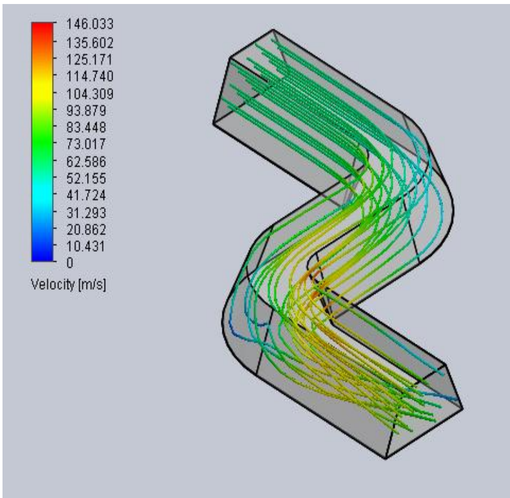


Figure-7

From the simulation analysis in the figure-7 thegraph shows that the

maximum velocity experienced by the proposed duct (trapezoid)is 146.033 m/s.

## SolidWorks FloXpress Report

SolidWorks FloXpress is a first pass qualitative flow analysis tool which gives insight into water or air flow inside the SolidWorks model.

### Model

Model Name: F:\project details\3d diagrams\trapezoidal\sw\HVAC_trapezoidal.SLDASM

### Fluid

Air

### Inlet Volume Flow 1

| Type | Volume Flow Rate |
|---|---|
| Faces | Face<1>@Lid2^HVAC_trapezoidal-1 |
| Value | Volume Flow Rate: 5.0000 m^3/s<br>Temperature: 150.00 K |

### Environment Pressure 1

| | Environment Pressure |
|---|---|
| Faces | Face<2>@Lid1^HVAC_trapezoidal-1 |
| Value | Environment Pressure: 101325.00 Pa<br>Temperature: 293.20 K |

### Results

| Name | Unit | Value |
|---|---|---|
| Maximum Velocity | m/s | 146.033 |

## IMPLEMENTATION AND RESULT

The proposed system of the duct model is implemented in the solidworks softwareand the result is observed. The proposed system over comes the existing system.

## CONCLUSION

The velocity and the mass flow rate is achieved at the desired level. The cleaning and the maintenance of the duct is easy and also it give rise to less formation of dust and sludge formation inside the distribution channel

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