FLUID POWER AND ADVANCED FLUID MECHANICS

Assignment 2

TOPIC: REDESIGN A VENTILATION SYSTEM

Submitted By,
Tony pauly -
Nikul

Tutor : Dr. Mohammad alrvi

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1. Introduction

Ducts systems are designed to distribute air within the building correctly. When the ducting systems are not well installed properly, results in discomfort, high cost of energy, low quality of air and increases the level of noise. Only by choosing the right size duct, makes a proper airflow in the duct system. Also, by adding dampers in the duct systems helps to adjust the airflow.

Here in this assignment the aims to update a duct system that makes sure the system is balanced. This task will involve calculated system pressure at each office is balanced and meets the specific requirement. redesigning the duct system on SolidWorks. The new design and the calculations for the device will be explained in the results section of this article. The discussion will compare the old and revised designs and any mistakes or problems identified during the task.

2. Method

2.1 Short description of current design

Figure 1 shows the basic initial design of a duct ventilation system. So, here in this design, there are four sets of grilles and it should be maintaining the flow rate of 0.57 m^3/sec in four-set of grilles. Also, there is a fan which is fixed after the intake louvre, which is used to control the mass flow rate of air in a duct system.

1. **Grille**

   It is a moving part which is capable of opening, closing, and directing the airflow, which is the part of designing a new heating, ventilation, and air conditioning (HVAC) system of a building or a house, which is shown in figure 1. HVAC is depending upon the location and size of the grille.

Figure 1:Grille

2. Fan

In a duct system fan is also playing a significant role to move the airflow rate through a duct system and to overcome the total pressure losses. A fan characteristics are usually obtained from a manufacturer and these would have been based on the standard test that measured a fans output for variety os conditions, flow rate and pressure.

Figure 2: Fan in a duct system

3. Tee

Here the main fuction of Tee is change the direction of the flow of air from the main duct to the girlles. Here in this current design there are two Tee junction, which is shown in the figure 4.

Figure 3:Tee juntion in a duct system

4. **90 degree elbow**

Here in this design, there are four set of 90 degree elbow are place in the grilles and this is the basic diagrammatic repersentaion of the 90 degree elbow shown in the figure 4.

Figure 4: 90 degree elbow

2.2 Basic methods for calculating the current duct system

Step 1:

- Flow rate of air in each part of a duct system, which is represented as 'Q' (m^3/sec). Also, note down the location of the fan in the current duct system.
- The overall airflow allowance for the intake duct and the fan outlet duct as the amount of all airflow supplied to conditioned space.
- Locate the fitting like Tees, elbows, and grilles.

Step 2

- Assume the velocity if it is not given (Example- 4.5m/s).
- After assuming the velocity, using the given cart (Figure 3), find the diameter of the duct by using the flow rate Q (m^3/sec) and assumed velocity (m/s).
- After finding the valve for hL from the chart, then the friction loss (HL) should be determined

  HL= hL*L

  L is the length of the sectioned duct (meters)
- $H_v = (\frac{v}{1.289})^2$

  V is the assumed velocity

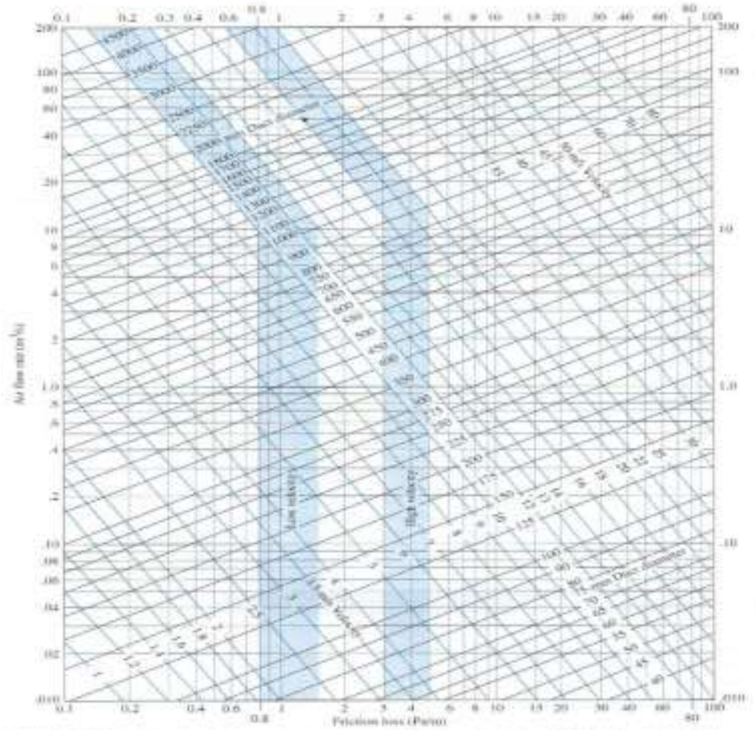

FIGURE 19.3 Friction loss in ducts—SI units. (Reprinted by permission from ASHRAE Handbook: 1981 Fundamentals)

Figure 5: Frictional loss and air flow rate source Chart

Step 3

- Here the shape of the duct is pacified as **Rectangular** and the size is said to be **1*1**
- Then the equivalent diameter of the louver should be calculated by using the equation

  De = $\frac{1.3(ab)^{5/8}}{(a+b)^{1/4}}$ De- Equivalent diameter for a rectangular duct
- Then the next step is to calculate the total energy loses (HL) in the intake duct and each duct section using these above equations
- After that, total energy loses from the fan outlet to each grill should be calculated.
- Also, specify if the energy losses for all path are balanced, which is equal in the pressure drop from the fan to each outlet grille. If their pressure drop is said to be unbalanced in the duct system, then reduce the assumed velocity that particular duct section were the places having the higher pressure drop.
- When all path have slight variations in the pressure drops, a moderate adjustment to dampers maintains equal

2.3 Issues with current design

- After calculating the total energy loses from the section B to each grill in the current design is different. As result, the pressure drop should be calculated b adding the dampers and reducing the veleocities in the each sections of the duct system, which is shown in the table 1.

- When there is any difference in the pressure drop in the each out let of the grill, creates different set of noices in the duct system. Also, there might have some viberations in the current duct design.

Table 1: pressure drop in four set of grille

Pressure drop form B to each grille	
Path 1 from B to grill 1	48.80314276
Path 2 from B to grill 2	54.90449431
Path 3 from B to grill 3	39.05982811
Path 4 from B to grill 4	43.04263888

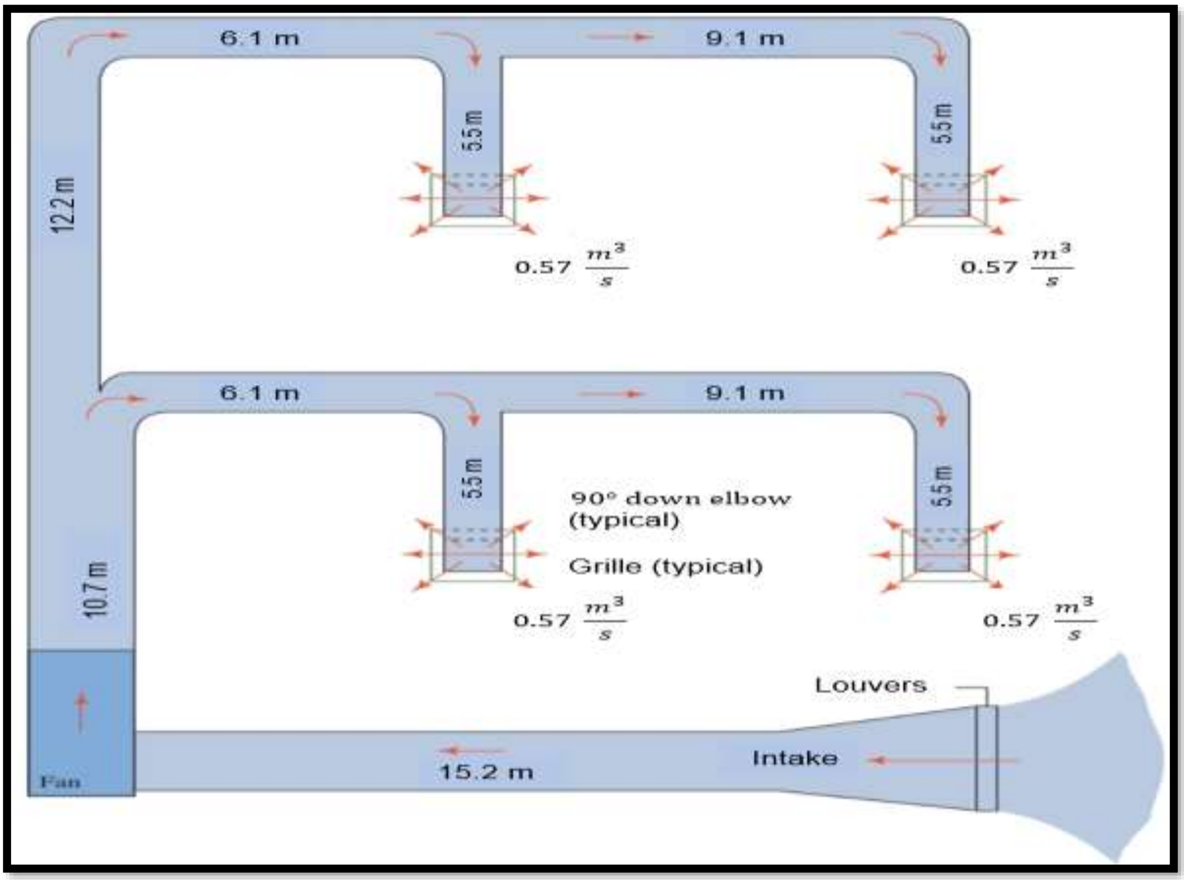

Figure 6: Duct system

3.Result

Table 2:Current design without Damper

Current Design- Without Damper							
	Q (m^3/s))	L(m)	de(mm)	Velocity (m/s)	Friction lose(hl)	HV	HL(Pa)
Intake duct A	2.28	15.2	870	3.5	0.15	7.372763	2.28
Intake duct B-FAN	2.28	10.7	725	5.5	0.42	18.20621	4.494
Intake duct C	1.14	6.1	675	3	0.15	5.416724	0.915
Intake duct C1	0.57	5.5	520	2.7	0.17	4.387546	0.935
Intake duct D	0.57	9.1	520	3	0.22	5.416724	2.002
Intake duct D1	0.57	5.5	520	3	0.22	5.416724	1.21
Intake duct E	1.14	12.2	500	5.5	0.7	18.20621	8.54
Intake duct F	1.14	6.1	550	4.5	0.4	12.18763	2.44
Intake duct F1	0.57	5.5	425	4	0.48	9.629731	2.64
Intake duct G	0.57	9.1	440	3.5	0.31	7.372763	2.821
Intake duct G1	0.57	5.5	440	3.5	0.31	7.372763	1.705
Intake louvers(total pressure drop (1*1)			1100				17
Gradual contraction(d1/d2)			1.26	C=0.12		7.372763	0.47923

Table 3: fitting used in the current Design

Fitting			
value from dynamic loss coefficient	C	HV	HL
Tee-1, From Duct B to Branch Duct C	1	18.20621	18.20621
Tee1, From B to Main duct E	0.1	18.20621	1.820621
Tee-2, From Duct C to Branch Duct C1	1	5.416724	5.416724
Tee2, From C to Main duct D	0.1	5.416724	0.541672
Tee-3, From Duct F to Branch Duct F1	1	12.18763	12.18763
Tee-3, From F to Main duct G	0.1	12.18763	1.218763
Elbow 90-Degree-Intake duct C1	0.22	4.387546	0.96526
Elbow 90-Degree-Intake duct D1	0.22	4.387546	0.96526
Elbow 90-Degree-Intake duct F1	0.22	9.629731	2.118541
Elbow 90-Degree-Intake duct G1	0.22	7.372763	1.622008
Elbow smooth Rectangular-Duct-D	0.18	5.416724	0.97501
Elbow smooth Rectangular-Duct-E	0.18	18.20621	3.277118
Elbow smooth Rectangular-Duct-G	0.18	7.37263	1.327073

Table 4: Total pressure at each grill and initial design with damper

INITIAL Design- With Damper							
	Q (m^3/s))	L(m)	de(mm)	Velocity (m/s)	Friction lose(hl)	HV	HL(Pa)
Intake duct A	2.28	15.2	870	3.5	0.15	7.372763	2.28
Intake duct B-FAN	2.28	10.7	725	5.5	0.42	18.20621	4.494
Intake duct C	1.14	6.1	675	3	0.15	5.416724	0.915
Intake duct C1	0.57	5.5	520	2.7	0.17	4.387546	0.935
Intake duct D	0.57	9.1	520	3	0.22	5.416724	2.002
Intake duct D1	0.57	5.5	520	3	0.22	5.416724	1.21
Intake duct E	1.14	12.2	500	5.5	0.7	18.20621	8.54
Intake duct F	1.14	6.1	550	4.5	0.4	12.18763	2.44
Intake duct F1	0.57	5.5	425	4	0.48	9.629731	2.64
Intake duct G	0.57	9.1	440	3.5	0.31	7.372763	2.821
Intake duct G1	0.57	5.5	440	3.5	0.31	7.372763	1.705
Intake louvers(total pressure drop (1*1)			1100				17
Gradual contraction(d1/d2)			1.26	C=0.12		7.372763	0.47923

Table 5: fitting used in fitting

Fitting			
value from dynamic loss coefficient	C	HV	HL
Tee-1, From Duct B to Branch Duct C	1	18.20621	18.20621
Tee1, From B to Main duct E	0.1	18.20621	1.820621
Tee-2, From Duct C to Branch Duct C1	1	5.416724	5.416724
Tee2, From C to Main duct D	0.1	5.416724	0.541672
Tee-3, From Duct F to Branch Duct F1	1	12.18763	12.18763
Tee-3, From F to Main duct G	0.1	12.18763	1.218763
Elbow 90-Degree-Intake duct C1	0.22	4.387546	0.96526
Elbow 90-Degree-Intake duct D1	0.22	4.387546	0.96526
Elbow 90-Degree-Intake duct F1	0.22	9.629731	2.118541
Elbow 90-Degree-Intake duct G1	0.22	7.372763	1.622008
Elbow smooth Rectangular-Duct-D	0.18	5.416724	0.97501
Elbow smooth Rectangular-Duct-E	0.18	18.20621	3.277118
Elbow smooth Rectangular-Duct-G	0.18	7.37263	1.327073
Adding Damper(C1)-WIDE OPEN	0.22	4.387546	
Adding Damper(D1)- 10 DEGREE	0.52	4.387546	
Adding Damper(F1)- WIDE OPEN	0.22	9.629731	
Adding Damper(G1)- 10 Degree	0.52	7.372736	
Grill			15

Table 6:Final Design with damper

Final Design- With Damper							
	Q (m^3/s))	L(m)	de(mm)	Velocity (m/s)	Friction lose(hl)	HV	HL(Pa)
Intake duct A	2.28	15.2	850	3.5	0.15	7.372763	2.28
Intake duct B-FAN	2.28	10.7	720	5.3	0.39	16.9062	4.173
Intake duct C	1.14	6.1	680	3	0.15	5.416724	0.915
Intake duct C1	0.57	5.5	540	2.7	0.17	4.387546	0.935
Intake duct D	0.57	9.1	520	3	0.22	5.416724	2.002
Intake duct D1	0.57	5.5	520	3	0.22	5.416724	1.21
Intake duct E	1.14	12.2	525	5.3	0.52	16.9062	6.344
Intake duct F	1.14	6.1	580	3.7	0.23	8.239438	1.403
Intake duct F1	0.57	5.5	475	3	0.22	5.416724	1.21
Intake duct G	0.57	9.1	440	3.5	0.37	7.372763	3.367
Intake duct G1	0.57	5.5	440	3.5	0.37	7.372763	2.035
Intake louvers(total pressure drop (1*1)			1100				17
Gradual contraction(d1/d2)			1.29	C=0.13		7.372763	0.47923

Table 7: Fitting Used in Final Design

Final Design- With Damper			
value from dynamic loss coefficient	C	HV	HL
Tee-1, From Duct B to Branch Duct C	1	16.9062	16.9062
Tee1, From B to Main duct E	0.1	16.9062	1.69062
Tee-2, From Duct C to Branch Duct C1	1	5.416724	5.416724
Tee2, From C to Main duct D	0.1	5.416724	0.541672
Tee-3, From Duct F to Branch Duct F1	1	8.239438	8.239438
Tee-3, From F to Main duct G	0.1	8.239438	0.823944
Elbow 90-Degree-Intake duct C1	0.22	4.387546	0.96526
Elbow 90-Degree-Intake duct D1	0.22	5.416724	1.191679
Elbow 90-Degree-Intake duct F1	0.22	5.416724	1.191679
Elbow 90-Degree-Intake duct G1	0.22	7.372763	1.622008
Elbow smooth Rectangular-Duct-D	0.18	5.416724	0.97501
Elbow smooth Rectangular-Duct-E	0.18	16.9062	3.043116
Elbow smooth Rectangular-Duct-G	0.18	7.37263	1.327073
Adding damper(D1)- 10 DEGREE	0.52	5.416724	2.816696
Adding damper(F1)- WIDE OPEN	0.22	5.416724	1.191679
Adding damper(G1)- 10 Degree	0.52	7.372763	3.833837
Grill,1,2,3,4			15

Table 8:Total loss at each branch

Total loss at each path	Without Damper	Initial Design	Final Design
Path 1 from B to grill 1	45.93	46.80970281	44.31117993
Path 2 from B to grill 2	42.36	45.18557848	43.56456482
Path 3 from B to grill 3	52.51	54.63644841	43.43153176
Path 4 from B to grill 4	42.64	46.47743543	43.64728569

The results obtained for the total loss on path 3 suggests that the initial design for the system is imbalanced and requires some amendments, which are corrected in the final design by changing velocity and addition of dampers in the system design.

3.1 Summary of the duct system Design

- Intake duct A = De = 0.850m = 33.46inch = 30*30
- Intake Duct B=De= 0.720m = 28.34 inch = 28*24
- Intake Duct C=De=0.680m=26.27 inch = 30*20
- Intake Duct C1=De=0.540m=21.25 inch = 24*16
- Intake duct D=De=0.52m=20.47 inch =22*16
- Intake duct D1=De=0.52m=20.47 inch =22*16
- Intake duct E=De=0.525M =20.66Inch=22*16
- Intake duct F=De=0.580=22.83.40 inch = 24*18
- Intake duct F1=0.475=18.70 inch+18*16
- Intake duct G=0.440m=17.32 Inch= 18*14
- Intake duct G1=0.440m=17.32 Inch= 18*14
- Pressure at Fan inlet= -26.65
- Pressure at Fan outlet=44.31
- Total pressure rise by the fan=70.96
- Total delivery by the Fan=2.28 m^3/s

4.Discussion

- The initial ventilation system showed good results by each duct's friction loss from the fan. The only the different is 9 Pa in the path 3 when we compared with each other. There may be possible measuring errors and thus marginally changing the results, even the selected fan could not be accurate to the requirements and therefore modifying the air flow rate through the system, but it can be assumed that this design is a reliable ventilation process.
- In the Final design , we achieved the balanced in the system by selecting proper velocity, tee ,elbow and damper in the system.
- The lose in the path b to grill 3 in the duct E is more higher than the other and the some reduction can be achieved by some change in the velocity in the duct B, E and F which is respectively 5.3 m/s and 3.7 m/s and achieve the balance in the system by removed damper in the duct C1 in the final design and maintain the lose in the grill 1(44.31) ,grill 2(43.56), grill3(43.43) and grill 4(43.64).
- The total energy loses in the system is calculated by adding the total loses in the fitting and total loses in the ducts which is about 111.3
- Also, there might have some chance of miss calculation can takes place while noting the values of the friction loss from the air flow and frictional loss graph. The values may not be accurate due to human errors.