ITRI
Industrial Technology
Research Institute

Numerical Study of Air Flow Fields in Air Handling Units with Different Internal Arrangements

Cheng-Shu Kuo and Hsiao-Chi Hsu
Energy and Environment Research Laboratories
Industrial Technology Research Institute

ITRI Industrial Technology Research Institute

Outline

1. Introduction
2. Computational Method
3. Results
4. Conclusion

Introduction

1. The air handling unit (AHU) provides sufficient air flow rates and desired thermal comfort or satisfies requested operation conditions for the specific space.

2. We found some problems in the field tests for air handling units, such as non-uniformity of outlet air temperature distributions of coils, air flow rates far below designed values and extra energy consumptions for ventilation.

3. Those problems are related to installation locations of internal components of AHUs.

   It is not easily to identify and resolve these problems by analytical methods or hands-on design manuals.

4. Under these conditions, we applied CFD software to compute air flow fields to examine the influences of different internal arrangements on the performance of air handling units.

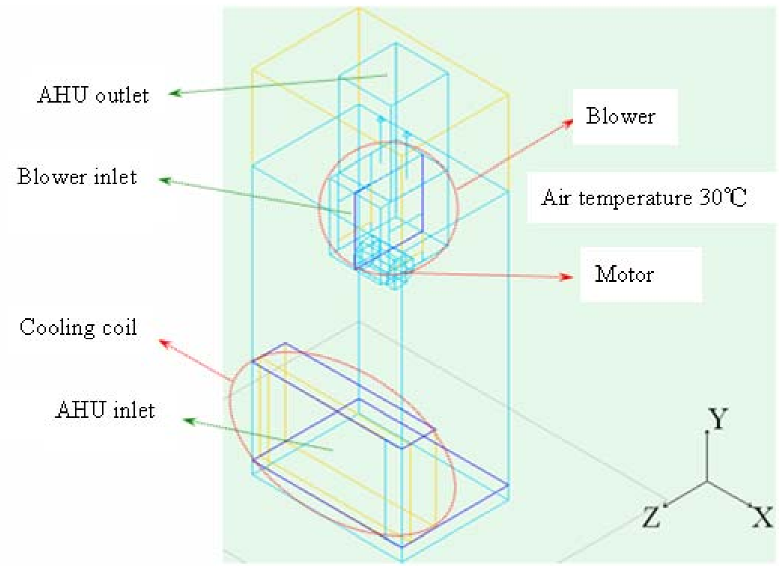
Computational Method

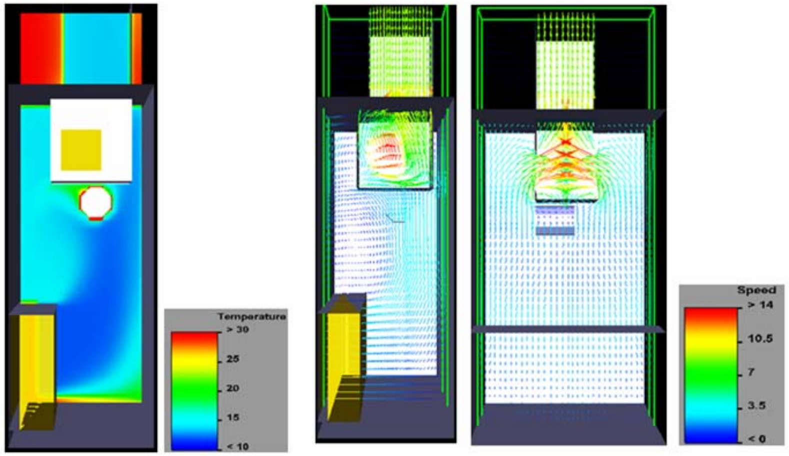
Using CFD software “ FLOVENT” to solve Navier-Stokes Eqs.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \left(\rho \vec{V}\right) = 0$$

$$\rho\left(\frac{\partial \vec{V}}{\partial t} + \vec{V} \cdot \nabla \vec{V}\right) = -\nabla p + \mu \nabla^2 \vec{V} + \rho \vec{f}$$

$$\rho C_p\left(\frac{\partial T}{\partial t} + \vec{V} \cdot \nabla T\right) = k \nabla^2 T + \mu \Phi_v + \dot{q}$$





(a) (b)

Table 1 Comparison between experimental and computational data

	experiment	computation
Outlet air temperature of AHU	13.5 ℃	13.63℃
exhaust air flow rate	2000 cfm	1975 cfm

Computation Results

1. Vertical Type of AHU

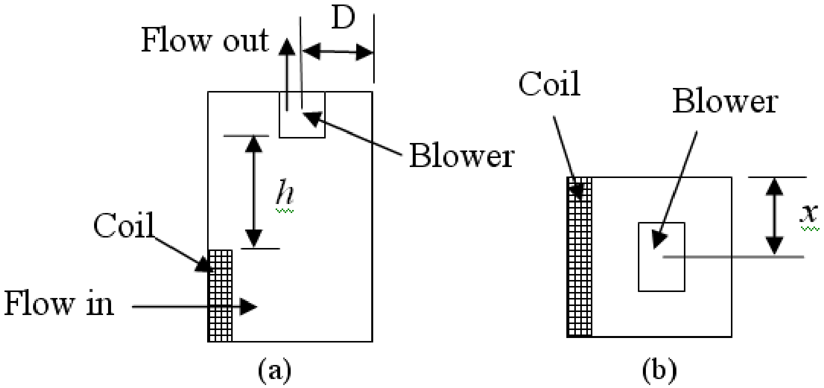


Fig.3 Relative positions of key components inside the vertical type of air handling unit: (a) Side view, (b) Top view

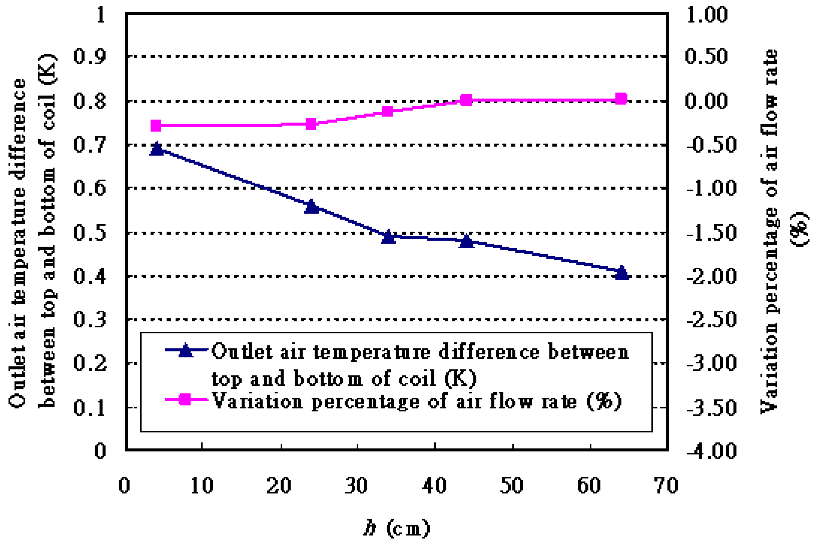


Fig.4. Effect of h on outlet air temperature distribution of coil and air flow rate of air handling unit. (h = 64 cm is baseline case)

Table.2 Effect of h on performance of vertical type of AHU (h = 64 cm is baseline case)

Distance between bottom of blower and top of coil h (cm)	Pressure drop between inlet and outlet of blower (Pa)	Outlet air velocity of AHU (m/s)	Air flow rate of AHU (cmm)	Outlet air temperature of AHU (℃)	Outlet air temperature difference between top and bottom of coil (℃)	Variation percentage of air flow rate (%)
64	30.52	8.85	55.94	15.50	0.41	0.01
44	31.08	8.84	55.93	15.49	0.48	0.00
34	31.62	8.83	55.85	15.44	0.49	-0.13
24	31.69	8.82	55.78	15.52	0.56	-0.28
4	32.82	8.82	55.77	15.51	0.69	-0.29

Computation Results

1. Vertical Type of AHU

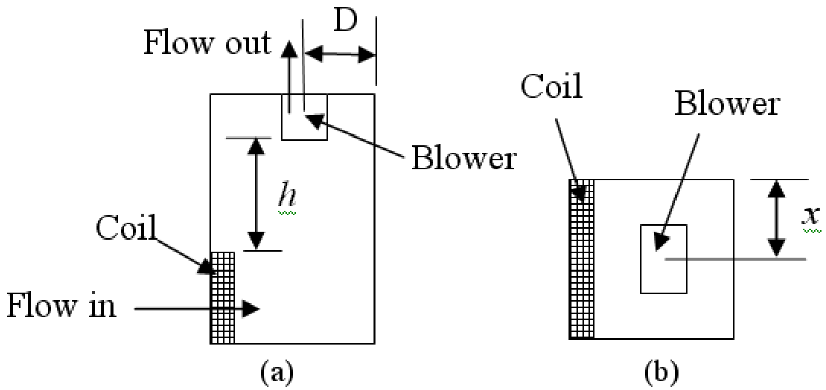


Fig.3 Relative positions of key components inside the vertical type of air handling unit: (a) Side view, (b) Top view

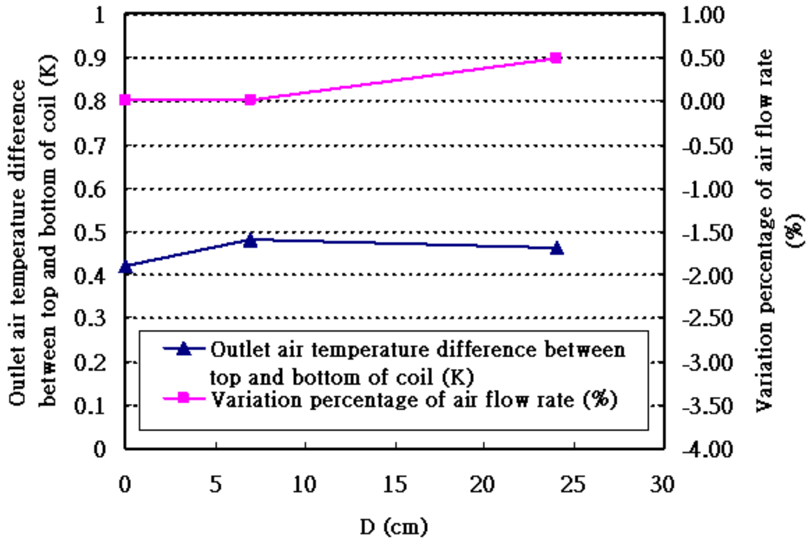


Fig.5. Effect of D on outlet air temperature distribution of coil and air flow rate of air handling unit. (D = 24 cm is baseline case)

Table.3 Effect of D on performance of vertical type of AHU (D = 24 cm is baseline case)

Distance between blower and rear wall of AHU casing D (cm)	Pressure drop between inlet and outlet of blower (Pa)	Outlet air velocity of AHU (m/s)	Air flow rate of AHU (cmm)	Outlet air temperature of AHU (℃)	Outlet air temperature difference between top and bottom of coil (℃)	Variation percentage of air flow rate (%)
24	31.15	8.89	56.20	15.50	0.46	0.48
7	31.08	8.84	55.93	15.42	0.48	0.00
0	30.81	8.84	55.93	15.38	0.42	0.01

Computation Results

1. Vertical Type of AHU

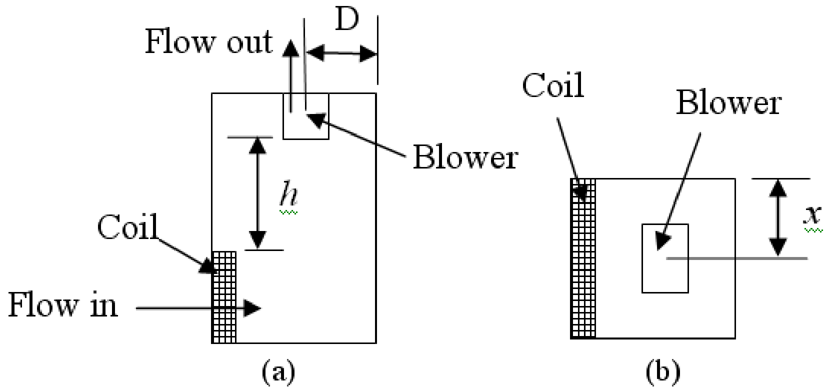


Fig.3 Relative positions of key components inside the vertical type of air handling unit: (a) Side view, (b) Top view

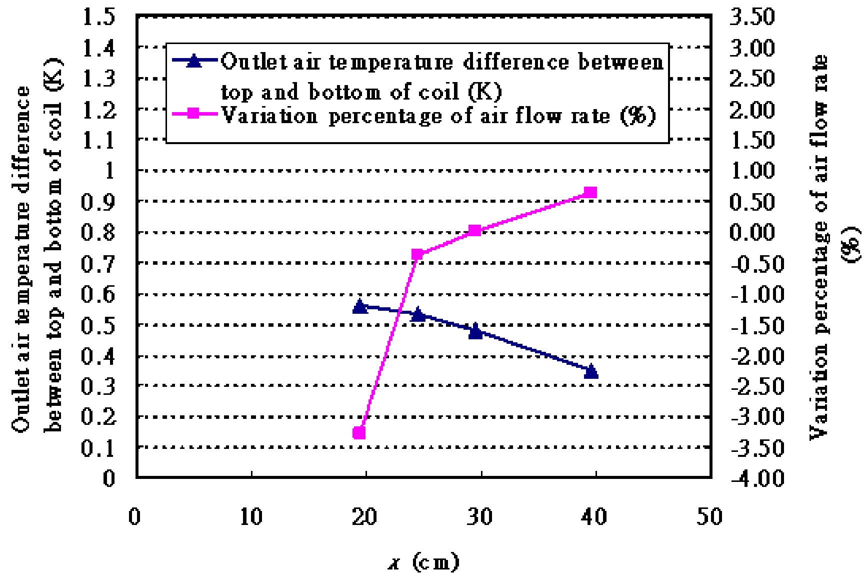


Fig.6. Effect of *x* on outlet air temperature distribution of coil and air flow rate of air handling unit. (*x* = 39.5 cm is baseline case)

Table.4 Effect of *x* on performance of vertical type of AHU (*x* = 39.5 cm is baseline case)

Distance between blower and lateral wall of AHU *x* (cm)	Pressure drop between inlet and outlet of blower (Pa)	Outlet air velocity of AHU (m/s)	Air flow rate of AHU (cmm)	Outlet air temperature of AHU (℃)	Outlet air temperature difference between top and bottom of coil (℃)	Variation percentage of air flow rate (%)
39.5	29.13	8.90	56.28	15.50	0.35	0.63
29.5	31.08	8.84	55.93	15.42	0.48	0.00
24.5	33.69	8.81	55.72	15.38	0.53	-0.38
19.5	38.43	8.52	53.89	15.38	0.56	-3.28

Computation Results

1. Horizontal Type of AHU

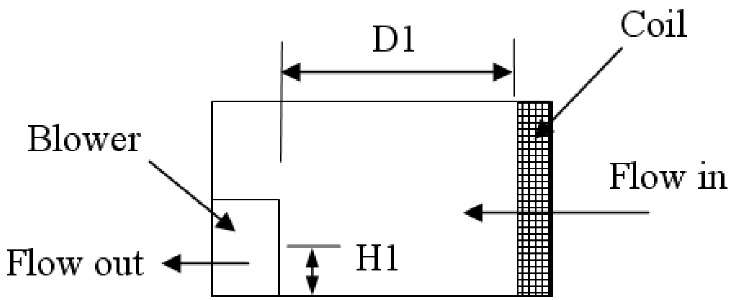


Table 5. Effect of blower location in horizontal type of air handling unit on air flow rate (D1/H1 = 3 cm is baseline case)

D1/H1	V_{out} (m/s)	Variation percentage of air flow rate (%)
3.00	19.53	0
1.57	19.32	-1.04
1.24	19.01	-2.66
0.65	18.99	-2.73

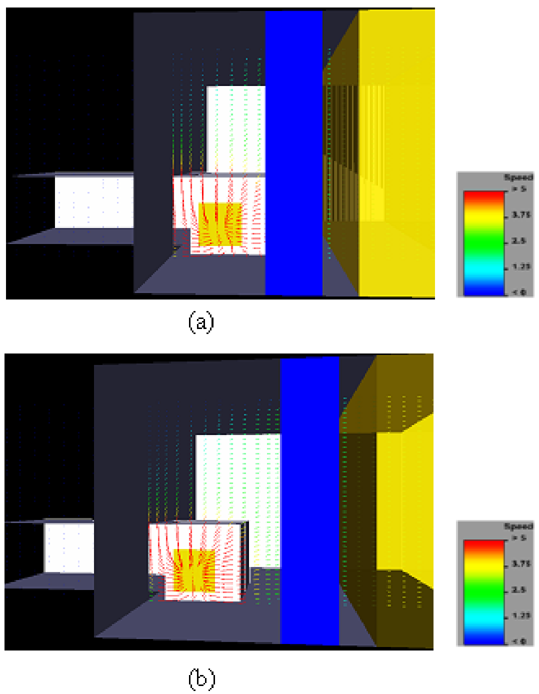


Fig.8 Air flow field inside horizontal type of air handling unit.
(a) D1 = 55 cm, (b) D1= 105 cm

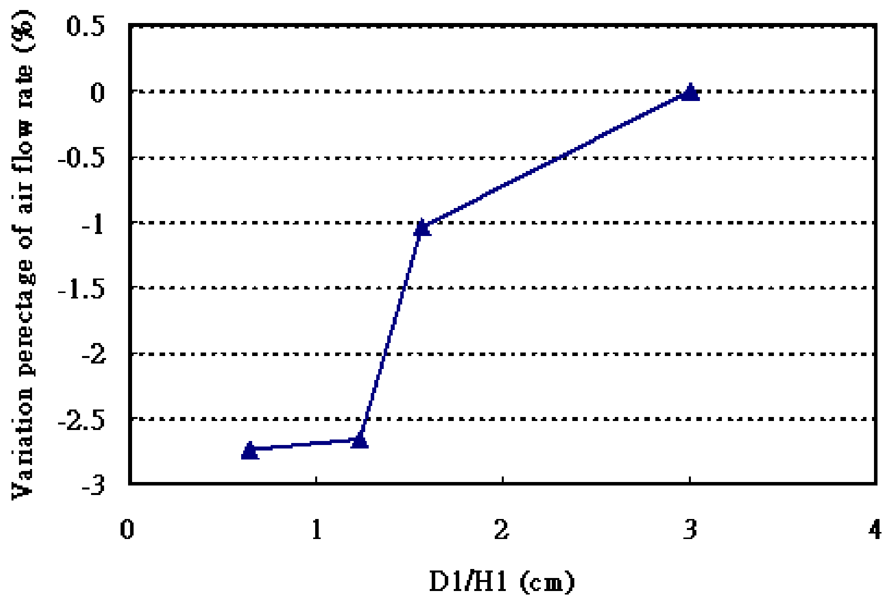


Fig.9 Effect of D1/H1 on air flow rate of air handling unit.
(D1/H1 = 3 cm is baseline case)

Conclusion

1. We have applied the CFD software to analyze the influence of internal component arrangement on velocity fields, temperature distributions and the performance of vertical/horizontal type of AHU.

2. In the future, we will apply CFD again for the wide range of sizes of air handling units to set up a design guide for internal component arrangement of AHU.