Importance of the Return Air Opening to Degree of Turbulence in an I-Grade Clean Operating Room

Suo-ming Cheng
Taiyuan University of Science and engineering
Taiyuan& China
E-mail:sxtycsm@163.com

Abstract: In this paper, a high Reynold K-ε two equation model has been used. The range of return air openings that can be used has been induced by numerical simulation to influence the return air opening and degree of turbulence in an I-Grade clean operating room in conditions that insure a degree of cleanliness and supply velocity. The size of the return air opening has been analyzed by comparing the results of the numerical simulation and experiment. The results will help the design of the I-grade clean operating room.

Key words: clean operating room; degree of turbulence; numerical simulation

1. INTRODUCTION

IT has been indicated that return Air Opening in I grade clean operating room should be disposed continuously in《Architectural technical code for hospital clean operating department》.But the range of return Air Opening don't give us definitely, many discommodity has been brought in engineering. In this paper, high reynold K-ε two equation model has been used. The range of return air opening that can be used has been induced by numerical simulation to influence of return air opening to degree of turbulence in I grade clean operating room in the condition of insuring degree of cleanliness and supply velocity, then the size of return air opening has been gained by comparing conclusion of numerical simulation and experiment, In order to help the design of I grade clean operating room.

2. MATHEMATICS MODEL AND PHYSICS MODEL

2.1 Hypothesis of physics model

1) There is no heat source in grade clean operating room.

2) The flow of air is steady flow.

3) The contaminant produced by contamination source is no mass.

2.2 Mathematics model

1) Continuous equation

$$\frac{\partial u_i}{\partial x_i} = 0$$

2) Momentum equation

$$\frac{\partial (u_i u_j)}{\partial x_j} = -\frac{1}{\rho}\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j}\left[(\nu + \nu_t)\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\right]$$

3)Turbulent flow artery kinetic energy equation

$$\frac{\partial u_j K}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{C_k}\right)\frac{\partial K}{\partial x_j}\right] + \nu_t \frac{\partial u_i}{\partial x_j}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) - \varepsilon$$

4) Turbulent flow energy equation

$$\frac{\partial u_j \varepsilon}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{C\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right] + C_1 C_\mu K \frac{\partial u_i}{\partial x_j}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) - \frac{C_2 \varepsilon^2}{K}$$

5) concentration equation

$$\frac{\partial (u_j C)}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\frac{\nu_t}{C_c}\frac{\partial C}{\partial x_j}\right) + Q$$

u_i ——velocity vector（m/s）

P ——pressure（Pa）

ν_t ——viscosity coefficient of turbulent flow（㎡/s），$\nu_t = \frac{\mu_t}{\rho} = C_\mu K^2 / \varepsilon$

ν ——kinematic viscosity coefficient（m²/s）

C——dust concentration（entries /m^3）

Q——concentration contamination source（entries /（m^3·s））

C_1=1.44 C_2=1.92 C_k=1.00 C_ε=1.30 C_μ=0.09 C_c=1.00

3. CASE DESIGN

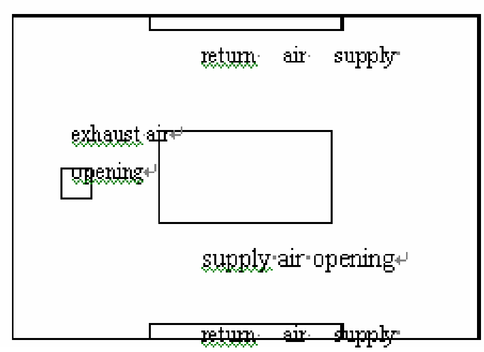

Fig.1 Air opening design of I grade clean operating room

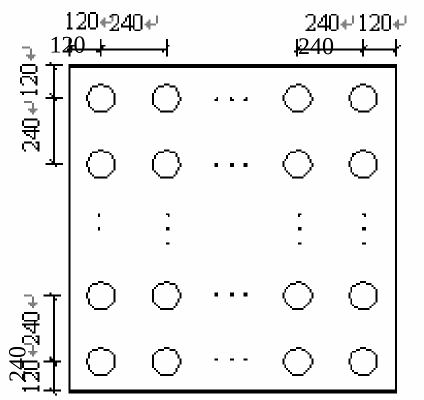

Fig.2 The position of calculating of degree of turbulence

AIR OPENING DESIGN of I grade clean operating room is showed in Fig.1.

Case design is showed in table.1.

The position of calculating of degree of turbulence is showed in Fig.2.

4. CONCLUSION ANALYSIS

Degree of turbulence is an important characteristic of I grade clean operating room , which indicate the disperse degree of velocity and can be indicated used formula as follows.

$$\beta = \sqrt{\frac{\Sigma\left(v_i - v_{pj}\right)^2}{K-1}} \Big/ v_{pj}$$

in formula:

$$v_{pj} = \frac{\Sigma v_i}{K}$$

v_{pj} ——average of velocity in work area（m/s）;

v_i ——velocity of code in work area（m/s）;

β ——degree of turbulence;

K——number of code in work area。

The conclusion of degree of turbulence in work area is indicated in table.2.:

Table.1 Case Design

Case number	Supply air（m^3/h）	Size of supply air opening mm×mm	Fresh air（m^3/h）	Exhaust air（m^3/h）	Return air（m^3/h）	Size of return air opening mm×mm
NO.1	6065.28	2400×2600	1000	800	5065.28	2400×200
NO.2	6065.28	2400×2600	1000	800	5065.28	2500×200
NO.3	6065.28	2400×2600	1000	800	5065.28	2600×200
NO.4	6065.28	2400×2600	1000	800	5065.28	2700×200
NO.5	6065.28	2400×2600	1000	800	5065.28	2800×200
NO.6	6065.28	2400×2600	1000	800	5065.28	2900×200
NO.7	6065.28	2400×2600	1000	800	5065.28	2400×250
NO.8	6065.28	2400×2600	1000	800	5065.28	2500×250

NO.9	6065.28	2400×2600	1000	800	5065.28	2600×250
NO.10	6065.28	2400×2600	1000	800	5065.28	2700×250
NO.11	6065.28	2400×2600	1000	800	5065.28	2800×250
NO.12	6065.28	2400×2600	1000	800	5065.28	2900×250

Table.2 Conclusion of Degree of Turbulence

Case Number	Conclusion	Case Number	Conclusion
NO.1	0.31	NO.7	0.30
NO.2	0.22	NO.8	0.20
NO.3	0.19	NO.9	0.17
NO.4	0.24	NO.10	0.23
NO.5	0.29	NO.11	0.26
NO.6	0.34	NO.12	0.31

In order to analyze, the conclusion of Table.2 has been curved. (Fig.3, Fig.4.)

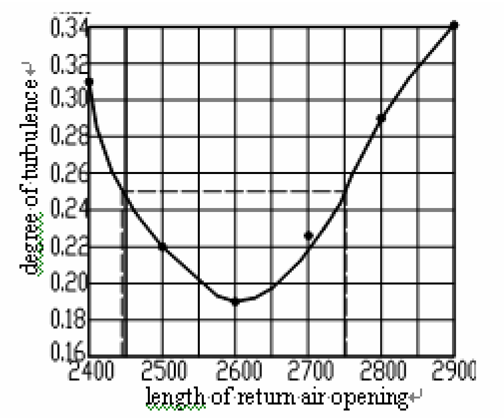

Fig.3 No.1～No.6 curve of degree of turbulence

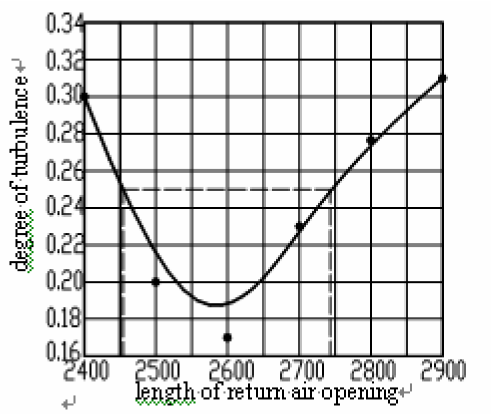

Fig.4 No.7～No.12 curve of degree of turbulence

Degree of turbulence is less than 0.25 to the I grade clean operating room[1]. It can be gained that degree of turbulence increase firstly, then decrease when the size of return air opening increase from Fig.3 and Fig.4. So we can know that size of return air opening can't too long or too short. The range of return Air Opening that meet need of I grade clean operating room is from2448 ㎜～2746 ㎜.

5. CONCLUSION COMPARE BETWEEN NUMERICAL SIMULATION AND EXPERIMENT

CONCLUSION of experiment has been curved.(Fig.5).

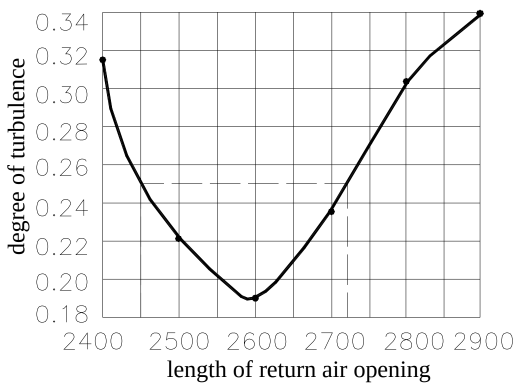

Fig.5 curve of degree of turbulence of experiment

Fig.5 indicated that the range of return Air Opening that meet need of I grade clean operating room is from2400 ㎜～2720 ㎜. Which is less than numerical simulation, because some factors don't take into account.

6. CONCLUSION

IN DESIGNING of I grade clean operating room, we should make the length of return air opening in the range of 2400 ㎜～2720 ㎜.

REFERENCES:

[1] Architectural technical code for hospital clean operating department,beijing: GB50333-2002,20. (In Chinese)