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Numerical Analysis of Infectious Ward Air Exchanges Rate

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Abstract

At present, our country regulated that the air exchange rate in infectious ward should be 10 to 40 times per hour. The United States, Australia, Britain regulated that the air exchange rate in infectious ward should be not less than 12 times per hour, under the conditions of restriction, the air exchange rate should be not less than 6 times per hour. However, for different forms of ventilation and room types, people need to specific study in order to achieve the reasonable air exchange rate. By the method of numerical simulation, with particle size of 5μm and 20μm as example, in the condition of the wall attached jet, the paper researched the effects of different air exchange rate for discharging indoor pollutant efficiency.

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Keywords: *Numerical analysis;Infectious ward;air exchange rate; Wall attached jet;aerosol particles*

1. Introduction

During the SARS outbreak in 2003, 20% of the infected group is medical personnel in our country [1]. The hospital has become the main place where the SARS spread. Therefore, improving the quality of air in the wards, which can not only protect the health of medical staff, but also can help the patients recover. According to the relevant provisions of our country promulgated, ventilation rate of infectious ward is 10-40 times per hour [2], under the conditions of restriction, the air exchange rate should be not less than 6 times per hour [3]. But the increase in ventilation rate will affect indoor heat and wet environment, increase the energy consumption of air conditioning, is not conducive to the patient's recovery. Therefore, it is necessary to study the infectious ward ventilation rate. This paper through the method of numerical simulation, studies under different ventilation rates, the patient produces droplets trajectory and the change of the concentration of aerosol particles, from the perspective of the patient's comfort and control of pollutants within a reasonable design infectious ward air conditioning ventilation rate.

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2. Methods

2.1.Math model

The literature 4 points out that the indoor air flow should be used in RNGK-Ɛ turbulence model [4].The RNGK-Ɛ model and standard K-Ɛ model are similar, there are following improvements:

- The RNGK-Ɛ model adds a condition in Ɛ equation, effectively improve the accuracy;
- Considering the turbulent eddies, the aspect of accuracy is improved;
- Standard K-Ɛ model is a kind of high Reynolds number, and the RNG model provides the analytic formula a considered low Reynolds number flow viscosity. So this paper uses the RNGK-Ɛ turbulence model.

The particle trajectory was solved based on Lagrange coordinates [5]. The Lagrange method can solve a single particle (group) equation of motion (by Newton’s second law of motion) to get the velocity of particles. Particles in the flow field are affected by multiple forces together. Among them, for the small aerosol particles, bassett force, pressure gradient force and mass force can be negligible, but Saffman force will not be ignored. As a result, the trajectory equation for the end form is:

$$\frac{du_p}{dt} = \frac{18\mu_a}{\rho_p d_p^2 c_c}(u - u_p) + \frac{g(\rho_p - \rho_a)}{\rho_p} + Fs \tag{1}$$

In the equation, the u_p is the particle velocity, m/s; t is the time, s; μ_a is the air viscosity, Pa·s; the ρ_p is particle density, Kg/m³; d_p is particle diameter， m; c_c is correction coefficient; u is air velocity, m/s; ρ_a is air density, Kg/m³; Fs is Saffman force, N.

Particle concentration equation is:

$$c = \frac{M\sum_{i=1}^{m} dt}{V} \tag{2}$$

In the equation, c is the average mass concentration of particles in a cell; M is the flow of each trajectory; dt is particles in the cell residence time; m is track number; V is the cell volume.

2.2.Physical model

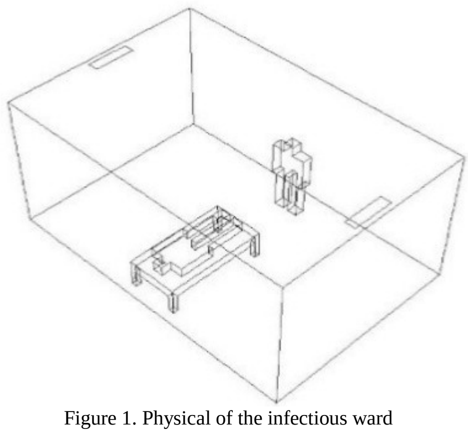

Figure 1. Physical of the infectious ward