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The dynamics of the body motion induced wake flow and its effects on the contaminant dispersion

Yan Wu [a], Naiping Gao [b,*]

[a] Department of Building Services Engineering, The Hong Kong Polytechnic University, China
[b] Institute of Thermal and Environment Engineering, School of Mechanical Engineering, Tongji University, China

A R T I C L E I N F O

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A B S T R A C T

Occupant movements have been identified to impact the indoor contaminant dispersion and to increase the airborne infection risks. In the present study, numerical methods were validated against experimental data and adopted to simulate the impact of the human body motion in a displacement ventilated office room. The computational domain was divided into dynamic mesh zone and static mesh zone, the layering grid updating approach of dynamic mesh method was employed to update the deformed grids generated by the motion. The dynamics of the human wake and its interaction with the thermal plume were investigated. The effects of the motion on the indoor airflow and contaminant dispersion were explored. The results show that it depends on the moving speed whether the thermal plume could be ignored or not when studying the wake dynamics near a moving body. The indoor airflow is affected by the motion significantly, and the contaminant transports in both horizontal and vertical directions are strengthened. This study would make a small step in the investigation of anti-disturbance characteristics of the thermally stratified indoor environment.

1. Introduction

Indoor air quality (IAQ) and thermal comfort are the bases for the health of the indoor occupants, and bad IAQ will lead to the "sick building syndromes" [1]. In modern buildings mechanical ventilation is one of the most effective approaches to improve IAQ [2]. Benefit from the thermal stratification phenomenon, bottom supply and upper exhaust mode displacement ventilation has a relatively higher ventilation efficiency and provides better IAQ compared with other types of mechanical ventilations [3]. In previous studies, the indoor environment was always treated as static, which was inaccurate since that in real life the occupants are usually in active state.

Investigations have shown that human activities could impact the indoor environment and ventilation performance [4–6]. Mazumdar and Chen studied the effects of a moving person on the airflow in an aircraft cabin using CFD methods. They found that a strong longitudinal flow was created by the motion [7]. Shih revealed that the airflow field could recover itself within a quite short period after the moving body stopped in a CFD study on the airflow simulation in an isolation room [1]. Contaminant dispersion highly depends on the airflow patterns. So, it could also be influenced by the human motion, which has been proved by many studies [8–11]. Mazumdar et al. [12] found that the moving body could carry the contaminant to any places it reached in the cabin. Some other research even shown that the movement of human arms could also change the contaminant distribution around them [13,14]. Previous studies mainly concentrated on the effect of human motion on the contaminant spread in some certain places where high cleanliness level was required or where infectious risks of diseases were high, such as operating rooms, isolated wards, clean rooms or aircraft cabins. Besides, few research focused on the impact mechanism of above phenomenon, i.e., the dynamics of wake flow induced by the body motion. Edge [15] numerically explored the wake structures using a human model with refined head and legs. Welling [14] investigated the relationship between indoor wind speed and human wake length

* Corresponding author.
E-mail addresses: gaonaiping@tongji.edu.cn, gaonaiping@gmail.com (N. Gao).

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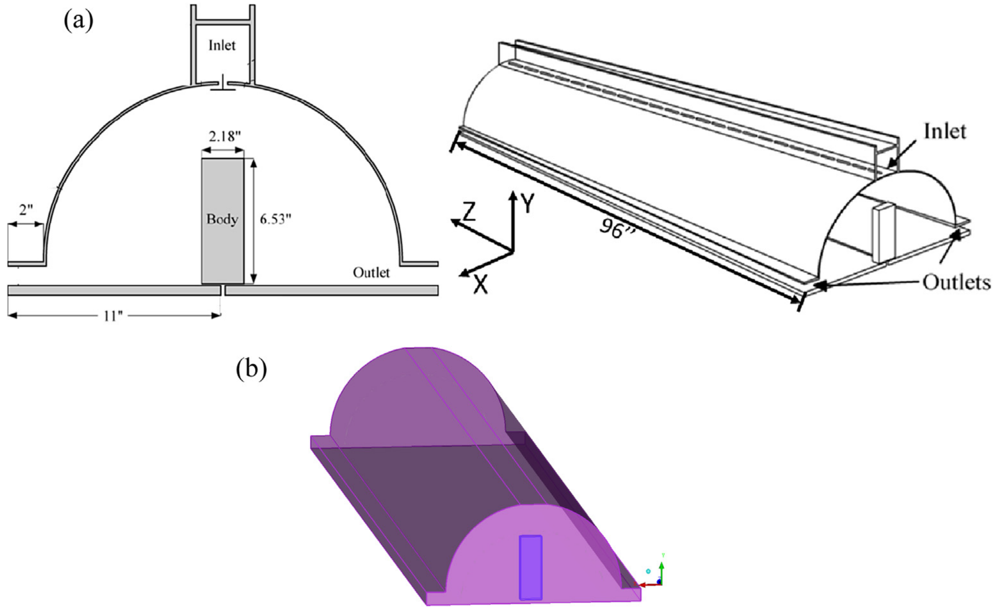

Fig. 1. (a) Sketch map of the aircraft cabin model in Poussou's experiment [18]. (b) The aircraft cabin model in the CFD simulation.

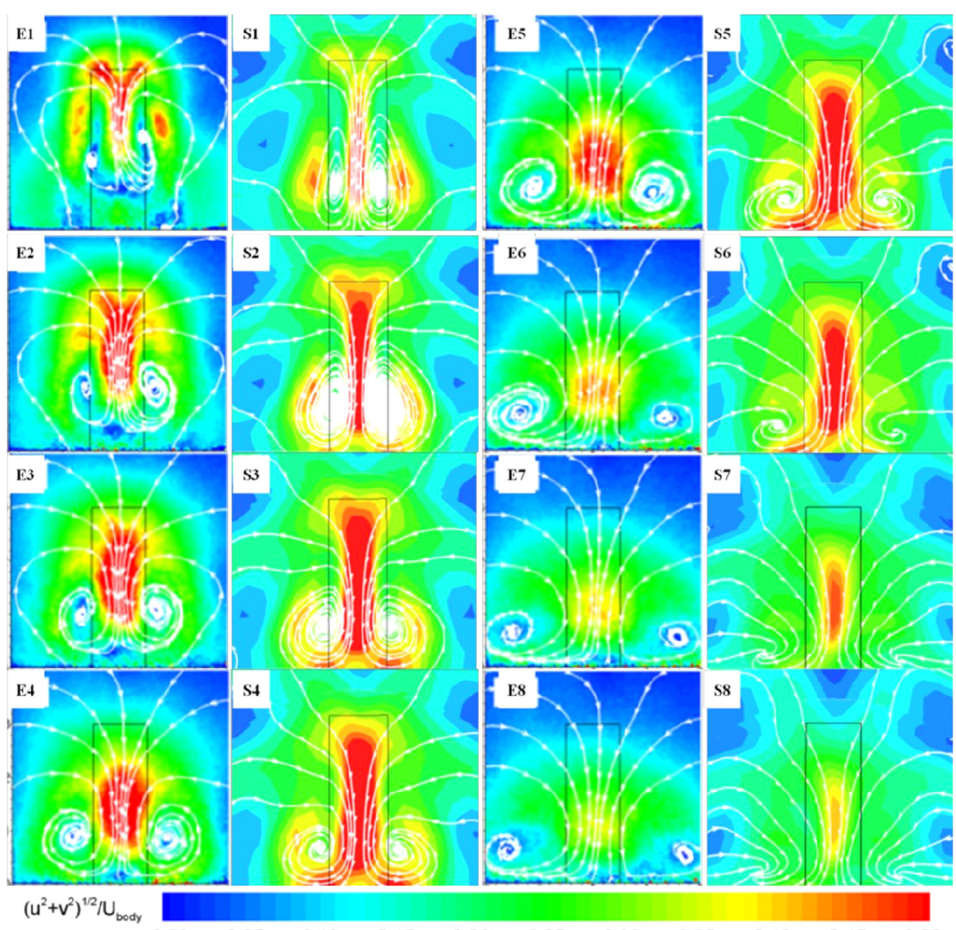

Fig. 2. Comparison of the streamlines and velocity distribution.