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Analysis on Thermal Environment of Office Room Equipped with Radiant Cooling Workstation

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Abstract

In this paper, an experiment was designed to compare the thermal environment between the fan coil unit system (Case 2) and the combination of radiant cooling workstation and fan coil unit system (Case 1). Through the numerical simulation software, namely Airpak, the indoor air temperature and velocity were compared in two cases. Compared to Case 2, there are 81.82% and 7.81% decrease in vertical and horizontal temperature difference, respectively. However, the vertical air temperature difference between head and feet is 0.97℃, which is higher than Case 2. Also, the mean air velocity in Case 1 is lower than Case 2, and the air velocity in occupied zone of Case 1 ranges from 0.065 m/s to 0.12 m/s.

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Keywords: Radiant cooling workstation (RCW); Thermal environment; Computational fluid dynamics (CFD)

1. Introduction

Radiant cooling systems were introduced into China about 20 years ago [1], and there are quite a number of applications [2]. Comparing the conventional air conditioning system, much less energy is consumed to cool the conditioned room because relatively low pumping energy is required. The high operation temperature of radiant cooling systems enables a chiller to operate at high efficiency, which leads to the significant reduction in primary energy consumption [3]. D.Petras reported an investigation of energy performance and indoor environment in two modern office buildings equipped by a high temperature cooling system. The results showed that the high temperature cooling system has great potential to create a comfortable indoor environment at low energy consumption [4]. For the last two decades, there has been an increasing interest in task air condition (TAC), which is

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defined as a space conditioning system that allows thermal conditions in small, localized zones to be individually controlled by occupants [5]. The individual control of task conditioning system contributed to create the preferred environment [6]. H.Zhang designed TAC system that heats only the feet and hands, and cools only the hands and face, which provided thermal comfort in a wide range of ambient environments. The results showed that TAC system used less than 41 W for cooling and 59 W for heating [7]. N.Mao demonstrated that using the ductless bed-based TAC could lead to a better ventilation performance and energy saving performance, but a poor thermal performance in terms of a higher draft risk than using the FAC system [8].

In this paper, a new type radiant cooling workstation (RCW) was proposed. An experiment was carried out in a test room in Changsha city. Through testing and comparing the indoor air temperature field and air velocity field of the combination of RCW and FCU system (Case 1) and FCU system (Case 2), the study results indicated the proposed RCW system outperform the traditional FCU system.

2. Experiments

2.1. Experimental facilities

The room located in the Floor 1st of a laboratory building at Hunan University. The distribution of experimental room is shown in Fig.1. Except the north wall, the rest ones are interior walls. There is a door (1.0m×2.1m) located in the south wall, and a window (1.5m×1.8m) in the north wall. Above the work station there is a fluorescent lamp. A supply air outlet (0.8m ×0.25m) is placed at 2.3m above the floor level.

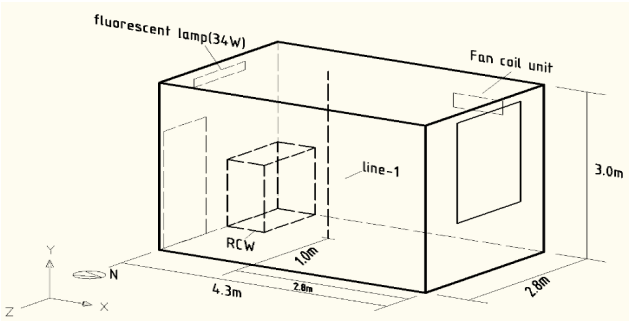

Fig. 1.The experiment room

RCW mainly consisted of five radiant panels (Fig. 2). The size of each radiant panel is 1200 mm×600 mm×20 mm. The surface is made of aluminum alloy while the back of panels was attached with rubber-plastic insulation lay. The diameter of plastic capillary tubes inside the panels was 3 mm. RCW is supplied with cool water which is re-circulated by a cooling machine.

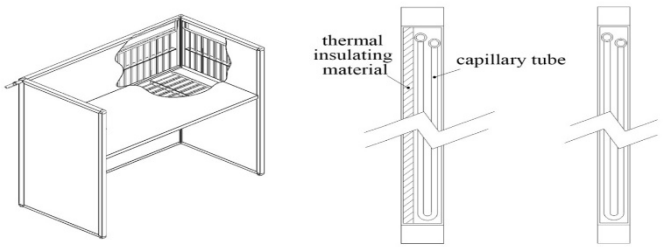

Fig. 2.Radiant Cooling Workstation