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Effect of raised floor height on different arrangement of under-floor air distribution performance in data center

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Abstract

In the more and more expanding and complicated data center, requirements on air conditioning system and the air distribution arrangement are getting higher and higher. One of the resolutions is improving the airflow uniformity and cooling the local over-hot area by raising the floor in the data center. With a typical mode of four rows of cabinets in the data center as a sample. This paper uses Computational fluid dynamic (CFD) to investigate the influence of the six raised floor heights (0.2m, 0.4m, 0.6m, 0.8m, 1m and 1.2m) on the airflow distribution of three types of under-floor air distribution (the open aisle, the cold aisle containment and the hot aisle containment). Optimization is done on performance indexes, including supply/return heat index (SHI/RHI), return cooling index (RCI) and return temperature index (RTI), with which the condition of subcooling / overheating of all cabinets and the characteristics of the airflow organization in the data center are reflected and the thermal environment in the data center is revealed. Normally, the cooling effect and the uniformity of the airflow can be improved by raising the floor height. However, this won't work well when the floor height reaches a certain level. Therefore, based on the comparative analysis on the 18 different cases in this investigation, the recommended range of raised floor height in data centers of different construction can be obtained and verified in the experimental tests. The experimental results turn out to be in accordance with the simulation results, which proves the range recommended in this investigation is valuable.

Keywords: Data center; Raised floor; CFD; Under-floor air distribution; Verification test

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1. Introduction

Now, the data center is gradually pursuing efficiency and low cost, while maintaining the safe and reliable operation. Therefore, one of the most important savings in operation expenses is in order to reduce the power consumption of IT servers and cooling systems. The dramatic increase in energy consumption in the data center has become a problem at a national level. In the past 10 years, energy consumption in data centers doubled every four years [1]. The dramatic increase in the amount of heat generated by the IT server has resulted in an increase in the energy generated by the cooling system to about 40% of the energy consumption of the data center. Dramatic increase of IT server's heat density led to increase in energy consumption of cooling systems to about 40% of data center's energy consumption. High heat flux density equipment, the equipment unit area heat dissipation and equipment throughout the year running present a serious challenge to the cooling system [2-3]. Therefore, reducing the energy consumption of the cooling system is the key problem of data center energy conservation. In the premise of sufficient cooling capacity, improving the airflow distribution can effectively increase the IT server's cooling efficiency and reduce the data center to generate local overheating [4-5]. Therefore, this paper aims to improve airflow uniformity to improve the utilization of cold air, reduce local overheating and data center's energy consumption. The main problem of improving airflow is to optimize the flow field under the raised floor. With a typical mode of four rows of cabinets in the data center as a sample. 18 different cases in this investigation including six raised floor heights and three types of under-floor air distribution was imitated by Computational fluid dynamic (CFD). Through performance indexes, the condition of all cabinets and the characteristics of the airflow organization in the data center are reflected [6-8].

2. Methods

2.1. Data center design

The experiment was to be in accordance with the simulation results. Research procedure is shown in Figure. 1.This paper presents two kinds of variable factors including six raised floor heights (0.2m, 0.4m, 0.6m, 0.8m, 1m and 1.2m) and three types of under-floor air distribution (the open aisle, the cold aisle containment and the hot aisle containment). IT servers are designed according to ASHRAE TC 9.9. Each cabinet in this paper is arranged in 2kW/rack and consists of 20 servers(1U). Each server(1U) is configured as Table 1. For simulation convenience, the 20 servers in the cabinet are divided into four modules. Each module has five servers and distributes heat on average [9-10]. The outlet temperature of air conditioning is 18℃ and the total supply air volume of the two air conditioning units is 5m^3/s. The data center is designed as Table 2.

Table 1. Server configuration.

	Power (W)	Heat (W)	Size
1 IT server	100	97	450W×600D
20 IT servers	2000	1940	

Table 2. Data center design.

Cabinet size	Cold aisle	Hot aisle	Floor size	Floor perforation rate
600mm×1100mm×2000mm	1200mm	1200mm	600mm×600mm	50%