Sustainable Cities and Society 14 (2015) 64–69

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Experimental study on both cleaning effect and motion performance of the duct-cleaning robot

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ARTICLE INFO

Article history:
Available online 27 July 2014

Keywords:
Duct-cleaning robot
Cleaning effect
Moving performance

ABSTRACT

With increasing consideration on public health, the cleaning industry for central air-conditioning systems has been flourished in China with the rapidly developed of both duct-cleaning technology and cleaning robots. By testing the performance on the experimental platform, this paper presents the cleaning effect and motion performance of the duct-cleaning robot designed by our expert group. The result indicates that the cleaning effect is not satisfied at corners and elbows, where the pollution is relatively serious. At the end of this paper, it points out the development direction for China's duct-cleaning robot and its experimental platform, which can provide an important basis to standardize the test platform, tools and methods for the evaluation of robot's performance.

1. Introduction

With the rapid development of economy, the central air-conditioning and ventilation system has been widely used to improve the indoor air quality. The pollution of ventilation system in public buildings with different functions in both south and north regions was investigated (Song et al., 2010; Zhao et al., 2011), and the conclusion was that the amount of dust, bacteria and fungi on the inner surfaces of duct had reached to 288.48 g/m^2, 1575 cfu/cm^2 and 1440 cfu/cm^2 respectively. Researchers pointed out that the contaminated ventilation system not only fails to dilute the pollutant concentration by air supplying, but also diffuses the spread of contamination (Chen, Zhao, & Yang, 2009). The cleaning of duct systems and equipments is an effective way to reduce pollution and improve indoor environment quality. With its automatic control system and visual function, the duct-cleaning robot performs well in cleaning work, which brings a great convenience to the cleaning of central air-conditioning and ventilation systems (Li, Zhang, & Li, 2009). The duct cleaning equipment was first developed in US in 1950s, and the technique was introduced to China in 2000s. The duct-cleaning robot is newly appeared in the market, and with using advanced control systems, it has advantages of intelligent and humanized. However, in China, there is no relevant technical standard to evaluate the performance of the cleaning robot to make the domestic industry of duct-cleaning robot extensive widely (Luo, Cao, & Song, 2009; Yang, 2004). This may threaten the robot's quality and performance. In this situation, our group has developed the robot-integrated system and set up an experimental platform for the robot's performance test. Based on the tests for robot's cleaning effect and motion performance, this paper presents the standardization of the test platform, tools and methods applied in the evaluation of robot's performance. The systematic study on key problems revealed in cleaning work is also included in this paper.

2. Design scheme of the experimental platform of the duct-cleaning robot performance

The test platform consists of rectangular and round ducts in various dimensions and elbows to better simulate different kinds of complicated conditions of the robot working process. Sorts of experiments such as tests for robot's adaptability in ducts, cleaning effect, turning and climbing performance can be operated on this platform (Luo, 2009; Yong, Yunyou, Dan, & Lisi., 2009).

The principle layout and size of the experimental platform is shown in Fig. 1 and the real picture is shown in Fig. 2. In the installation, one side of the rectangular duct and a quarter of the round duct were replaced by transparent boards which is made

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http://dx.doi.org/10.1016/j.scs.2014.07.005
2210-6707/

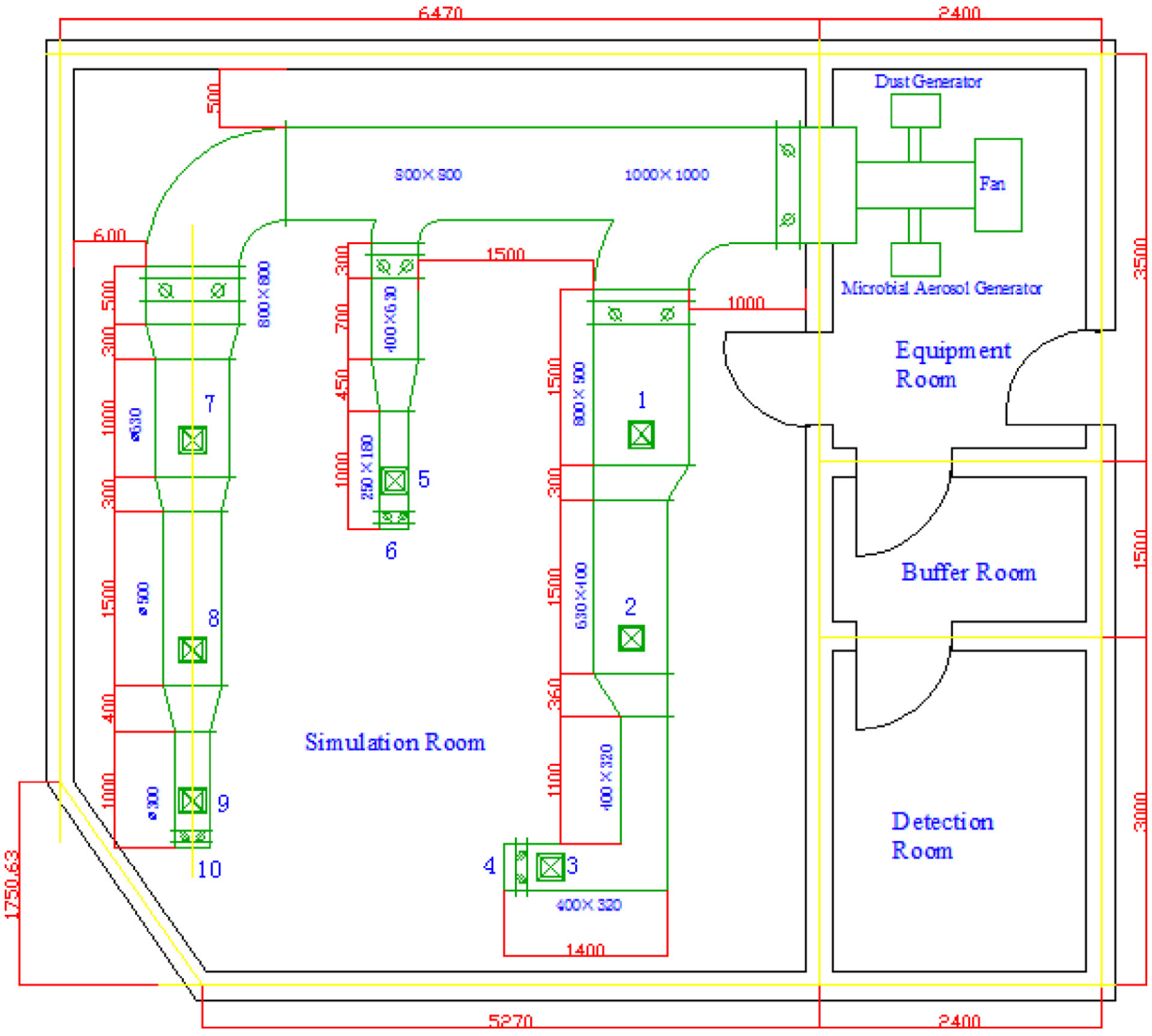

Fig. 1. Principle layout of the experimental platform.

by plexiglass and the ducts were set 0.8 m high to the ground so that the working process of the robot can be observed outside. Square holes were opened as an access for the robot and sampling. HEPA filters were installed on the ends of branch pipes and 4 exhaust vents. When the experimental dust is emitted, the other exhaust vents are turned off and the air flows out from the filers only so that the dust can uniformly be deposited on the inside surface, and the pollution outside ducts can be avoided at the same time.

Fig. 2. Picture of the experimental platform.

3. Experiment scheme of cleaning effect of the duct-cleaning robot

The pollution inside ducts was distributed by artificial approach. By using the dust generator and microbial aerosol generator, the pollution was generated, and the fan blew the pollution into the ducts then the robot was sent to clean. The robot consists of 4 parts, including the moving body, the cleaning brush, the control system and the monitoring system. The moving body of cleaning robot is shown in Fig. 3. The moving body carries the cleaning brush and moves in the ducts, the brush cleans the inner surface of the ducts. The working scene is shown in Fig. 4. Wiping method was adopted in the dust sampling, and the microbial sampling uses the swab-wiping method. After that, the microbe was generated and analyzed after collected. The TSI DUSTTRAK 8520 smart dust detector and the six-level sieve air-percussive samplers were respectively utilized in the sampling of inhalable particulates and microbe from