Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 164 (2016) 121 – 126

Procedia Engineering

www.elsevier.com/locate/procedia

Creative Construction Conference 2016, CCC 2016, 25-28 June 2016

Air Conditioning Ducts Inspection And Cleaning Using Telerobotics

Alexey Bulgakov[a], Daher Sayfeddine[b]*

[a]*Southwest State University, 50 let Oktyabrya st. 94, Kursk, 305040, Russia*
[b]*Platov South-Russian State Polytechnic University (NPI), Prosveshenia st. 132, Novocherkassk, 346428, Russia*

Abstract

Manual period maintenance and cleaning of HVAC ducts systems are time consuming and mundane task. In some cases, it lead to unexpected accidents and overhead costs. In addition, the cleaning procedures can be detrimental to HVAC cleaning specialists, especially in hazardous environments such as hospitals, medical and electronic components manufacturers. Taking into consideration that robotics aims to replace the human-operator in preforming dangerous tasks, we focus this paper on studying the feasibility to integrate telerobotic solutions in HVAC duct inspection and cleaning procedures. The paper is divided into two major sections: firstly, we study health and norms memorandums pertaining hygiene factors and metrics in certain building such as hospitals, then we analyze the possibility of using telerobotic solution in order to improve and automate the cleaning process of the air ducts, removing debris and dust. In addition, a mathematical model based on BioVac robot specifications is represented, focussing on positioning control system of the robot in the HVAC duct. For better manoeuvrability, fuzzy logic position controller was introduced thus to improve spray guns and manipulator reachability.

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2016

Keywords: Duct cleaning; site management; telerobotics

1. Introduction

Air and water quality are one of the major elements directly affecting human being. Therefore, historically, most conflicts sparkled in order to acquire healthy and fertile lands. The evolution of the humanity imposed changes to life styles and habitations. With population growth, lands have become luxurious and rare resources. In parallel, importing enough water and services to habitats such as building drainage, water supplies and roads became traditional social

* Corresponding author. Tel.: +7 961 271 2523; fax: +7 4712 504850.
E-mail address: a.bulgakow@gmx.de

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2016
doi:10.1016/j.proeng.2016.11.600

and technical problems to deal with.

Many technologies were founded to improve services and making them reachable to human being. For instance, to fight the heat, earlier Arab constructors have designed ducts on top of the roof infiltrating the ceiling of the building, allowing continuous air circulations inside particular rooms (fig. 1).

Fig. 1. Ventilation ducts - traditional Arabic architectural signs

Nowadays, buildings are designed to accommodate centralized air conditioning and heating systems. Taking hospitals as an example, operating theaters and recovery rooms are totally dependent on the air supply unit being designed, as it affects the pressure rate and the air curtain created above the patient. The quality of air supplied is very important. Therefore, recently ultraviolet lamps are installed in the air duct to kill germs. Heath and Safety engineers did not exaggerate while adopting the statement "*what is in your duct is what in your lung"*.

Duct cleaning is performed manually by accessing pre-identified areas. Some air supply systems can be purged, so the enclosed air inside the ducts is sucked out to filtering station. Intelligent solutions are also present with telerobotics. This approach consists basically of a telescopic snake robot or a mobile robot equipped with spraying guns.

Looping back to old supply ducts systems, the purging solution cannot be used, while manual method consumes lots of time. The telerobotic solution seems to be the optimal choice [5]. Additionally, this approach can be used frequently, essentially for buildings occupied by citizens with special needs (i.e. in-house ventilated patients).

In this paper we discuss the telerobotic solution for duct cleaning for newly built and old structures. In addition, we highlight setup requirements, implementation constraints and possible improvements.

2. Case study

In this paragraph, we present case study on the influence of the air conditioning ducts on hygiene factor inside hospitals. The subject of calibrating, testing, commissioning and inspecting of air ducts and laminar air flows (LAF) in Ultra Clean Ventillation (UCV) OR's is dealt with in different publications including HTM [11], ASHRAE and ISO14644 documentation. In general, the following should be carried out an annual basis for each operating theatre:

a. Particle counting within the area to assure room compliance with ISO5 or ISO7 limits. With this test we used to select 2 significant particle values for compliance, which is normally 0.5µm and 5µm, although the 2015 revision of ISO14644 has removed the 5µm limit from the specification for class 5 [12];
b. Air flow measurement to ensure the correct velocities and air change rates;
c. Filter face scanning involving an upstream injection of smoke / oil drops (DOP) and then systematic scanning of the filter face to measure how much contaminant gets through. This does require an injection point to be designed in upstream of the canopy to the supply ductwork and will shut down the area for the duration of the test.
d. Entrainment test to ensure that particles are not being drawn into the area from outside the air stream (particle counts at perimeters)
e. Microbiological sampling can be used but the above tests are often sufficient.

According to British standard code BS 14065 "Decontamination of linen for health and social care: Guidance for linen processors implementing" used to regulate construction in healthcare premises, soiled and clean areas should be