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Fabrication of Duct Cleaning Setup

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ABSTRACT

In the world of globalization and modernization where air conditioning system acts as the pulse of every modern infrastructure, in which air supply plays a prominent role in cooling. The duct systems work as nerves of these air conditioning units. Also, its maintenance is required for greater efficiency to prevent damage. Our research focuses on the non-destructive techniques to clean the dust, fungi, foreign particles and it also detects flaws, cracks, and corrosion inside the ducts. The technique if used on a regular basis, we can increase the efficiency and life of ducts and the cooling units. This research involves a wirelessly controlled robot powered by batteries, having wheeled and wall tire system for movement inside different cross-sectional ducts. The prime objective is to clean the ducts by a cleaning probe attached to the robot, different probes like scrubber, dust, fungi, and bacteria from ducts. Helping to provide the healthy conditioned air supply to the chambers. The robot equipped with infra-red cameras for the live view of inside the ducts. As dust, fungi, bacteria and corrosion affects the efficiency, the cleaning probe provides the removal of these impurities. The simple design of robot makes it more convenient and useful for varying cross section ducts and helps to build its bond at consumer ends. Indoor Air Quality (IAQ) has become public concern recently. Air ducting is used in Mechanical Ventilation and Air Conditioning (MVAC) system to deliver air to the building occupants. Without proper maintenance of the ducting system, it will affect the IAQ of overall building. Monitoring air ducting is the preliminary step to get real view inside the ducting. This study focused on the development of the Mechanical Ducting Robot to monitor the ducting and data collection at real time.

Keywords : Robot, Wireless Control, Effective Cleaning, Various Duct, Monitoring.

I. INTRODUCTION

This chapter discusses the background of the research problem. It generally describes the importance of Indoor Air Quality (IAQ). This chapter also highlights the problem statement based on the background provided as well as the objectives, limitations and significance of the study.

The main purpose of the ventilation system and air duct is to supply fresh air into closed spaces such as buildings and subway stations where people work and spend most of their daily hours. The air duct and ventilation system controls various air flows, i.e., outdoor air, supply air, return air, and exhaust air. The ventilation system also consists of mechanical components such as dampers, fans, filters, and duct terminals. Various particulate matters are initially filtrated with particle filters installed at the side of the supply air duct. The filters commonly used, however, are insufficient to prevent the entrance of all the particulate matters from outdoor air into the duct. Therefore, transported dust and other impurities are accumulated at the duct surface inside the ventilation system. Accumulated dust inside air duct may also

originate from the facility construction phase or from ventilation duct installation.

To provide fresh and clean supply air through the ventilation system into the closed space such as subway stations, eliminating source for the pollutants and contaminants is the most cost effective than cleaning and replacement of the air. The main purpose of the ventilation system and air duct is to supply fresh air into closed spaces such as buildings and subway stations where people work and spend most of their daily hours.

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To provide fresh and clean supply air through the ventilation system into the closed space such as subway stations, eliminating source for the pollutants and contaminants is the most cost effective than cleaning and replacement of the air. The main purpose of the ventilation system and air duct is to supply fresh air into closed spaces such as buildings and subway stations where people work and spend most of their daily hours. Robotic Duct Cleaning system is the new revolution in Air Duct Cleaning Industry.

Robot Duct Cleaner system is very useful for Property Owners, AMC companies or anyone who wish to inspect, clean and spray commercial, industrial and residential ventilation systems. It is designed to improve the quality of cleaning ventilation ducts by removing the dirt, debris and other contaminants of the air. Air Duct Cleaning is a very important subject which directly relates to human health. Quality of Air Supplied by the Air Conditioner, especially in Centrally Air Conditioned Buildings depends upon the ducts condition, Air quantity and quality would be better cleaner where ducts are cleaned at regular intervals.

On the other hand Cleaning of Ducts is a challenge for the Building Owners as well as for Maintenance Companies. High labour intensive job requires human expertise for the job to take place.

AIRBOT ONE ROBOT is the 1st Robot in India used for cleaning the ducts without using any manpower. It is launched in India by Pal N Paul Incorporation and LTE Canada Incorporation. AIRBOT ONE is a combination of Ducts Inspection, Cleaning and Painting Jobs. Airbot One is capable of doing job in tiny ducts of size 7"x7". Once it is put into the duct it is ready to go for the job, main control unit remains outside which contains Control Panel, Air Pressure Adjustment and Motion Control Mechanism. Robot is equipped with Front and Back Camera for surveillance, while in motion camera give real time video of the ducts from inside. High Pressure Air and Brushes are used to clean the ducts by blowing the dust away from the Robot unit.

Rusting is also a very big trouble for the dusts which requires ducts to be changed only at the last stage when GI Sheet gets cracks due to oxidation. Airbot One Robot is capable of Painting the Ducts from inside, since it is equipped with Cameras which give real time video of the inside, so when operator observes rusting inside the ducts it is painted. Optional Painting Kit is used with the Airbot One Robot which does the painting job inside the ducts. When you have hygienic ducts then air quality automatically increases.

Classification of duct systems:

Ducts are classified based on the load on duct due to air pressure and turbulence. The classification varies from application to application, such as for residences, commercial systems, industrial systems etc. nothing is specified, then a velocity of 5 to 8 m/s is used for main ducts and a velocity of 4 to 6 m/s is used for the branches. The allowable air velocities can be as high as 30 m/s in ships and air crafts to reduce the space requirement.

Commonly used duct design methods:

Due to the several issues involved, the design of an air conditioning duct system in large buildings could be a sophisticated operation requiring the use of Computer Aided Design (CAD) software. However, the following methods are most commonly used for simpler lay-outs

- Velocity method
- Equal Friction Method
- Static Regain method

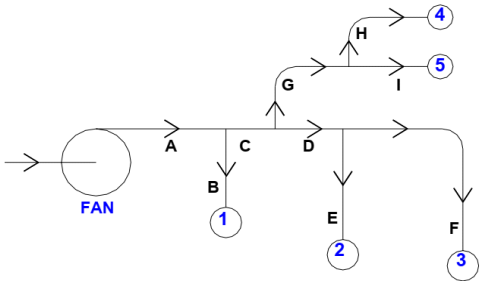


Figure 1. Typical air conditioning duct lay-out

Velocity method:

For example, let the duct run A-C-G-H be the index run the total pressure drop in the index run is 100 Pa. If the pressure drop in the shortest duct run (say A-B) is 10 Pa, then the damper in this run has to be closed to provide an additional pressure drop of 90 Pa, so that the required airflow rate to the conditioned zone 1 can be maintained.The velocity method is one of the simplest ways of designing the duct system for both supply and return air. However, the application of this method requires selection of suitable velocities in different duct runs, which requires experience. Wrong selection of velocities can lead to very large ducts, which, occupy large building space and increases the cost, or very small ducts which lead to large pressure drop and hence necessitates the selection of a large fan leading to higher fan cost and running cost. In addition, the method is not very efficient as it requires partial closing of all the dampers except the one in the index run, so that the total pressure is reduced.

Scope of the Study

The scopes of study include the following,

- The robot could travel in various range size of ducting.
- The robot must be equipped with lamp and camera.
- The robot operates wirelessly.
- Data communication between robot and user interface.

PROBLEM STATEMENT

Poor indoor air quality will give negative impact to the building occupants. Some of the health problems related to poor indoor air quality are Sick Building Syndrome (SBS), Building Related Illnesses (BRI), and Legionnaire's disease According to Fotoula P.Babatsikou (of buildings that are served by automated 2011), SBS usually occurs in certain types heating, ventilation and air conditioning system. Poor IAQ due to microbial contamination can cause people eye incitement, asthma, allergic dermatitis, pneumonia, and even death (Wan Rong and Kong Dequan, 2008, Guoqing Cao,2008 and DOSH,2010). The major factor contributing to poor indoor air quality is poor maintenance of air conditioning and ventilation system including dirty duct. Therefore, a monitoring device should be developed to monitor the actual condition inside the duct so that the necessary maintenance work can be carried out.

OBJECTIVE

- To develop and fabricate more user friendly and affordable mechanical setup for air duct monitoring.
- To examine the setup model performance in terms of camera range and travel range due to different control methods.
- To qualitatively investigate the ducting conditions using mechanical setup.
- To quantify the level of IAQ parameters using mechanical setup in three
- different ducting operational conditions namely daily use duct, seldom use duct and abandon duct.

II. LITERATURE REVIEW

1. DESIGN OF INSPECTION AND CLEANING ROBOT, HASSAN AND LARSO (1978)

In power plants, there are several places such as vessels, surface, nozzle pipes which need to be inspected and cleaned regularly. To ensure the integrity of power plant, these various places must be periodically inspected using ultrasonic sensors and visual cameras. The surfaces and many parts of the plant should be cleaned as many times as required to prevent contaminations. Cleaning of power plants is a tedious task with high efforts regarding time and personnel costs. The advances of technologies for mobile robotics enable the application of robots to increasingly complex tasks. Robots were initially used in the automation sector to handle repetitive and simple tasks reliably, with the objective of cost reduction per product. Along with the increased speed of embedded micro controllers, the service robotic sector has started to grow. Robots do tasks such as handling heavy radioactive loads and performing tricky repair and maintenance operation in contaminated areas. This paper investigates a robot which is guided using wireless communication by a remote location to inspect and clean various fields effectively. The robotic system is devised to reduce inspection time along with effective cleaning scheduled in places where human exposure is risky. This paper presents the design and implementation of an inspection and cleaning robot in power plants.

2. DUCT INSPECTION AND CLEANING ROBOT, KUMARUZAMAN(2001)

In the world of globalization and modernization where air conditioning system acts as the pulse of every modern infrastructure, in which air supply plays a prominent role in cooling. The duct systems work as nerves of these air conditioning units. Also, its maintenance is required for greater efficiency to prevent damage. Our research focuses on the non-destructive techniques to clean the dust, fungi, foreign particles and it also detects flaws, cracks, and corrosion inside the ducts. The technique if used on a regular basis, we can increase the efficiency and life of ducts and the cooling units. This research involves a wirelessly controlled robot powered by rechargeable batteries, having wheeled and wall tire system for movement inside different cross-sectional ducts. It comprises of several sensors like ultrasonic, humidity, gas, thermography and pressure sensors to provide the great visuals for inspection of various parameters inside the ducts. The prime objective is to clean the ducts by a cleaning probe attached to the robot, different probes like scrubber blades, abrasive blades are attached further for removing the dust, fungi, and bacteria from ducts. Helping to provide the healthy conditioned air supply to the chambers. The robot equipped with infra-red cameras for the live view of inside the ducts. As dust, fungi, bacteria and corrosion affects the efficiency, the cleaning probe provides the removal of these impurities. The simple design of robot makes it more convenient and useful for varying cross section ducts and helps to build its bond at consumer ends.

3. FORCE CONTROL OF A DUCT CLEANING ROBOT BRUSH USING A COMPLIANCE DEVICE, CHIANSUWAN (2002)

Conserving clean air and removing contaminants and particular matters accumulated in the ventilation system of the subway stations are key issue for high air quality and green environment. Accumulated various pollutants at inner duct surface can cause secondary air contamination and injure subway passengers' respiratory system and health. In fact, periodic duct cleaning works can improve indoor air quality, but cleaning entire ventilation system takes high cost and manpower. This study proposes a newly developed duct cleaning robot to provide autonomous air duct cleaning. In addition, effective cleaning method with an automated robot device is developed. In particular, the new duct cleaning robot has functionality that cleans four sides of inner duct surface simultaneously with a constant pressure by using a force compliance brush. Control method with the compliant device has also been analyse. The proposed design of autonomous duct cleaning robot is expected to save the operating cost of subway ventilation system and sustain clean indoor air quality by providing easier and faster cleaning tools.

4. COMPONENTS DESCRIPTION

4.1 Arduino Board
4.2 RF Module
4.3 Motor Driver Board
4.4 Battery
4.5 MS sheet
4.6 DC Gear motor
4.7 Wheel
4.8 M.S Shaft
4.9 L-Shape Channel
4.10 Bolt and Nut
4,11 Brush
4.12 Mobile holder
4.13 Spring

III. METHODS AND MATERIAL

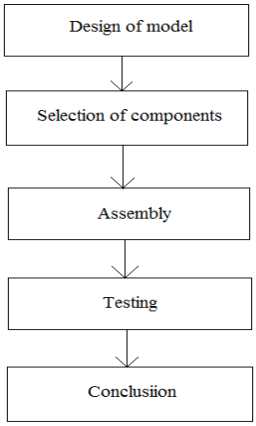


Figure 2. System Flow

WORKING PRINCIPLE

Our project focused on the development of the Mechanical Ducting Robot to monitor the ducting and data collection at real time. The developments of the Mechanical Duct cleaning Robot have been performed in three phases. Mechanical Duct cleaning Robot were controlled wirelessly, and equipped with lamp and camera to get real visual inside the ducting.

The robot consists of a base body, four rubber tire wheels, a camera module, LED light and two brush arms; front and low arm. Seven motors have been used to provide proper torques for duct works. The continuous tracked wheels of previous model have been exchanged to four tires by considering various obstacles such as screws or pins on duct surface, but also to reduce weight of the robot platform.

The lower brush arm is attached at the front of platform body and the upper brush is located at the end effector of the upper arm. The upper arm is height adjustable for handling various duct sizes . The compact force compliance device is installed between two cylindrical rotary brushes at the end of the upper arm. The compliance device consists of two springs and linear sensors to read deflection of the spring.

The two springs are connected each other at the end point to read two directional force.

Design diagram

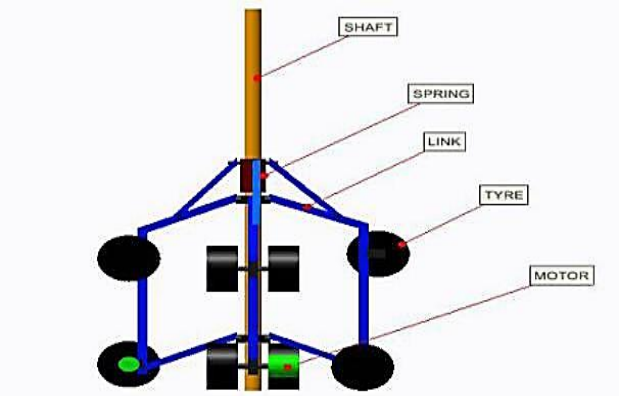
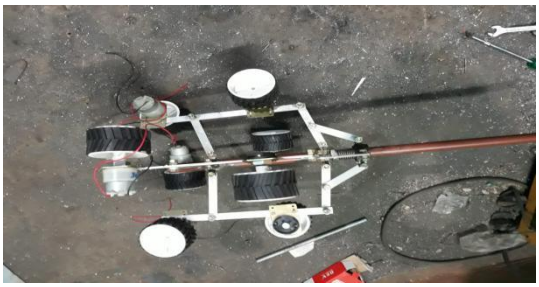


Figure 3. Duct Cleaning Set up

PHOTOGRAPHY



ADVANTAGES

- Our set up are very helpful even just in places which are not possible to reach
- Cleaning activity of our set up can be monitored through mobile phone
- Cleaning can be done effectively
- Cleaning time is reduced
- Man power is reduced

IV. CONCLUSION

In this study, a new type of duct cleaning robot has been designed and prototyped. In particular, the robot has functionality that cleans four sides of inner duct simultaneously with a constant pressure by using a force compliance device. For more dedicated control of brush pressure, the stiffness of brush should be empirically achieved. The adjustable arm brush can make it possible to use in different size of ducts. However, there are still more room for improvement, especially on the autonomous system. In a real ductwork, there are many components at the inner duct such as dampers, fans, joints and curves that make it difficult to operate the robot consistently and autonomously., more intelligent operating system has to be implemented to improve the cleaning process Therefore effectively. The developed prototype robot will be continuously upgraded and tested at the test-bed of air duct terminal.

V. REFERENCES

[1]. Brosseau, L. M., Vesley, D., Kuehn, T. H., Melson, J., Han, H. S. 2000. 'Duct cleaning: A review of associated health effects and results of company and expert surveys', ASHRAE Trans, 106, 180-187.

[2]. Finnish Society of Indoor Air Quality and Climate (FiSIAQ). 2001. Classification of indoor climate 2000, Espoo, Finland.

[3]. Foarde, K. K., Menetrez, M. Y. 2002. 'Evaluating the potential efficacy of three antifungal sealants of duct liner and galvanized steel as used in HVAC systems', J Int Microbiol Biotech, 29, 38 –43.

[4]. Hanlim Mechatronics Co. Ltd., XPW-601 Duct Robot, http://www.ductrobot.com, Korea

[5]. Holopainen, R., Tuomainen, M., Asikainen, V., Pasanen, P, Sateri, J., Seppanen, O. 2002. 'The effect of cleanliness control during installation work on the amount of accumulated dust in

ducts of new HVAC installations', Indoor Air, 12, 191-197.

[6]. Holopainen, R., Asikainen, V., Tuomainen, M., Björkroth, M., Pasanen, P., Seppanen, O. 2003. 'Effectiveness of duct cleaning methods on newly installed duct surfaces', Indoor Air, 13, 212-222.

[7]. HVCA, 1998. Cleanliness of Ventilation System, Guide to Good Practice Cleanliness of Ventilation Systems. Heating and Ventilating Contractors' Association, London, HVCA Publications.

[8]. Jung, Y. H., Ahn, B. W., 2003. "Measurements on Contamination in Air Duct and Air Handling Unit," Journal of the Korean Society of Living Environment System, Vol. 10, No. 1, pp. 41-46.

[9]. Morey, P. R. 1988. 'Experience on the contribution of structure to environmental pollution'. In R. B. Kundisin (ed.), Architectural design and indoor microbial pollution. Oxford University Press, New York: 40-79.

[10]. Pasanen, P. 1998. 'Emissions from the filters and hygiene of air ducts in the ventilation systems of office buildings'. Doctoral dissertation, Department of Environmental Sciences, University of Kuopio, Kuopio, Finland.

[11]. Robotic Design, ANATROLLER ARI-100, http://www. roboticsdesign.qc.ca/mobile-robots, Canada

[12]. Rawls, H. R., Mkwayi-Tulloch, N. J., Krull, M. E., 1990. 'A mathematical model for predicting toothbrush stiffness'. Dental Materials, Vol. 6(2), pp. 111-117.

[13]. Wang, Y., Zhang, J., 2006. 'Autonomous Air Duct Cleaning Robot System,' Proc. of International Midwest Symposium on Circuits And System, pp. 510- 513, 2006

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