

An Analysis of the Several Approaches that can be taken to Clean Air Conditioning Ducts

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Abstract

Cleaning the AC ducts is vital since it creates problems such as poor indoor air quality, which leads to health problems, as well as significant system maintenance. In unclean air ducts, fungi, dust, and deadly germs proliferate. The causes and repercussions of this item are given below. Traditional methods as well as robots can be used to clean air conditioning ducts. The conventional method involves manual cleaning with specific tools. Robots cleaning the ductwork would be a good solution. Many different types of robot systems, including as crawling robots, articulated robots, and inspection robots, are employed for the application. Depending on the size and kind of duct, many types of robots and accompanying equipment are available. Cleaning rectangular ducts is more difficult than other forms. Finally, it is found that cleaning ducts is the most important component, and that using robots is the best way to do this.

Keywords: *Indoor Air Quality, Robot, Sanitation, Cleaning, AC Duct*

INTRODUCTION

IAQ is one of the most serious environmental risks, along with lead poisoning and hazardous wastes. 1 In big cities, indoor air quality is thought to be five times worse than outside air quality. 1,

2, 3 Indoor air quality difficulties can be caused by the installation and design of cooling and heating equipment, building design and structure, number of people, occupant activities, airborne pollutants, and human physiological features. 4, 5

HVAC units can harbour mould, fungi, and other microbiological contaminants. Dirt, dust, and fibre components can build inside the ductwork. The easiest strategy to maintain great indoor air quality in residential buildings is to clean their HVAC systems and ductwork on a regular basis. 6 Air conditioners are devices that lower the temperature, extract humidity, and circulate it throughout the structure to improve human relaxation. Its demand is skyrocketing these days, and distribution tactics are becoming more diversified, resulting in the complete system. These distribution lines must be monitored on a regular basis to preserve their high efficiency and prevent air conditioner losses. 7 The HVAC system in a building contributes significantly to indoor air quality while also guaranteeing thermal comfort in the interior environment. The HVAC system is polluted with dust in ordinary operating conditions, and there is proof of this. This dust serves as a

breeding ground for microorganisms. Because of their position in the structure, we are unable to clean the 8 AC ducts manually. To finish the job, we'll need to use a vacuum or a cleaning robot. We will have serious problems with air quality, health concerns, and system maintenance if we do not clean the ducts. We need a reasonable and viable way to clean the ducts. The ducts must also be sterilised since dust collection promotes the growth of fungi and bacteria. As a result, sanitation should be combined with duct cleaning. Occupants using the HVAC system may be exposed to biological, physical, and chemical contaminants due to a lack of duct maintenance and cleaning. These systems can increase the exposure of these agents to those who work on maintaining and cleaning these systems, putting their respiratory health at risk. Figures 1 and 2 depict typical circumstances seen in these sorts of systems. 9



Figure 1 Air duct accumulated with dust



Figure 2 Presence of insects in the air ducts

Concern for Indoor Air Quality

According to worldwide research, the HVAC system is responsible for 70% or more of all IAQ difficulties, with the bulk caused by poor system care and maintenance. The air ducts, which act as the "lungs" of a structure, can collect construction waste, dust, cigarette tar, smoke, insects, and other airborne contaminants. Dirty air ducts can also be a breeding ground for mould spores, mildew, pollen, bacterial colonies, and other potentially dangerous pathogens. Because they routinely breathe this duct air, the occupants are exposed to all of this dirt, as well as fungal and mould growths inside the coils and drain pans of the air handling units.

HVAC Sanitation Methods

Contact Vacuum Method: Cleaning the interior duct surfaces with a vacuum is part of this operation. Exit apertures and outlets are used to get access to the vacuum. The vacuum cleaner's cleaner head is placed into the duct at the most upstream opening.

The vacuuming proceeds slowly enough downstream to capture all dirt and dust particles. The suction device is taken out of the duct and placed in the next available hole. When checks reveal that the duct section has been thoroughly cleaned, the process is repeated for the other duct openings.

Air Sweep Method: A vacuum collection device is connected to the downstream via an aperture, and the portion being cleaned is cleaned in this manner. A hose with a 'skipper' nozzle inserts compressed air into the duct. This nozzle is built such that compressed air propels it through the duct at the same time. This removes dirt and debris from the system, which become airborne and are sucked out by the vacuum collection device downstream through the duct.

Rotary Brushing Method: This method employs the use of a vacuum collecting device connected to the downstream end

of the segment being cleaned via an aperture. On HEPA-equipped ductwork sections, a negative air device is employed. To remove dust and debris, a rotary brush is introduced into the ducting and turned either automatically or manually. 1

LITERATURE REVIEW

In their work, Y. Tanise et al. [11] revealed the construction of a robot that cleans the duct by crawling. Cleaning units are mounted to the crawling robot and are used to clean the ducts as the robot goes forward. The robot is built for a duct with a diameter of 75 mm and a curvature radius of 70 mm. The robot travels in a duct-like manner similar to that of an

earthworm. The robot performs 99% of the cleaning. Figures 3 and 4 depict the crawling motion robot's construction.

Marina Mijanovic Markus et. al [12] presented in their study about the conceptual arrangement of the robot for cleaning the air duct. The main targets are to clean the ducts by a cleaning brush joined to the robot, and ducts inspection by using a camera, which will provide the good conditioned air supply to the occupants. It is tough to develop a universal robot that can clean all of the ducts since there are many different shapes and sizes.



Figure 3. The appearance of the robot



Figure 4. Experimental arrangement for duct cleaning

There are numerous robots designed for cleaning and inspection of the ventilation system, but most of them have issues with different types of geometrical shapes ventilation channels come in. This robot can clean rectangular, as well as circular ventilation ducts. The wheels of the robot are attached to the duct accurately. This is done by fitted tyres with a huge friction coefficient. Brushes can be mounted on the robot, and they can move vertically utilizing linear actuator with a stroke length of 50 mm and power of 36 W.

In additional cleaning equipment, there are three types of brushes also:

- Brush with Pneumatic Whips
- Rotational Brush with Round Cross Section
- Brush with a rectangular cross-section

There are many brushes available for the robot to clean various types of ventilation

ducts and perform various cleaning tasks. The right brush for the operation must be chosen based on the state and shape of the ventilation duct. The brush may also be positioned horizontally to clean not just the floor and top of the duct, but also its side walls. Figure 5 illustrates a duct cleaning robot.

In their study, Wootae Jeong et al. [13] highlighted that persuasive air-duct-cleaning technologies have been investigated to improve the quality of the ventilation duct network widely used in businesses and buildings. Duct cleaning robots and gadgets that use programmed devices to improve their operability in the dark and restricted area inside the duct. As a result, sophisticated controllers, sensors, skid-steering capabilities, and brushing-arm mechanisms have been developed for various ventilation-duct-cleaning robots.



Figure 5. Small inspection robot and cleaning robot

Mechanical brushing systems, in particular, have been efficiently linked for the evacuation of dust deposited on interior air-duct surfaces using linkage-arm-based mechanical brushes. During the cleaning operation, the revolving brush of the cleaning arm creates interacting forces between the brush and the target surface of the inner duct. The duct surface produces lateral wheel slippage in the dynamic demonstration of the mobile robot due to contact forces between the revolving brushes, necessitating a skid-steering control system.

To accomplish persuasive control of the duct-cleaning robot, it is necessary to create a dynamic model of the system that includes unknown parameters such as nonlinear deformation of the brush filaments and unknown friction coefficients at each contacting point of the cleaning mechanism. Furthermore, the tangential loads of the mobile robot and the reciprocating motion of the upper-arm brush provide an imbalance in the robot's centre of mass. The duct-cleaning technique is carried out by rolling brushes on a moving robot that make continual contact with the interior duct surfaces. The mobile robot should be positioned along the reference trajectory, which is made up of the locations required for the brush to

maintain pressure on the inner side of the duct. The theory of perfect speed tracking requires a complete dynamic model that does not take into account external-disturbance effects in velocity control. Unknown dealing forces in the brushing mechanism can cause the control system to become unbalanced by transmitting all force to the wheels and the duct's base.

In their study, Irtishad Ahmad et al. [6] focused on the association between HVAC duct cleaning practises and improved indoor air quality. The research was carried out in the form of an inspection of two particular residences with the identical duct construction and floor designs. The survey included three phases of assessing indoor air quality using diverse techniques: before, during, and after the cleaning procedure. The investigation focused on several contaminants found in indoor air, such as aerosols, fungus, and dust. The study revealed that the air sweep approach is the most effective for reducing pollutants from ducts.

According to Alexey Bulgakov et al. [14], the job is straightforward and does not need advanced manoeuvres, hence an articulated robot is used. There are several methods for controlling the mobile robot. Because of its simple construction and

functionality, the PID regulator was used often in this study. Adaptive control, on the other hand, is utilised in artificial intelligence development to reduce nonlinear effects such as friction and saturation of the DC motor. The conception robot is seen in Figure 6.



Figure 6. Autonomous/ Tele robotic concept design for AC duct cleaning

Filipe Santos et al. [15] proposed a rover concept in which, after additional investigation, the use of a tread was chosen, however it was originally planned to travel using wheels. The photos have to be transmitted to the operator in order for the rover to travel expertly or cautiously inside the air ducts for the notion to function. To address this issue, a wireless interface was used to connect the robot and the operator. Brushing the duct, bactericide and fungicide sprays, and other procedures allow for the sanitization and maintenance of the air-conditioning system. Figure 7 depicts the rover's movement.



Figure 7. Tread driven movement in air duct

CONCLUSION

This review research discusses the many types of AC duct cleaning processes. Because of the harmful and bad repercussions of not cleaning it, AC duct cleaning has become a necessary. The assessment includes all of the various types of robots and processes utilised to clean the AC ducts. The ducts may be cleaned normally, but the individual who works on them suffers as a result. As a result, it should be cleaned using the proposed robotic systems. Various brushes and robots may be used depending on the size and kind of robot. Based on our research, we determined that we can optimise the cleaning process by utilising a variety of new techniques and features. Following the conclusion of all of these research assessments, it is feasible to establish that duct cleaning is a critical component that may be achieved using various types of robots.

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