

# DESIGN AND FABRICATION OF DUCT CLEANING ROBOT

<sup>1</sup>A. Inayathulla, <sup>2</sup>P. Karthigayan, <sup>3</sup>J. Dhanasekar, <sup>4</sup>p.karunakaran

<sup>1</sup>Student, <sup>2</sup>Student, <sup>3</sup>Assistant professor, <sup>4</sup> Assistant professor

<sup>1,2,3</sup>Department of Mechatronics, <sup>4</sup> department of aeronautical engineering

<sup>1,2,3</sup>Bharath Institute of higher education and research, Chennai, Tamilnadu  
Excel engineering college, nammakal, tamilnadu

**Abstract :** In large scale industry, there are several central AC ducts which need to be inspected and cleaned regularly. To ensure the integrity of ventilation air, these various places must be periodically inspected using night vision camera. The surfaces and many places of the duct should be cleaned as many times as required to prevent contaminations. Cleaning of AC duct is a tedious task with high efforts regarding time and personnel costs. The intention of this project is to contribute a robot system for dust cleaning, by which it is possible not only to separate and remove dust and dirt but also can adjust the size of the duct. The robot constructions consist of three major works which are the hardware design, electrical design and software development. This robot moves by DC Motors which assemble at front side and the back side. The outline of the motors is assembled in such that to reduce the robot size. The whole system of this robot is controlled by arduino microcontroller circuits that perform as a brain which is designed in Proteus software while programming was written in arduino Compiler. This paper presents the design and implementation of an inspection and cleaning robot in central AC duct.

**Keywords :** Ducts, Robot design, Robot software, Robot hardware, Mobile robots.

## I. INTRODUCTION

Air ducting is the main parts in the cooling system. It will dirt soon when the operation is working in certain periods of time. When it occurs, the cool air created by air conditioner it will affects the people by dust and bacteria. Consequently, peoples who breathe the air will cause many health issues such as asthma, cough, hay fever and lungs diseases. It is easily attacks to small children. Manually duct cleaning system uses electricity as its source needs a lot of time and human intensity to control it. To clear this problem, duct cleaning robot is created. Duct Cleaning robot is a part of mechanical and electrical components for dusting and sweeping. It is higher to a normal vacuum cleaner because it is easier to use and it is more convenient to work. The overall cleaning progress doesn't need a person to handle and it reduces the load on the operation. The noise is lesser than the normal vacuum cleaner when it works. It can purify the air absorb toxic particles in the air with activated carbon in it. The system is compact and low weight but it can pure up with some particular type of ducts. In short, cleaning robot is connected with mobile robotics technology and dust cleaning work and it is creative and helpful. It is an environmentally, friendly, active, brilliant helping robot with a better future and a broad space of market requirement.

Nowadays, the development of the duct cleaning robots focuses on creating more efficient system. This project will develop prototype of a duct cleaning robot.

## II. ROBOT DESIGN PROCESS

### Problem Description:

The main process in designing a robot is description of the project for which it has to be built along with condition requirements. In our case, the task is to provide access to confined inaccessible places inside the duct system. It implies that there should be an environment sensing and real time reporting system on board on the robot along with on board power supply for movement and transmission system. The robot should be compact in size and low weight as it has to move in ducts and narrow cavities in ducts.

**Robot Fabrication:**

It is proposed to use ProE for designing mechanical designs of robot. It is designed to move forward and reverse direction. The controller, camera and vacuum cleaner attached to the robot are processed locally.

**Robot Programming:**

Following the fabrication stage, it is required to program the microcontroller in Arduino language. The programming also involves the design of interface.

**Control Logic:**

The major system of microcontroller is to control the action of robot in all directions. For making it to move in a particular direction, the ON 'logic will be given to the DC motors that moves the carrier to push in that exact direction.

**Environmental Mapping:**

The camera will be fixed on the robotic framework. This on board camera would be used to for the environment, by capturing images, accessible to the programmer through remote Graphical User Interface at the programmer end.

**Cleaning Operation:**

To actualize this, we have made a vacuum cleaner on the mechanical arm, joined to the robot body utilizing following fundamental parts:

- A consumption port, which may incorporate an assortment of cleaning frill
- An debilitate port
- An electric motor
- A porous sack
- A lodging that contains the various segments

Vacuum cleaner picks up dirt by driving a flow of air through air filter. The source of the vacuum cleaners suction depends on a number of factors.

Suction will be stronger or weaker depending on:

- **The power of the fan:** To generate strong suction, the motor has to runs at a good speed.
- **The blockage of the air passageway:** When a highest deal of debris builds up in the vacuum bag, the air faces higher resistance on its way out. Each speck of air moves more slowly because of the increased drag. This is why a vacuum cleaner works better when the bag is just replaced than during vacuuming for a while.
- **The size of the opening at the end of the intake port:** Since the velocity of the vacuum fan is constant, the measure of air travel through the vacuum cleaner per unit of time is also invariant. It doesn't mean that what size of intake port has, the same number of air speck will pass into the vacuum cleaner every second. If the port is faster, the particular air speck will have to place much slower in order for them in a particular amount of time. At the particular point the air speed increases, pressure decreases. Since they create a stronger suction force, narrower vacuum meet at a point and pick up heavier dirt particles than wider attachments.

**Power Scheme:**

The robot would be operated by using carrier mounted one rechargeable battery. Two 12V batteries are connected to supply 12 V to DC motors driving the wheels. 12V supply is converted to 5V (for circuitry) voltage regulator.

**III. SOFTWARE ROBOT DESIGN**

The robot software integrates the hardware architecture of the robot helps basic low-level hardware control that performs reading the sensors value and controlling the motor speed.

**Arduino Program:**

It is a powerful, feature rich development tool for Arduino microcontroller. It is designed to help the programmer with the easiest solution for performing applications for embedded systems, without compromising performance.

**Visual Basic Program:**

This is used for interfacing between PC and the Robot. Web Cam easy displaying of visual elements, availability. It is one of the easiest ways to monitor the system to implement functions using it.

**Arduino:**

It is used as the brain of the robot that can be programmed by connecting the USB serial port of the computer to PIC microcontroller. The serial port operates at  $\pm 5/0V$ , and the Arduino serial operates at  $+5V/0V$ . MAX232 is used as a level shifter to connect the serial port of the computer to pins RX/TX on Arduino.

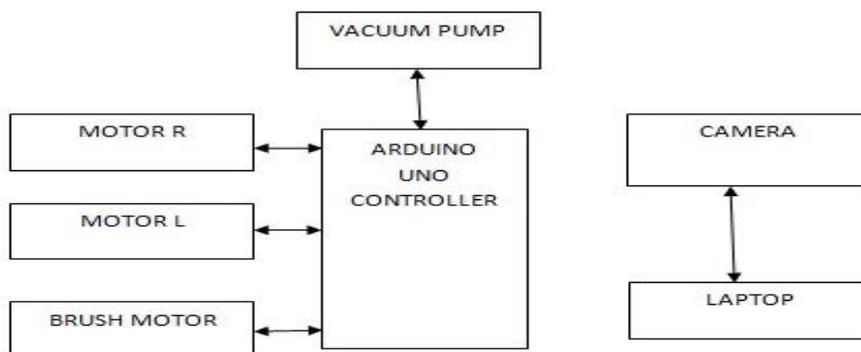
**Arduino Software:**

Arduino is a device for making computers that can sense and manipulate more of the real world than your desktop computer. It's an open source external computing stage based on an ordinary microcontroller board, and an increase status for coding software in the board. Arduino can be used to grow the related targets, send inputs from a different of switches or sensors, and controlling a variety of lights, motors, and other real objects. Arduino projects can be stand-alone, or they can interact with software operating on your computer (e.g. Flash, processing, MaxMSP) The boards can be created by manual and the open-source IDE can be downloaded for free.

The Arduino programming dialect is an accomplishment of Wiring, a comparative physical registering stage, which depends on the Processing media programming condition.

**IV. BASIC DUCT SYSTEM COMPONENTS**

- Supply Plenum - usually on top of air handler for the basic distribution air conditioned through connected ductwork.
- Return Air Drop - brings air from living space to air handler for re-distribution and conditioning
- Flared Rectangular Take-off – It start ductwork by connecting the plenum.
- Reducer -main trunk is connected usually by 3 or 4 branches before a reducer changes duct size. It can be rectangular, square.
- Top Take-off – It connect to the main supply trunk for connecting the round branch lines. Can be round-to-round, square-to-round, oval-to-round. Often it is used as side take-offs also.
- Boots -It delivers conditioned air into particular space.
- Stack head - a stack for a wall register.
- Wall stack - To feed a stack head inside a wall of ductwork
- Outside Air - therefore a free flowing outside air is equal to the return ducting to keep some pure air placed into the particular place. In severe climates this ducting must be insulated.

**V. BLOCK DIAGRAM WITH DESCRIPTION:**

From the figure above, this robot is divided into two major parts which are the control part and the motor part. Main part is the control part which is the microcontroller system. The microcontroller used is Arduino as a brain of the System. To programming the micro, it used Arduino language. The second part is the motors which are consist of DC motor for wheel system, and the DC motor for the cleaning of the brush system.

## VI. HARDWARE DESIGN PROCESS

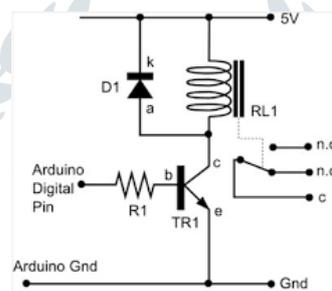
### DC Motor:

A DC motor believes on the real that like magnet poles repel and unlike magnetic poles attract each other. A coil of current carrying wire through it supply an electromagnetic field aligned with the middle point of the coil. When the current on or off in a coil it gets magnify can be switched on or off or by switching the way of the current in the coil the control of the induced magnetic field can be switched 180°. A basic DC motor usually has a fixed set of magnets in the stator and an armature with a series of two or more windings of wire protected in insulated heap slots over iron pole pieces (called stack teeth) with the last of the wires terminating on a commutator.



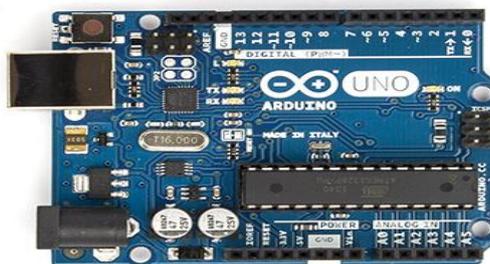
### Relay Board:

This relay board supplies a suitable way to add relay outputs to your project, its permits you to switch high-current loads such as AC appliances, motors, and more. This board contains four SPDT (single pole double relay) relays, relay driver circuits, and safety diodes. Quickly provide the board with power, combine your logic-level signals to the external inputs and the relay contacts are ready to use. The relay contacts are electrically separated from the rest of the board, which access the board to be used in a variety of applications, containing both AC and DC loads.

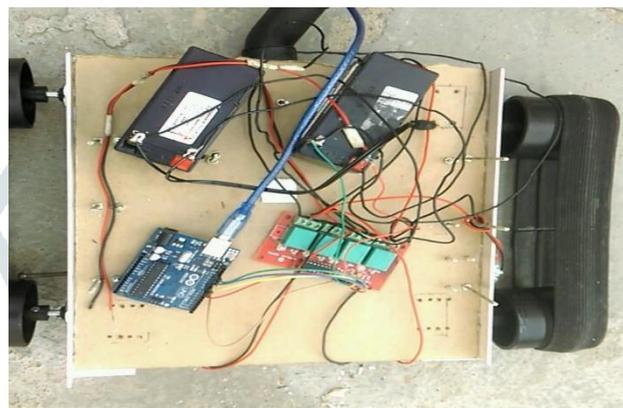
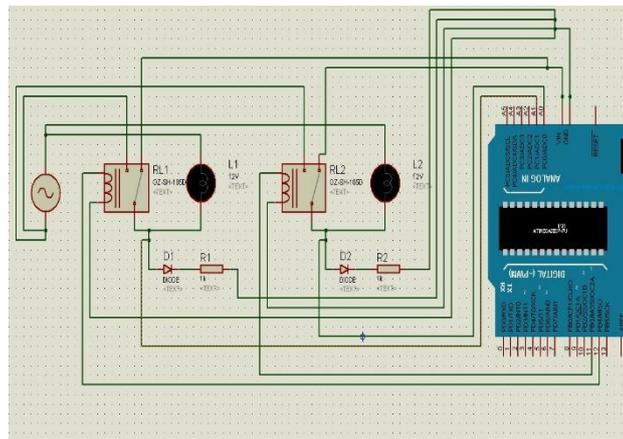


### Arduino uno board:

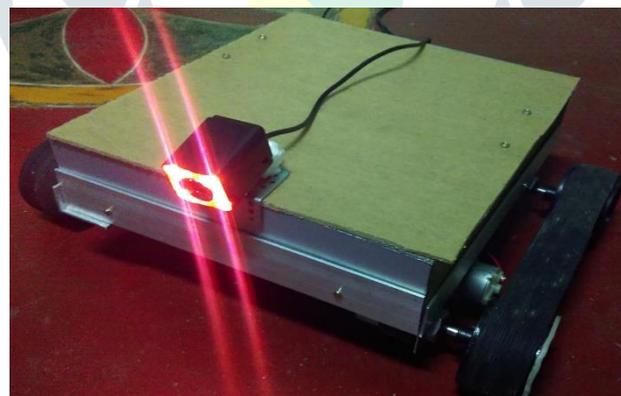
The hardware used for the project is Arduino Uno R3. Arduino Uno is a microcontroller related on ATmega328 (Arduino Uno). It uses 5V of source to operate. The suggested input voltage is 7-12 V and the limits is 6-20 V. It is made up of 14 digital input/output of which 6 transfer PWM(pulse width modulation) output and 6 analog input pins. It combined with a USB connector, a power jack, an ICSP (In-Circuit Serial Programming) header and a reset button.



## VII. CIRCUIT DIAGRAM WITH DESCRIPTION



The Arduino Uno is connected to the relay board (RL1, RL2, RL3, RL4), relays connect to 12v dc gear motor (M1, M2, M3, M4, M5) when 12v power source is connect to Relay Board. The relay is ready to trigger with arduino uno through the serial communication, when laptop key F pressed arduino uno output is given to relay to switch RL1 & RL4 ON. Then 12V dc gear motor START moving forward and cleaning brush start to clean. If laptop key R pressed arduino uno output is given to relay to switch RL2 & RL3 ON and robot starting to move reverse direction and cleaning brush stop rotating. Finally, to stop robot press laptop key s.



Working module

## VIII. CONCLUSION

This duct cleaning robot has been in for long period of time but emerging trend is to deploy reliable and humanly-controlled robots inside facilities that could carry out tasks that assist humans. The main reasons are to reduce risks and limits to workers. In this paper, design of prototype inspection and cleaning robot is proposed which is guided by serial control to perform required tasks in various type of ducts. Our proposed robotic operation may provide in different reason such as providing approach to limited and humanly inaccessible spaces. The proposed application of robotics can also be utilized for cleaning. At present, we are working on implementation and electronic hardware increased of this project. Process so far is skilled for strong deployment in the certain environment at next stages.

**IX. REFERENCES**

1. Basil Hamed - Design and Implementation of Stair - Climbing Robot for Rescue Applications, International Journal of Computer and Electrical Engineering, Vol.3, No. 3, pp. 461-468, June 2011.
2. Floor to floor navigation for a mobile robot- jung tae kim, young ho choi, jongdeuk lee – International conference on ubiquitous robots and ambient intelligence. Oct 2 nov 2013.
3. Ms. R. Abarna, S. Devadharsini, S. Dhileep, M. Dinesh -Design and fabrication of automatic floor cleaning machine, International journal of science and engineering research, 6, issue 4 April -2018.
4. Soowoong Kim, Jae-Young Sim and Seungjoon Yang- Vision based Cleaning Area Control for Cleaning Robots, IEEE Transactions on Consumer Electronics, Vol. 58, No. 2, pp. 685-690, May 2012.

