GLASS CLEANING ROBOT

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

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GREATER NOIDA
2020

CERTIFICATE

This is to certify that the Research work titled **GLASS CLEANING ROBOT** that is being submitted by **ARUNAVA GUPTA , AMBRISH YADAV , RAUNAK RAJ & SURYA VIKRAM SINGH** is in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

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Approval Sheet

This thesis/dissertation/project report entitled **GLASS CLEANING ROBOT** by **ARUNAVA GUPTA , AMBRISH YADAV , RAUNAK RAJ & SURYA VIKRAM SINGH** is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ACKNOWLEDGEMENT

The contributions of many different people, in their different ways, have made this possible. I would like to extend my gratitude to the following.

We are grateful to our guide **Dr. SWET CHANDAN** for providing us the proper guidance for this project.

We are grateful to project coordinator **Dr. MANIRAJ M** for granting us permission to work on our project and giving us some important feedback on different occasion which help us to improve our project idea.

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ABSTRACT

In universities and college glasses and windows have been clean by manual and human labor is involved and this process is risk of the human life. So, we have mentioned in this paper were designing a robot that cleans the glass automatically and reduce the risk of human life. Here we are using two pneumatic cylinder – Pneumatic cylinder are used for motion in X-Y direction, suction cup- Suction cup is used for support on glass. Micro controller -Micro controller is used to improve the movement of step, Bluetooth – Bluetooth is used for wireless motion of the robot.

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CHAPTER -1

Introduction

Recently, there have been many demands for automatic cleaning systems on the outside surface of buildings such as window glass by increasing modern architectures. Some customized window cleaning machines have already been installed into the practical use in the field of building maintenance. However, most of them are mounted on the building from the beginning and they need very expensive costs. Therefore, requirements for small, lightweight and portable window cleaning robots are also growing in the field of building maintenance. As the results of surveying the requirements for the window cleaning robot, the following points are necessary for providing the window cleaning robot for practical use:

1) It should be small size and lightweight for portability.

2) Clean the corner of the window because fouling is left there often.

3) Sweep the windowpane continuously to prevent from making striped pattern on a windowpane

4) Automatic operation during moving on the window.

1.1 PROJECT MOTIVATION

The use of robotic application will be a hot shot in the current era, this would help us to easy many of our problem. It is shown by the emergence of many robotics products with self and single concept for example autonomous vacuum robot , museum tours guide robot (Burgard et. al., 1998) and etc. When dealing with hazardous job, it is better to replace human with robot that can perform a task without continuous human guidance or autonomous robot to overcome human risks , this woud automatically reduce cost and save human life.

Office window cleaning is a hazardous job and it involves high cost. Cases reported to Health and Safety Executive had shown that there had been between 3-10 window cleaners were killed each year in India and 20-30 suffer major injuries while doing cleaning jobs . By using conventional method, human involvements are needed to the do all the task. This gives us the need for small, lightweight and portable window cleaning robot for office glass ,window to replace human involvement in high risk activities.

1.2 PROJECT BACKGROUND

Nowadays, cleaning an office window by using conventional and old methods is implemented widely. It is either through human involvement or by a machine. There are three types of conventional methods that is used to clean office window and glass. First method is by using workers suspended in the air and risking their life. It

can be done by using abseiling techniques or by gondola or stairs . Second method is by ground cleaning. In the glass cleaning, there are several ways that can be used. It can be done by reaching and washing technique, using mobile elevated working platform , using scaffold or using a ladder . The third method is by using a customized window cleaning machines and robots.

The advantage of conventional method by human is the job can be done for many different type of office or building structure. The disadvantages of conventional methods by human can be described in four major points. First point is manual labour. Manual labours for conventional and old method undeniably gamble with high risk of human life and long time consumption. The second point is limited efficiency. The process could be very slow as it depends on human expertise to finish the job. The third disadvantage is budget constraint. Using conventional method by human or by customized machine involves high cost for its equipment and suppliers, labours cost, insurance , and by the machine itself. The last point is limiting factors. There are certain limiting factors with job done by human. If the job is done by human, it depends on two factors mainly weather and daylight . This project is hoped to overcome the limitation of conventional methods. The project is focusing on developing a small cleaning robot for office window and glasses in the buildings.

1.3 PROJECT PROBLEM STATEMENT

Cleaning is routine in our life. It involves many activities in our daily life. It is a hard work job and a lot of time is consumed and human life is also at risk. Window cleaning is also one aspect of office maintenance and cleaning activity. The clean windows will provide a comfortable environment to the office inhabitants and workers. The two main points that are stressed in this project are to overcome the hazard of human involvement in cleaning office window activity and reduce high cost by the conventional method of cleaning window. It becomes necessary to overcome the limitation. The project will help to replace or minimize human involvement in cleaning the window by replacing it with a small glass cleaning robot for office window with several capabilities. The abilities are; portable, small size, lightweight, automatic operation and can clean all the corner of the office window and glass .

1.4 PROJECT OBJECTIVES

The project is conducted to achieve the following objectives:-

a) To design a small cleaning robot for office window and glass that is portable, small size, lightweight, automatic operation and can clean all the corners of the office window and glass.

b) To write the software program for the glass cleaning robot mobile appliation.

c) To build the electrical part of the glass cleaning robot.

d) To build the mechanical part of the glass cleaning robot.

e) To assembly and testing the glass cleaning robot that can be operated on the office glass window and glass .

1.5 PROJECT SCOPES

The scope of this project covers several issues listed as below:-

i. The developed small cleaning robot is only a prototype and not readily functioning as a commercial product.

ii. The developed small cleaning robot can only operate without any other disturbance such as natural disaster like rain, storm and earthquake or by other disturbance while operating.

iii. The developed small cleaning robot is operated using a battery.

iv. The developed small glass cleaning robot will be operated on the window with no obstacles.

v. The developed small glass cleaning robot is limited under each rectangular glass.

vi. The developed small glass cleaning robot is independent with operating time

constraint.

vii. The operating time of the small cleaning robot is limited which depends on the

battery lifetime of the robot.

CHAPTER 2

LITERATURE REVIEW

Our Project is not from the scratch several previous works has been done on this topic. Some of the notified work done in this regard are given below.

As studying from the work of Requirement of Glass Climbing Robot **Houxiang Zhang** and jianwei Zhang from university of Hamburg in 2004, so that have tried to operate by the pneumatic cylinder but our team concluded that overall cost of the project is much higher and they summarised and compared with three sky cleaner robot.

Tohru MIYANKE, Hindenori ISHIHARA , Ryu Shoji (2006) Paper Development of small size window cleaning robot by wall climbing mechanism.in this project he has used two independently driven wheels and active suction cup but the robot has errors in the attitude but we have overcome this issue.

AlBAGUL, A- ASSENI , O. JOMAH , M. OMER , B.FARGE (2010) paper Design And fabrication Of Automotive robot In this motion will generated by the three servo Motors in the time span of 2.5 Minutes.

Ritesh.G Mahajan 1, Prof. S.M Patil (2013) paper Development of wall climbing robot for cleaning application It clean the large glass surface area with the wiper attach on the front of surface.

Sachan, Avinash patil (2016) Paper Design of electrostatic adhesion pads for wall climbing robot They developed the robot which can climb vertically with the help of electrostatic adhesion technology. Nazim Mir-Nasiri, Hudyjaya Siswoyoj and Md. Hazrat Ali (2018) paper Portable autonomas window cleaning robot the robot works on the pattern and sensory system was investigate to navigate the robot.

Following paper are used for this project

A. Development of Wall Climbing Robot

Ritesh G. Mahajan and Prof. S. M. Patil explained, that the Wall Climbing Robot have the capability that it can attach on a vertical as well as inclined surface and can easily move over the surface. The targeted ability to stick with wall can be achieved by suction cups. Suction cups creates a vacuum pressure that can be used to attach with any type of surface. For movement of robot it is necessary that some of suction cup should release & that position is obtained by developing the structure such that in which one frame is used to hold the robot to wall & other for climbing in x-y direction . The whole action is controlled by an arduino and the commands sending on the Zig-bee through the mobile.

B. Design And of a Glass Climbing Robot for Several Applications.

Avvaru Subramanyam, Y. Malikarjuna and S. Suneel explained that, A suction cup, also sometimes known as a sucker is an object that uses negative fluid pressure of air or water to adhere to nonporous surfaces. And the climbing robot should be sucked to the surface on which it is climbing safely and overcome its gravity. That is the one of the main difference between a climbing robot and an ordinary walking robot on the ground. The robot should have a function to move in both the up-down direction as well as the right-left direction to get to every part on the glass. Once the task signals are sent by the user, the robot should keep itself attached to and move on the surface, to meet the requirements of all kinds of functions, precise motion control is needed. The accurate position control of the motion will begin automatically as soon the signals are received.

C. Development of small legged wall climbing robot with passive suction cup

Soichiro Kawasaki, Koki Kikuchi explained that, the weight is proportional to the mass, i.e., the length cubed, the smaller the body size, the more advantageous it is for vertical wall climbing. From this viewpoint, the passive adhesive mechanism is suited to a small wall climbing robot moving with a few degrees of freedom (DOF). In particular, a passive suction cup has unique characteristics such as the edge of the suction cup is detached easily and the suction cup exerts far larger adhesion force than pushing force to attach it.

D. Development of small-size window cleaning robot by wall climbing mechanism

In this paper we studied about that, there are two units in the robot. One is for motion of the robot and other is meant for cleansing purpose. The motion of robot is achieved through motion unit. The motion unit comprises of 2 rotating discs, suction-cups, DC motor. Every additional climbing strategy or principle that is explored, improved or tested can increase the probability that a suitable method could be found for a (future) climbing task.

CHAPTER 3

COMPONENTS DESCRIPTION

The major components used in

1. Pneumatic cylinder
2. Arduino microcontroller
3. Bluetooth
4. Suction cup
5. Brush
6. Container
7. Battery
8. Android app

3.1. Pneumatic cylinder

Pneumatic cylinder is a mechanical device which uses the power of compressed gas to produce a force and helps in a reciprocating linear motion.

Like hydraulic cylinders, some forces a piston to move in the assigned direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. We sometimes prefer to use pneumatics because they are quicker, cleaner, and do not require large amounts of space for fluid storage.

Since the operating fluid is a gas, leakage from any of the pneumatic cylinder will not occur and it will not contaminate the surroundings and environment, making pneumatics more desirable where cleanliness is a requirement.

Fig . 3.1 Pneumatic Cylinder

3.2 Arduino microcontroller

Arduino is a microcontroller board based on the concepts of ATmega328. It has 14 digital input output pin 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; that is simply connect it to a computer with a USB cable or power it with an AC to DC adopter or battery to get started. The Uno is different from all preceding boards that does not use the FTDI USB to serial driver chip.

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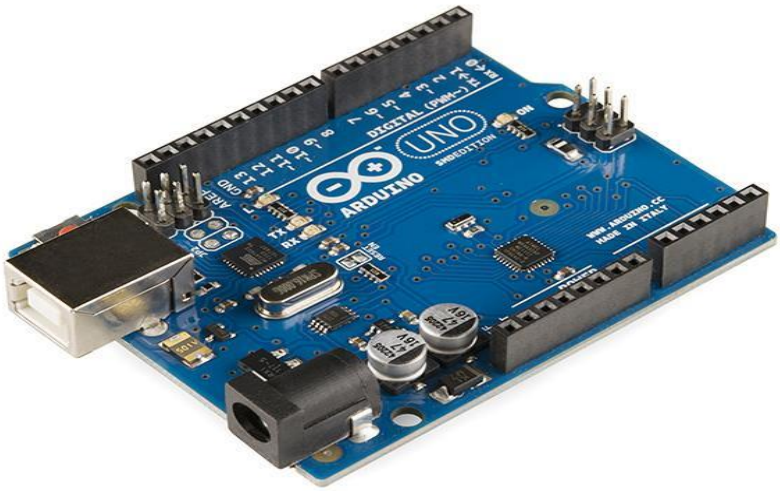


Fig 3.2 Arduino

Technical Specifications:

- Microcontroller: Microchip ATmega328P [7]
- Operating Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts
- Digital I/O Pins: 14 (of which 6 can provide PWM output)
- UART: 1
- I2C: 1
- SPPI: 1
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g

3.3 Bluetooth

Bluetooth is a wireless technology standard which is used for exchanging data between fi mobile devices over short distances using short-wavelength radio waves in the industrial, scientific and medical radio bands, and building personal area networks . We are using Bluetooth device to control the motion of robot.

Bluetooth can be use transfer small files but the speed for transferring files in Bluetooth is less. The IEEE has standardized Bluetooth as IEEE 802.15.1, but it no longer maintains the standard of its specification. The Bluetooth SIG has the responsibilityfor the development of the specification, and it manages the qualification program, and protects the trademarks. A manufacturer must meet Bluetooth standards to market it as a Bluetooth device. A network of patents are applied to the technology, which are licensed to individual qualifying devices.

3.4. Suction cup

Suction-cups are typically made up of material such as rubber or soft plastics. Vacuum suction-cups can hold, lift or turn virtually any kind of material and is used extensively. The contact between a suction-cup and the object to be soft and light. Vacuum suction cups are the link between the work piece and the handling system. They consist of the suction- cup and a connecting element. Suction-cups are used to grip and move work pieces in a or on a robot and helps to maintain the grip.

A suction-cup could not attach itself to the surface of a work piece and it requires an exteral support. Instead, the air pressure presses the suction- cup against the work piece as soon as the pressure is greater than the pressure between the suction-cup and the work piece. This pressure difference is achieved by connecting the suction-cup to a vacuum generator which releases the air from the space between the cup and the work piece. If the suction-cup is in proper contact with the surface of the material , no air can enter it from the sides and a vacuum is generated and it gets attached properly.

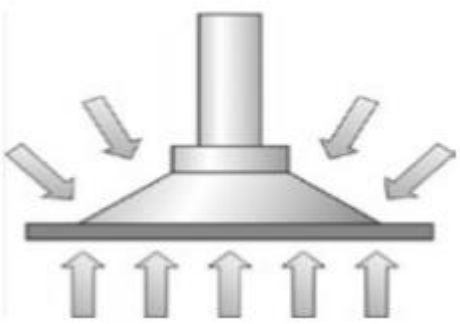


Fig 3.3 Suction Cup

3.5 Battery

A battery is a device that consist of one or more electrochemical cells . When a battery is supplying electric power, its positive is cathode and its negative is anode. The

terminal negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to external supply, a reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. The term "battery" specifically referred to a device multiple cells, however the usage has evolved to include devices composed of a single cell.

3.6 Android app

An app is designed to control the cleaning robot Manually and automatically this app is connected through the Bluetooth module which is already interfaced with the robot microcontroller .

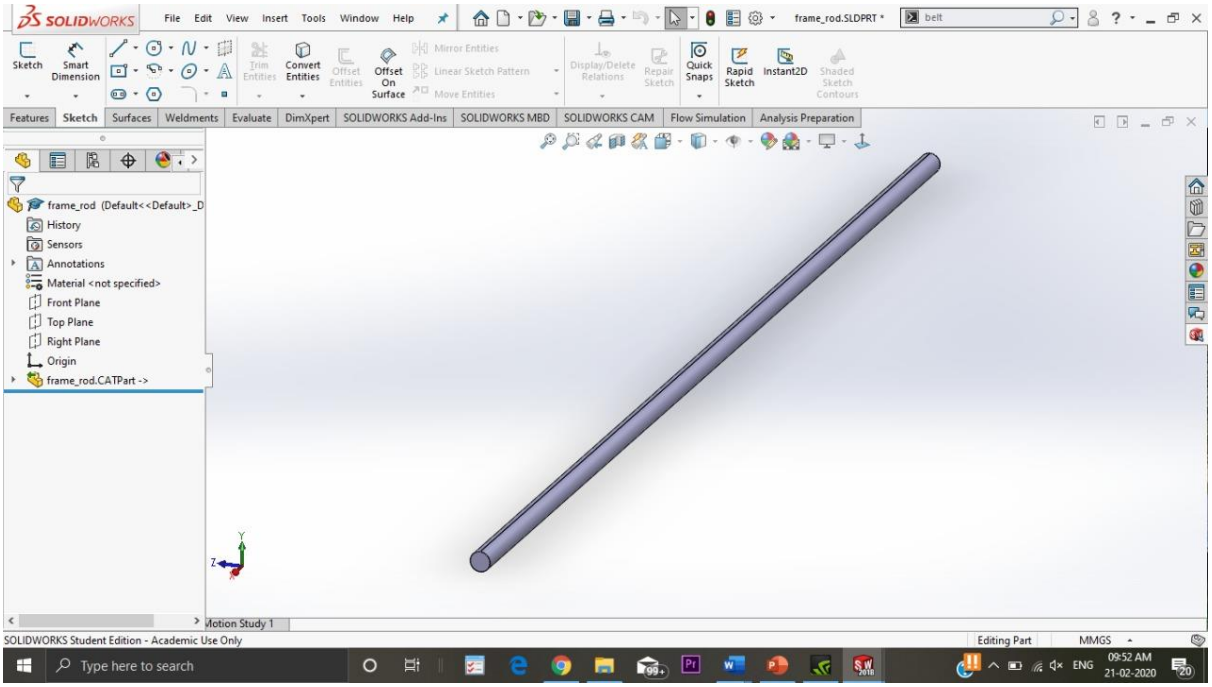
Fig 3.4 Android app

CHAPTER 4

SYSTEM DESIGN

There are two units in the robot. One is for motion of robot and other is meant for the cleaning purpose. The motion of robot is obtained through motion unit. The motion unit comprises of 2 rotating discs, suction-cups, DC motor. When the PLC gives command to motor to rotate in either forward or reverse direction, the motor rotates. A gear is attached with shaft of the motor which drives the rotating disc. Suction-cups are attached to the bottom of this disc. There are 10 suction-cups beneath each disc, which makes the total of 20 suction-cups. And the arrangement is such that, at a time 4 suction-cups from each disc gets active. So, total 8 suction-cups are active at a time. For activating suction-cups, we use activation switches, when pressed activates the corresponding suction-cup. This switches are used because, the vacuum is only needed in 8 suction-cups at a time. But if switches are not provided, suction pressure is reduced, which leads to poor vacuum in the required suction-cups. To support the rotating disc aluminum plate is being used. On this plate rotating discs are fixed. A tilt of 10 degree is provided on both the sides of plate, where rotating discs are mounted. This tilt helps in the activation and deactivation of suction-cups. Due to this tilt at a time only 8 suction-cups get in contact with the glass surface. In order to make this robot as lightweight as possible, the material for rotating discs is Polypropylene which is the lightest and most economical fiber material.

Diagrams of system designs:



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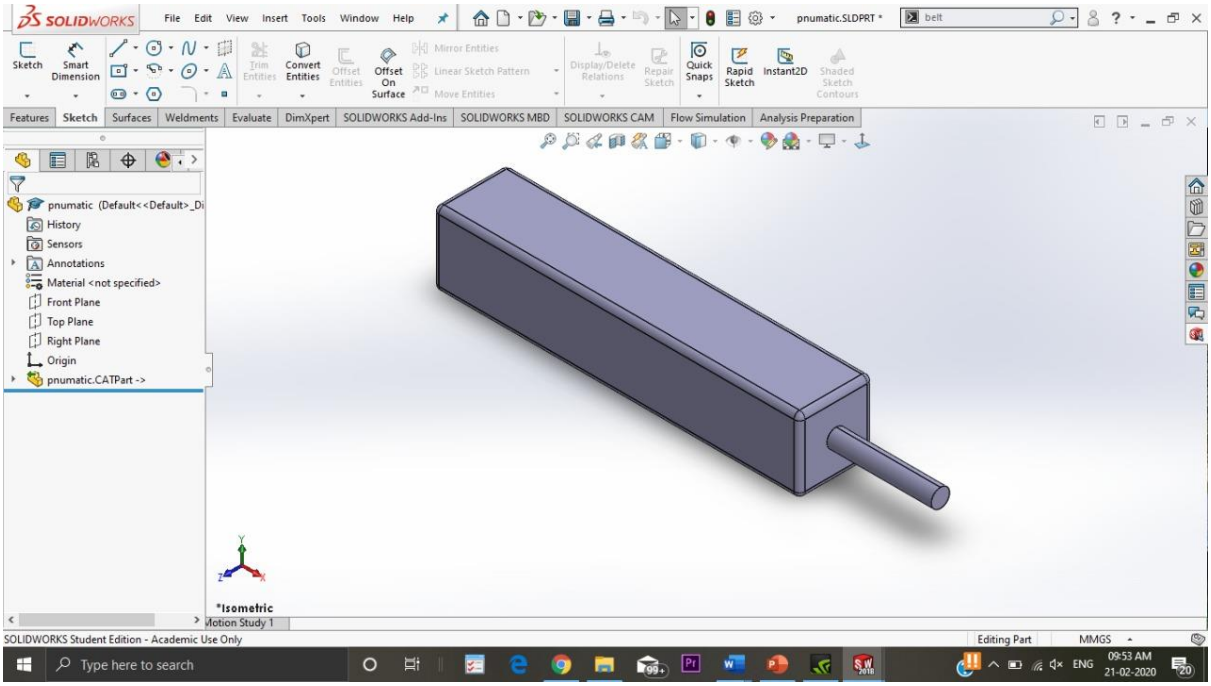

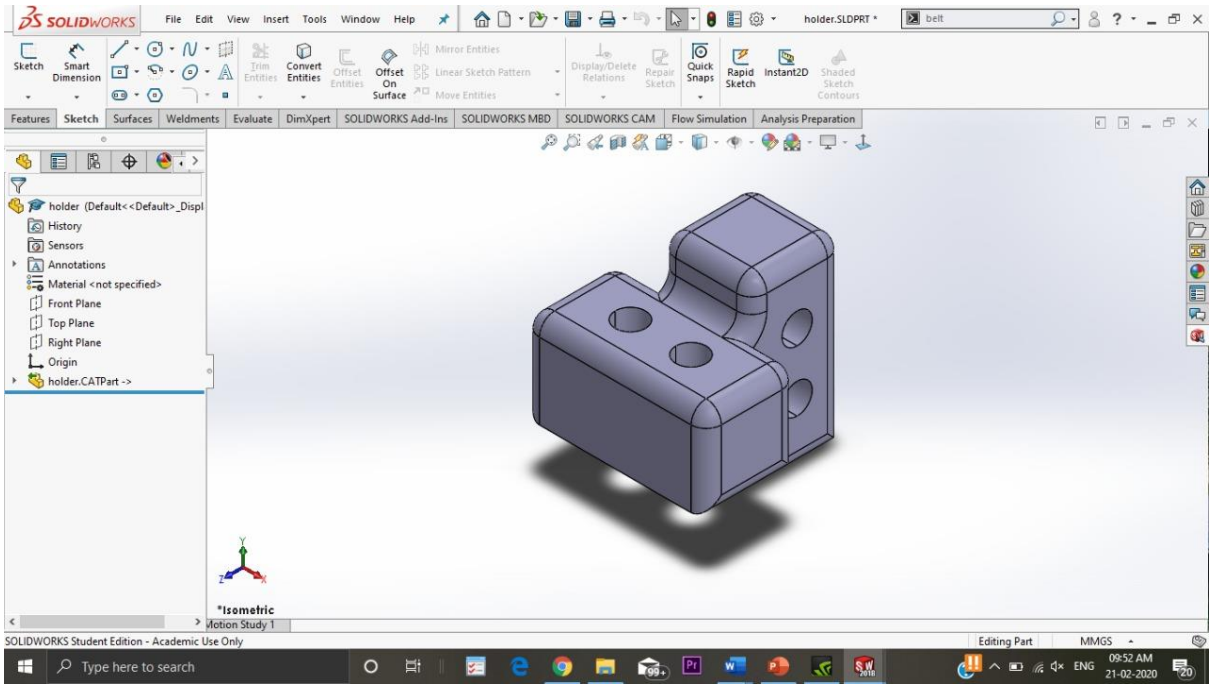
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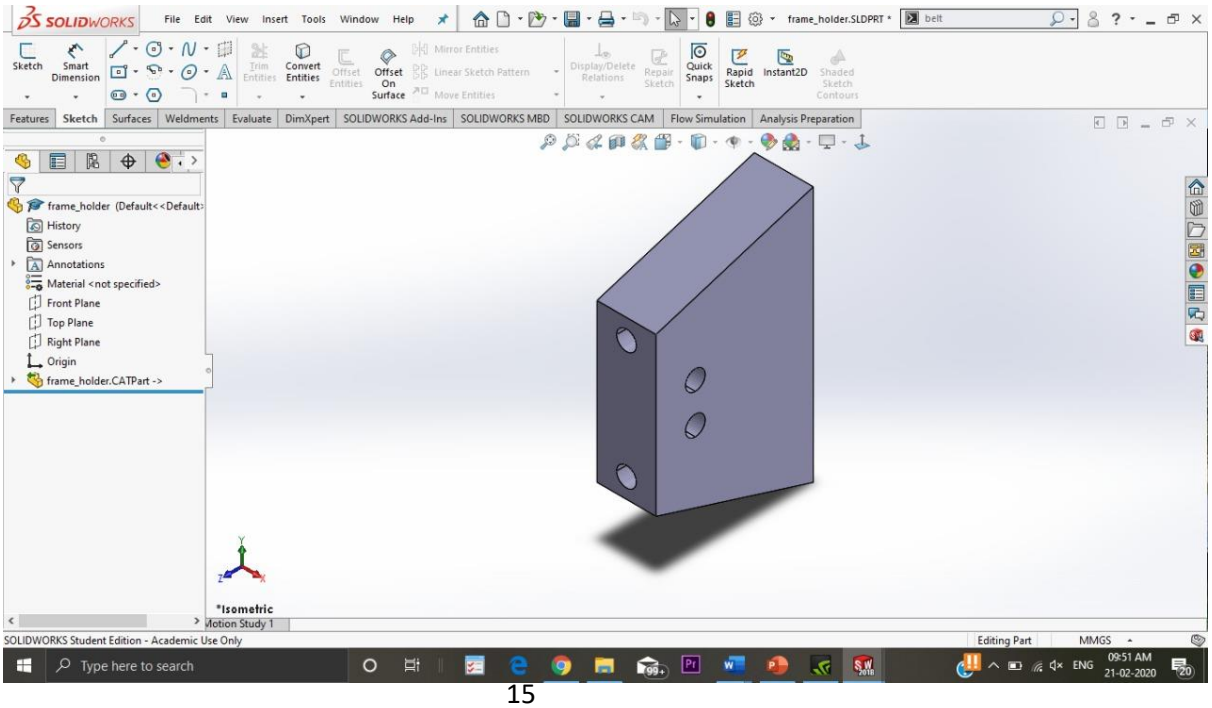
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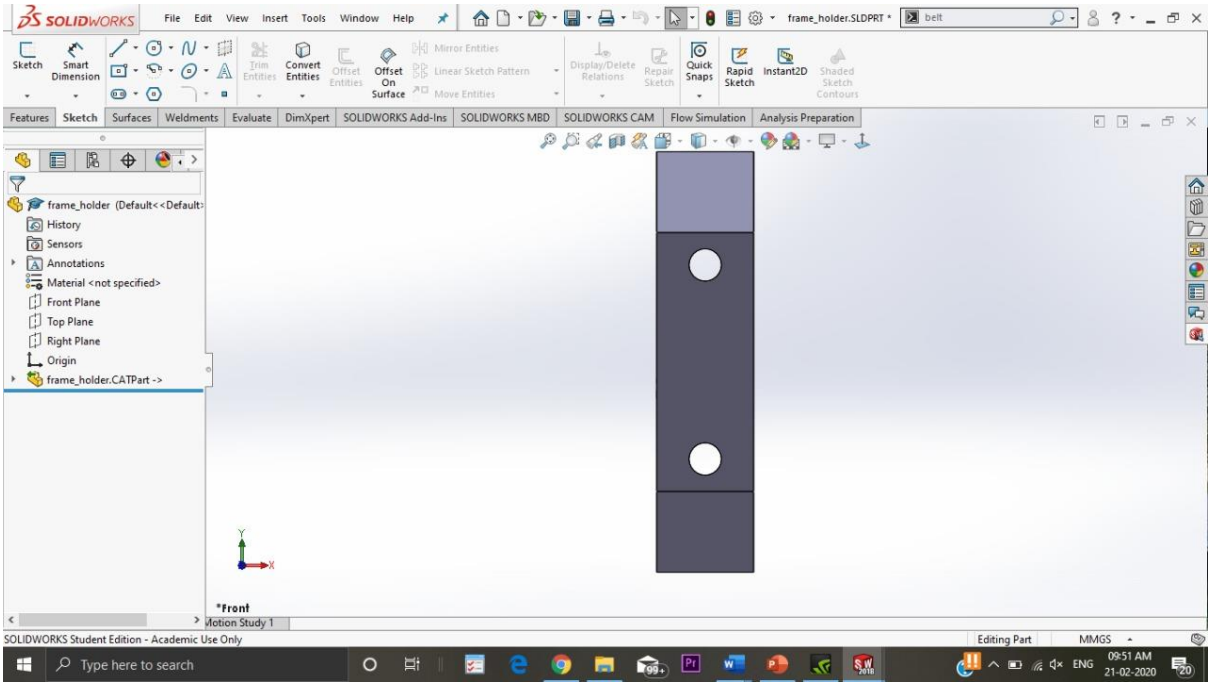
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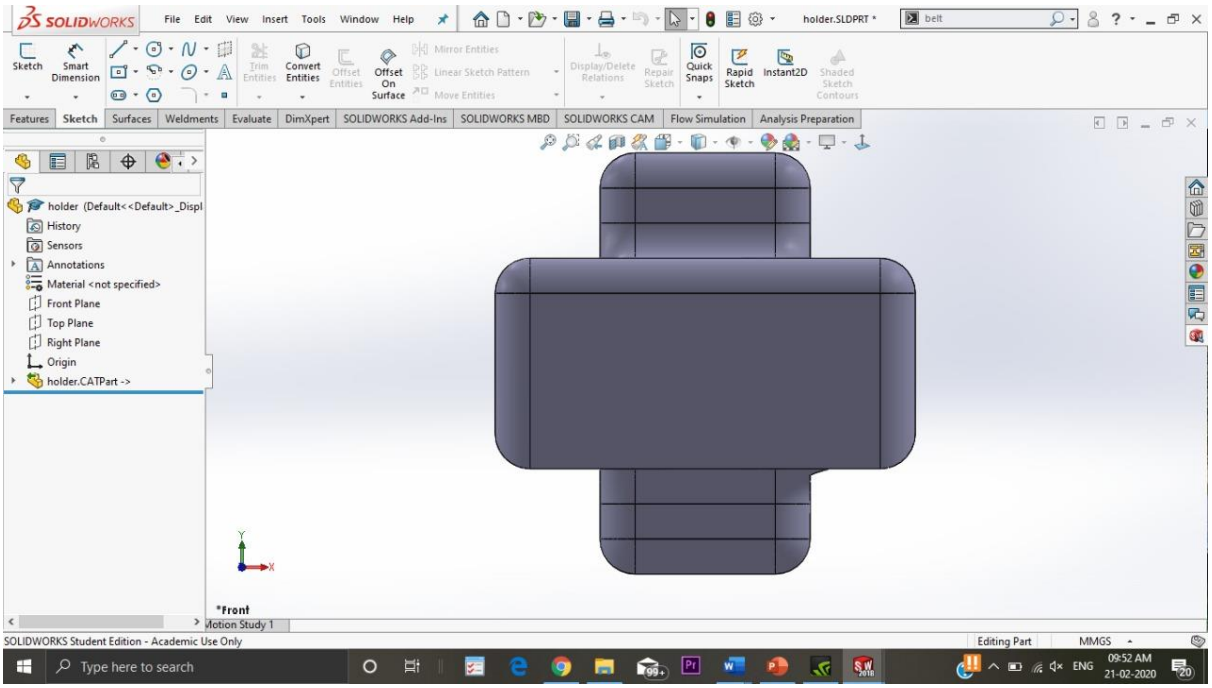
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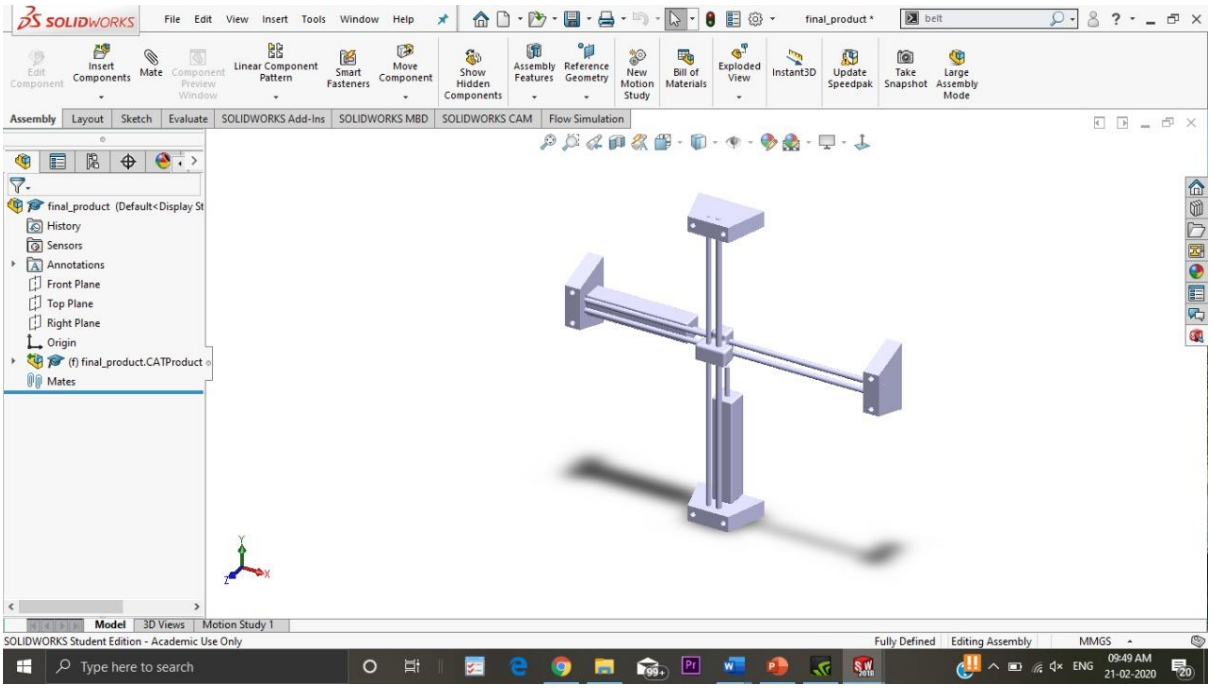
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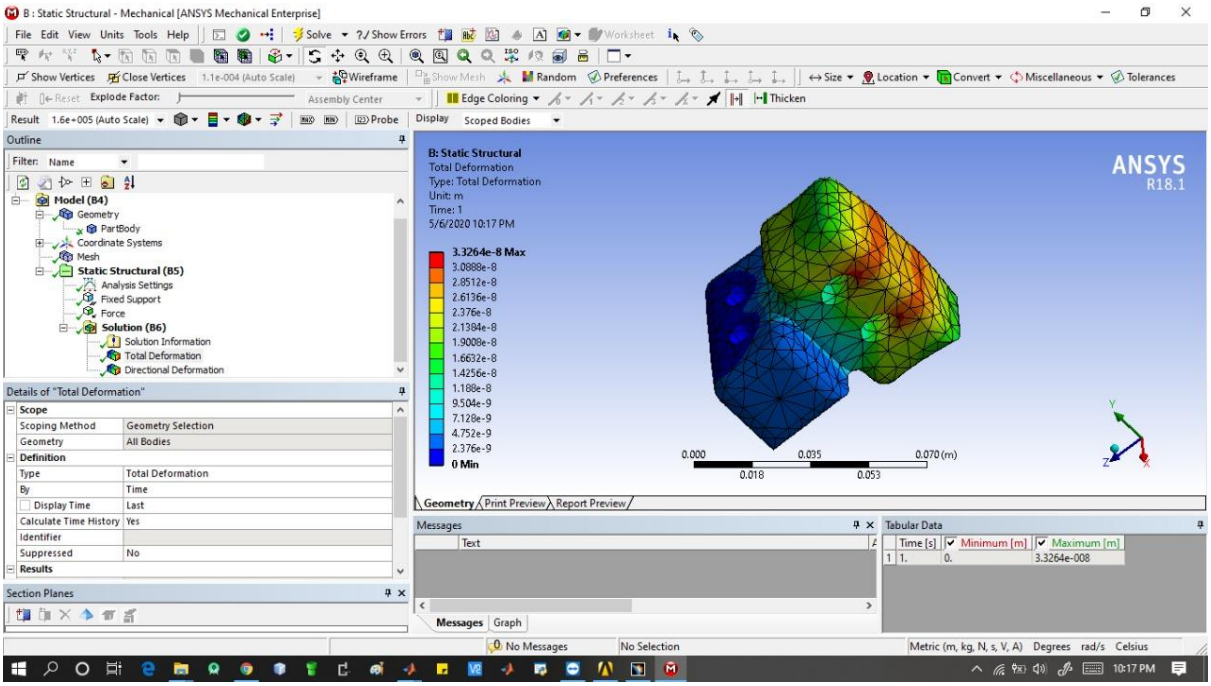
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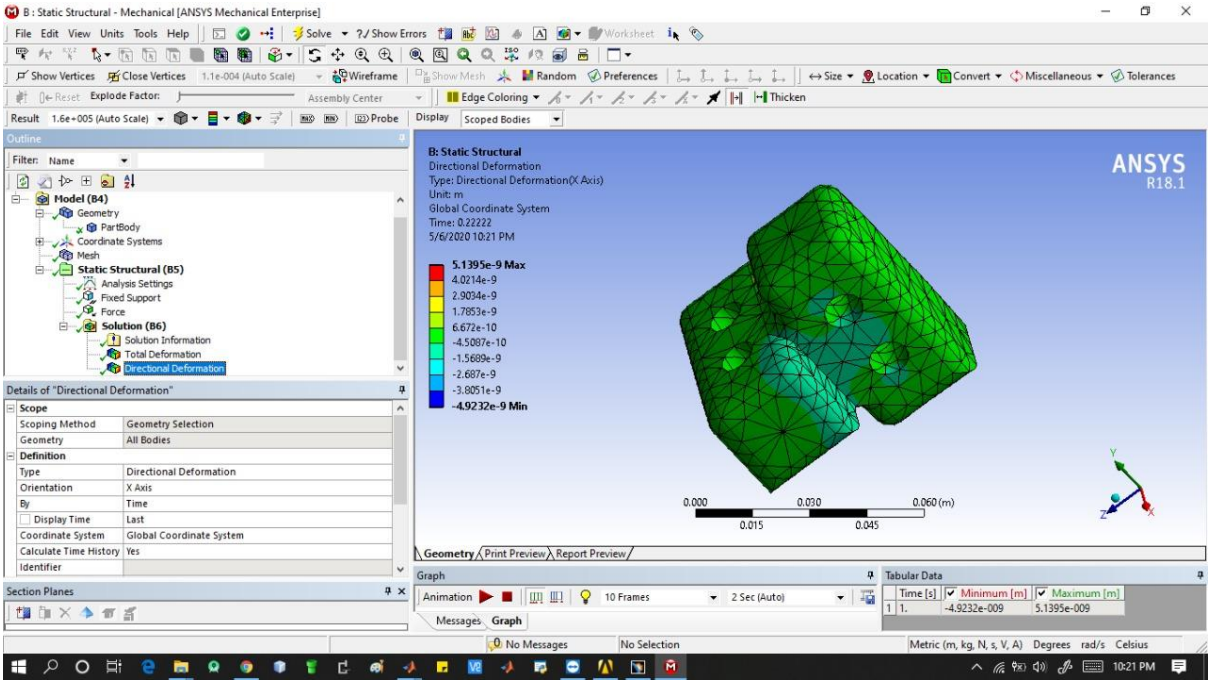
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Fig 4.9

CHAPTER 5

WORKING PRINCIPLE AND CIRCUIT DIAGRAM

5.1 Working Principle Of Glass Cleaning Robot

It consists of two threaded rods attach at the ends of two rectangular bars at right angle, the pneumatic cylinder is fixed at each threaded rod at right angle. One is used for creating suction in horizontal member and another in vertical. When horizontal pneumatic cylinder is on horizontal member gets attach to glass via suction cup and hence vertical member is free to move in vertical direction similarly when vertical

cylinder is ON vertical member gets attach and hence other member is free to move in horizontal direction.

For moving the member two motors are attached to threaded rods, one motor is attached to horizontal rod and other to vertical. The threaded rod moves inside a square bar having internal thread. When the motor rotates it rotate the threaded rod with it and hence the rod is forced by axial force because of threaded to move in axial direction. This process is done in both X and Y direction.

In the moment of the robot the first 4 suction cups are released and 4 suction cup are sticked at the same location. the 4 released suction cups axis moves in the both up and down direction and the same mechanism is used in the motion of the other axis. In the motion of the axis the major role is played by the pneumatic cylinder. And the pneumatic cylinder is attached with the solenoid valve and solenoid valve is operated by a microcontroller (arduino).

8 Suction cups are used for attaching the robot to the glasses, the robot has 4 Trapezoidal Pods, each pod Two suction Cups will be attaching hence at total 8 on 4 pods. All 8 suction cup are attaching to the pneumatic cylinder. The pneumatic cylinder creates suction for attaching the robot to the glass.

A small container of 200 ml size will be attaching at the centre of the robot which will spray water to the glass, a brush attach at the bottom of the robot will help in cleaning the glass. The container will be

connected via pipe to the main water supply task at the the top of building by this the weight of the robot is reduced to much greater extent. For controlling the robot an arduino based microcontroller is used, which can be controlled by phone via Bluetooth signal.

Motion of the Robot :

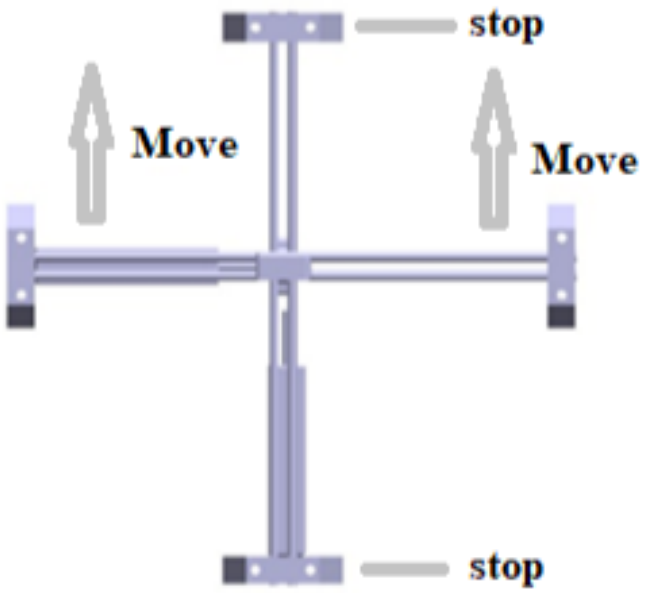


Fig 5.1-motion of the robot direction

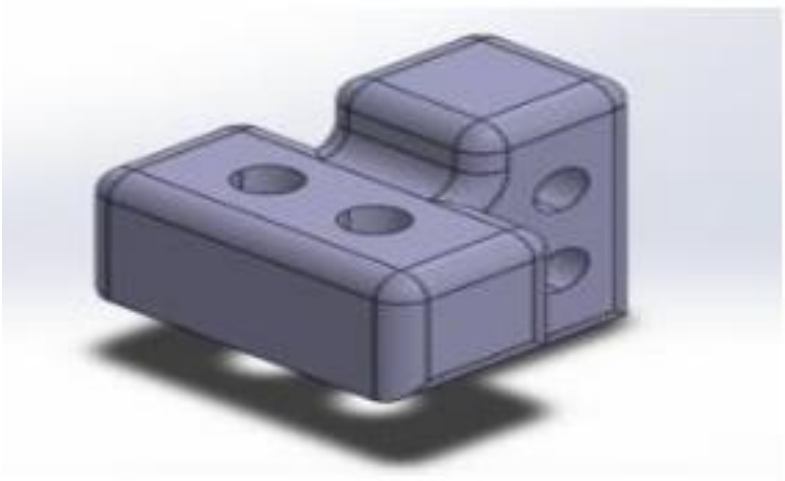


Fig 5.2-Threaded rod is fixed at the right angle

5.2 Circuit Diagram

The microcontroller is connected to relay and the relay is connected to the solenoid valve. The Bluetooth receive data from android app and sends instruction to the microcontroller the controller is already programmed for each instruction. And it operates according to the instructions of the machine .

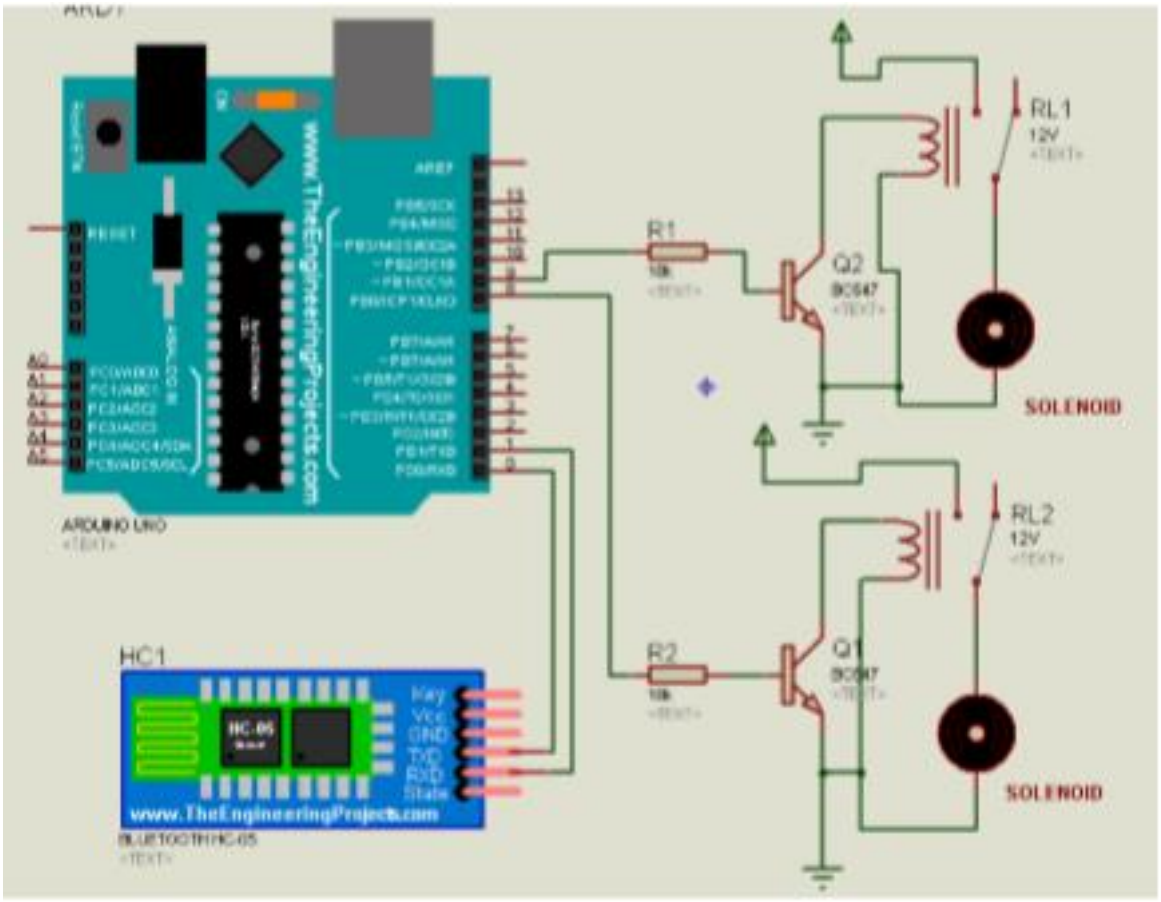


Fig. 5.3 Circuit Diagram

The total power consumption in the system = Suction cup power + water pump power + relay operation power +dc motor cleaning

Suction cup power = 12v* 2amp =24watt

water pump power = 12v* 1amp = 12watt

relay operation power = 5v *1amp = 5watt

dc motor cleaning = 12v *1amp =12watt

total power consumption = 53 watt

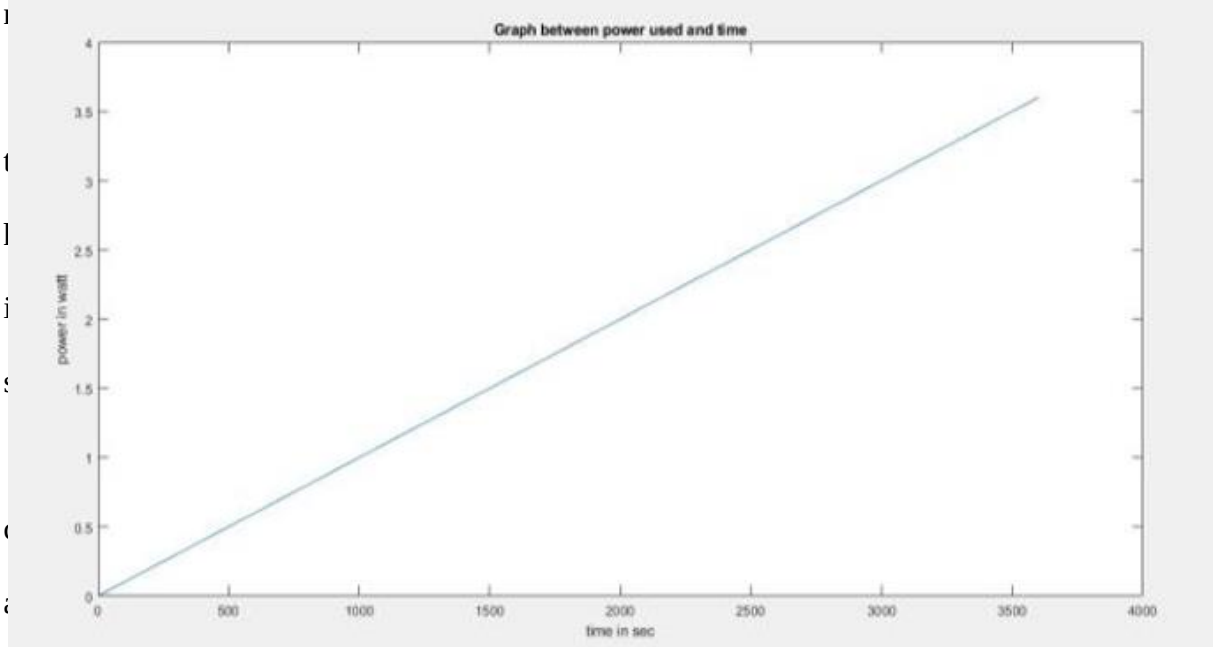
battery output =12v *7amp =84watt

time of running = 84/53=1.54 hrs (when 100% charged)

if we consider arduino and Bluetooth power then arduino 5v *250mAmp =1.25watt

Bluetooth =5v *250mAmp= 1.25 watt

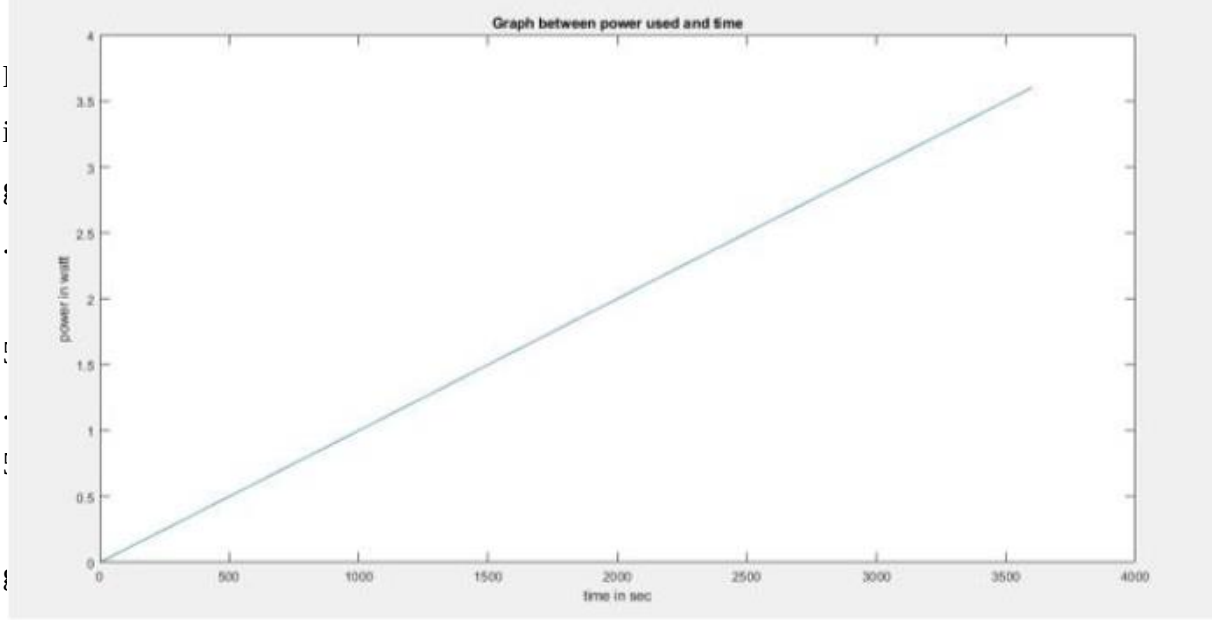
I



s

e the running time will be 1.51 hrs

Fig 5.4 plot between the time and dust



aph between time in send and power in watt

CHAPTER 6

RESULT

Robot Dimension : (l * b * h) = 50 cm * 50 cm * 15 cm;

Weight of the robot, W = 6.5 kg;

Force acting on it, F = 6.5 N;

suction-cup Area = Pi*R*R = pi* (3.5) = 38.465 cm^2

= 3.8465 * 10^-3 m^2

Safety Coefficient, S = 2;

Coefficient of Friction, μ = 0.5;

Pressure inside the suction cup, P = F*S/A* μ

= 6.5*2/3.8465*10^-3 *0.5

= 6.759 KPa

= 0.06759 bar = 50.696669 Torr

Total Pressure, TP = 0.623 bar

= 4.6799 Torr

Speed of the cleaning motor, Smotor = 30 rpm;

For best cleaning Effective Speed of the robot, Sr = 10 cm/min;

CHAPTER 7

CONCLUSION

Our paper has described the application and uses of glass cleaning robot. The glass cleaning robot is light wait and small size and it can be easily handled. The robot has suction cup that helps it to stick on the glass surface and it also helps in the smooth functioning of the robot. The above robot made by us was prototype. With some further modification we can also use it as a wall painting robot.

This project will be used at the high rising buildings and in schools or universities having the external as well as internal glass wall for cleaning those glass walls. It can be used for another various applications like painting a wall, monitoring the conditions of the glass walls etc. This glass wall cleaning robot will very useful at colleges, institutes, hospitals, companies, etc

Our paper described the application of small-size , light weight wall climbing robots for window and glass cleaning. This robot moved on the window smoothly with adhering by a suction cup. And this robot has a function to change a traveling direction at right angle at the corner of the window. Above mentioned window cleaning robot was prototype and its mechanism and motion and some of characteristics were illustrated

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