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# AUTOMATIC PNEUMATIC GLASS WALL CLIMBING ROBOT

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***Abstract— Most of heavy Architectural structures today were built with glass fabrication, for the aesthetic looks. Due to present environmental conditions, those structures were filled with dust which became very difficult to clean manually. By using robotic technology most of the systems were developed for the same purpose, which were failed to reach elevated highly due to heavy body. In this project an automatic wall climbing robot was developed using the concept of pneumatics and programmable logic controller. Two pneumatic cylinders were used for the movement of up &down and right & left for wall gripping and the robot suction cups were provided on all sides of robot. The sequencing of the pneumatic cylinders pressure cups solenoid operated direction control valves which are further controlled by using a ladder logic in PLC. The sensors were provided on 4 sides of the robot for detecting obstacles such that it can automatically change the direction of movement. The size and weight of the robot was reduced by using minimum number of components in the system, which are necessary for efficient running of the robot and feasibility of vertical transportation.***

***Keywords— PLC module, TIA Portal, Direction control valves, Suction cups, Vacuum generators,***

## I. INTRODUCTION

An Automatic pneumatic glass wall climbing robot is a special purpose robot that can be used for climbing walls, mainly on vertical surfaces as well as cleaning the glasses of buildings. The Automatic pneumatic wall climbing robots are used in a variety of applications like Painting on large vessels, cleaning on glass slabs of high rise building etc. an automatic wall climbing robot was developed using the concept of pneumatics and programmable logic controller. Two pneumatic cylinders were used for the movement of up &down and right & left. For wall gripping and the robot pressure cups were provided on all sides of robot. The sequencing of the pneumatic cylinders pressure plates solenoid operated direction control valves which are further controlled by using a ladder logic in PLC. The sensors were provided on 4sides of the robot for detecting obstacles such that it can automatically change the direction of movement. The wall climbing robot was fabricated using pneumatic cylinders, aluminium rods, aluminium plates and suction cups etc. The pneumatic cylinders are used for the movement of up &down and right & left movement. The aluminium rods and aluminium plates are used for the supporting purpose. The suction cups are used for the sticks on the glass or walls.

## II. LITERATURE SURVEY

[1]. Bsail Mathew T, Jinto Matew, Abin T issac, Delvin Dominic,Mobin P Abraham, Sachin K S"Wall painting with wall climbing robo" : This paper helps to perfection of Painting by itself and cleaning done by automatically.

[2]. Sahil Bharti, S.R.Sadhave, H.Ramkumar, S.Ishwarya Lakshmi, G.Muralidharan" Design and Development of cleaning system". International Journal of Soft Computing and Artificial Intelligence" this journal helps to areas which are not easy to reach, High rise buildings with glass windows.

## III. PROBLEM STATEMENT

Now a days most of the buildings are constructed with glass fabrication materials to maintain aesthetic looks. But due to present environmental conditions those structures were filled with dust particles, which becomes very difficult to clean manually. In order to clean those high end buildings sometimes operators may lose their life, based on as per the government of India information every year roughly around 5000 peoples are loosing their life's while cleaning multiflorous glass structural buildings. To avoid such incidents and solve their problems to some extent automatic pneumatic glass wall climbing robot is developed with the help of pneumatic and PLC Programmed concepts.

## Iv. PROBLEM SOLUTION

In order to achieve the objective of the project, this robot can be used for painting of wall of building as well as used for cleaning of glass of buildings. Wall climbing robots are special robots that can be used in a variety of application like

inspection and maintenance of surface of sea vessels; oil tanks, glass slabs of high rise building. In order to succeed the objective of this project, there are several scope had been outlined. The scope of this project includes using solenoid operated dc valve at both ends to actuation of the cylinder, build hardware and software for the robot, and interface the hardware to the pneumatic system like vacuum ejector and compressor. The robot will test until it able move vertically on the glass wall, not fell down and able to avoid obstacles. The main core of this project is to design and build a wall climbing robot which can adhesive on the glass wall and moving vertically on the surface of the glass wall. It also has the ability to avoid the obstacles and automatic operation during moving on the glass wall. Then, apply the concept to wall climbing robot. Then, the robot also is a wall climbing robot with using vacuum ejector. This is a challenge to make the robot stick on the smooth surface.

## V.EXPERMENTAL PROCEDURE

A. CONSTRUCTION AND WORKING

**The automatic pneumatic glass barrage climbing robot is made from gathering the resulting parts given in the table as follows:**

| Components | Specifications |
|---|---|
| Suction cups | Material – polyurethrene<br>Diameter- 40mm<br>Flat cup(round) shape, G1/8 connections.<br>Maximum suction force- 57.7 N<br>Weight -7.3g |
| Direction control valve | 5/2 DCV push button and solenoid operated at both ends for actuators<br>5/2 DCV Push button and solenoid operated at both ends for vacuum generators<br>Power- 4.8w<br>24 V dc coil |
| Vacuum generators | ZH10DS-06-06 (SMC COMPANY EJECTOR)<br>Nozzle diameter-1mm<br>Maximum vacuum pressure =-88kpa<br>Material is Aluminum alloys and rubber |
| PLC module | Model-12-3004NA<br>Operating voltage- 6-36 V DC<br>Type- NPN NO<br>Detecting range-4mm<br>Diameter of cylinder – 12mm |
| Proximity sensors | Model-12-3004NA<br>Operating voltage- 6-36 V DC<br>Type- NPN NO<br>Detecting range-4mm<br>Diameter of cylinder – 12mm |
| Cylinders | Double acting cylinders with bore 32 mm and stroke length 200mm<br>Operating pressure is 0.5-10 bar<br>Medium temperature is 5-60 degree centigrade<br>Material construction; cylinder barrel and piston rod -stainless steel |
| Sliding rods | Aluminum rods; diameter 16mm and length 300mm<br>M10 Threading at both ends of aluminum rods |
| Aluminum plates | Length -120mm, width -60 and thickness-20mm (for 4 plates) and other two plates dimensions-Length-100mm, width-60 and thickness-20 |
| Plastic blocks | Length -100mm, width-38mm and thickness-38mm |
| Pneumatic Hoses | 8mm |

**Table-1. Components are used in automatic pneumatic glass wall climbing robot and their specifications**

B. GLASS WALL CLIMBING ROBOT ASSEMBLY

The robot was assembled with two pneumatic with double acting cylinders, for one is vertical and other is horizontal. These two cylinders are the intersecting to each other's. At the end of the piston cylinders connected to two plastic rectangular blocks each to others. The Block having two holes, those holes are used to inserting the aluminum rods. At other end of the cylinders having threading, because we inserting the aluminum plates, those aluminum plates are providing all sides of the components. At end of the aluminum rods we insert aluminum plates both ends of the aluminum rods. Two pneumatic cylinders were used for the movement of up &down and right & left. Aluminum plates are used for the supporting purpose and remaining aluminum rods are used for sliding purpose. All four sides end of the robot we connected suction cups and those suction cups are used for sticking on the surfaces of glass walls. For suction cups sticking purpose we use vacuum generators, those are working the venture principle. When the fluid particles flow through the throat, at that throat pressure is decrease and velocity is increases similarly vacuum ejector working. Future grind will be toward mounting more competent indication control system and reducing size/weight of the climbing robot. The main applications of the automatic pneumatic glass wall climbing robot like inspection, buildings, maintence and safety in companies. Those are mostly adapted in where direct access by a manual operator is very large affluent, since of the need for framework or risky, due to the manifestation of Instructive location.

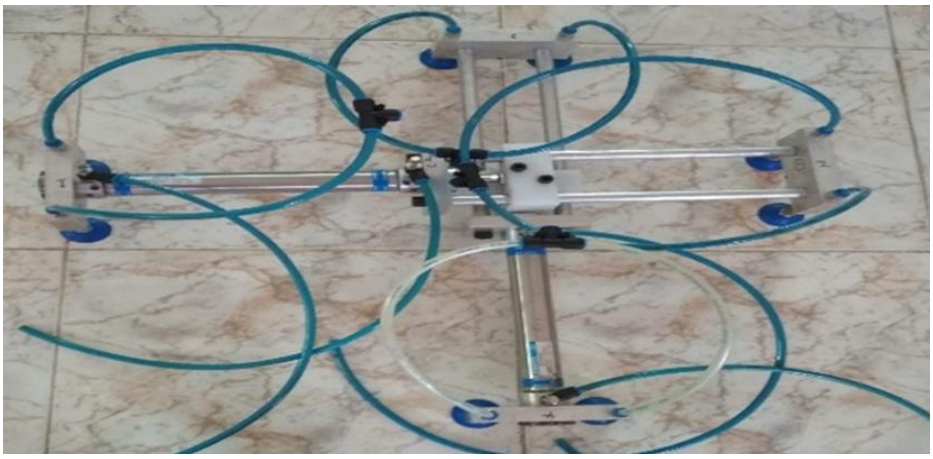


Fig.1 assemble of wall climbing robot

Recently there was extra demands for automatic cleaning system on surface of the building glasses by increasing of modern designs. However, most of them placed on the buildings from starting stage and required very high outlays.

C. PNEUMATIC CIRCUIT

The block diagram for the pneumatic circuit for the automatic glass wall climbing robot show in fig.

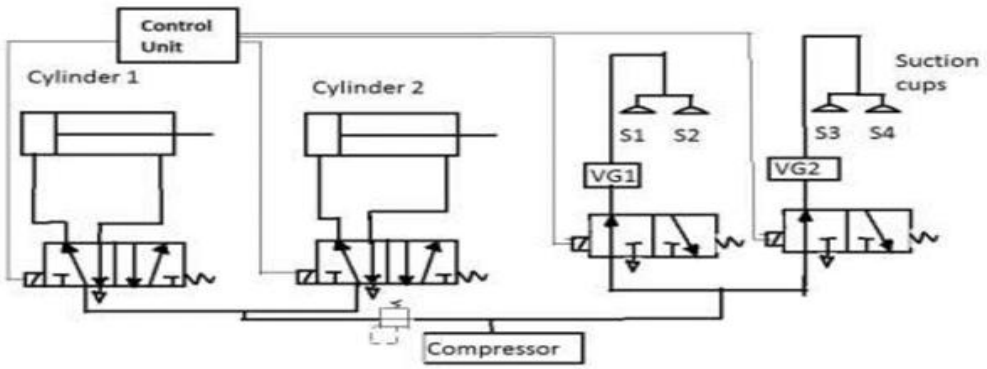



Fig.2 circuit diagram for glass wall climbing robot

I) Vertical member with pipe 1, drag cups S1, S2, S3 and S4 are straddling on clinder1.

ii) Horizontal limb container 2, draw cups S5, S6, S7 and S8 are mounted on cylinder 2.

D. SAMPLE CALCULATIONS

1) The selection of the suction cup diameter

The hypothetical plot strength mandatory to clamp the glass wall climbing robot against the wall is calculated first.

$F = (m/\mu) \times (g + a) \times S$

Where as the m= is mass of the glass wall climbing robot
μ = coefficient of friction, for oil surface=0.1, for the wet surfaces=0.2-0.3, for rough surfaces=0.6 and the wood, glass, stone =0.5
g = deceleration due to gravity
a = rushing of the glass wall climbing robot
S = safety factor, for the horizontal position =1.5 and vertical position =greaterthan2
Assuming a = 1 m/s^2 and g = 9.81 m/s^2,
F= (5/0.5) x (9.81+1) x 4
F= 432.4 N

Now we calculated for the suction force for indusial suction cups
F s= F/n. where n= no of the suction cups.
There for the F s=432.4/8
F s=54 N

| | | | | | |
|---|---|---|---|---|---|
| Suction cup diameter(mm) | 8 | 10 | 15 | 20 | 30 |
| Suction force(N) | 2.3 | 3.9 | 8.5 | 16.3 | 40.8 |
| Suction cup diameter(mm) | 40 | 50 | 60 | 80 | 100 |
| Suction force(N) | 69.6 | 105.7 | 166.2 | 309.2 | 503.4 |

Table.2 Suction cup diameters and corresponding suction force

The considered suction strength should be less than the allowable suction force. Hence, the suction cup of 40 mm diameter is designated since 54 <69.6 N.

2) selection of vacuum generator

The vacuum generators or ejector is mainly used for sticking the suction cups on the glass walls. The vacuum ejector working principle is the venture principle, is state that when the fluid particles flow through the pipe at the throat the fluid particles pressure is decrease and velocity is increase. This way vacuum generators working. The block diagram as shown in figure.

Fig.3 vacuum generator

| Vacuum generator model | Nozzle diameter(mm) | Maximum vacuum pressure (KPA) | Minimum vacuum pressure (KPA) |
|---|---|---|---|
| ZH10DS-06-06 | 1 | -88KPA | -48KPA |

Table .3 specifications of vacuum generator

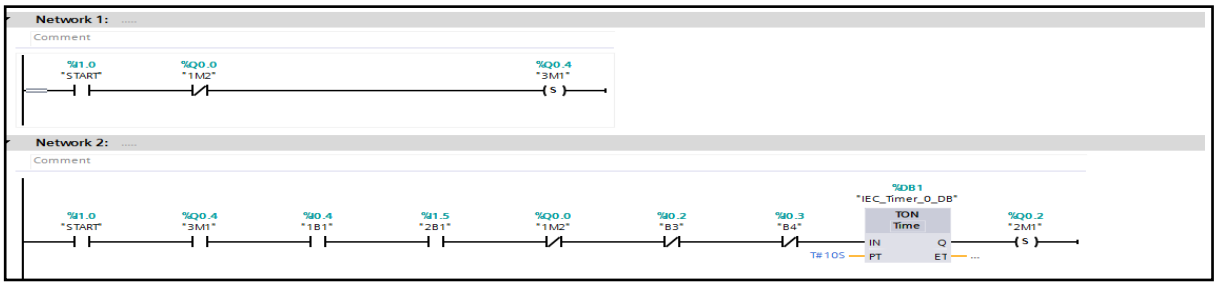
3) PLC program for glass wall climbing robot

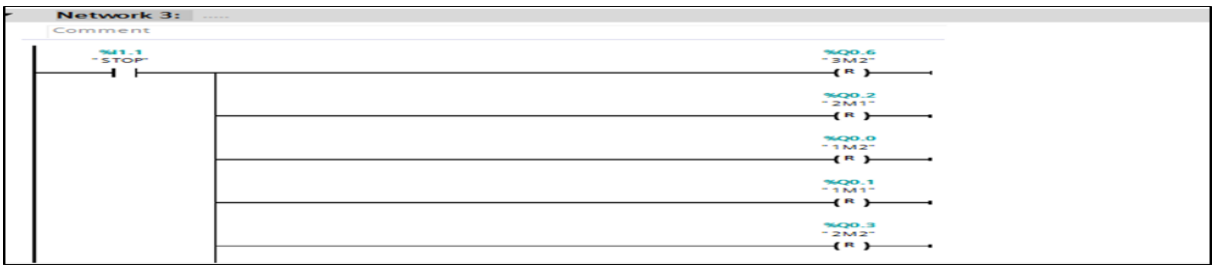
The plc program for wall climbing robot is as follows:

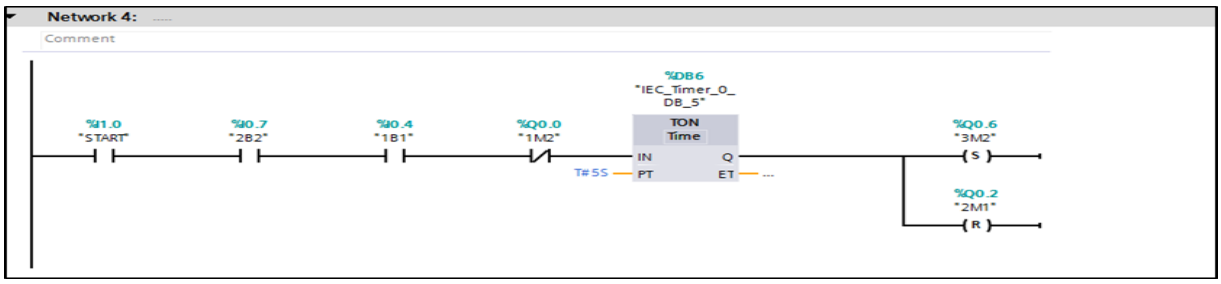
Hear assume 1A and 2A are cylinders

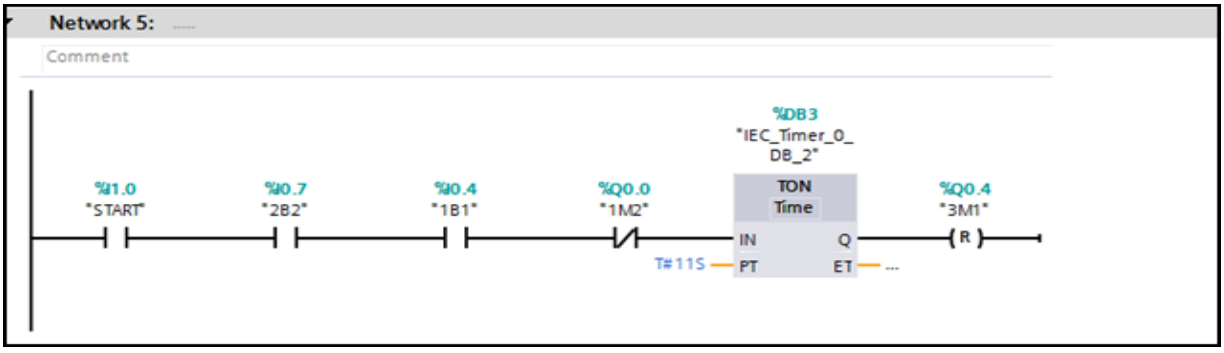
1B1, 1B2, 2B1, and 2B2 are reed switches

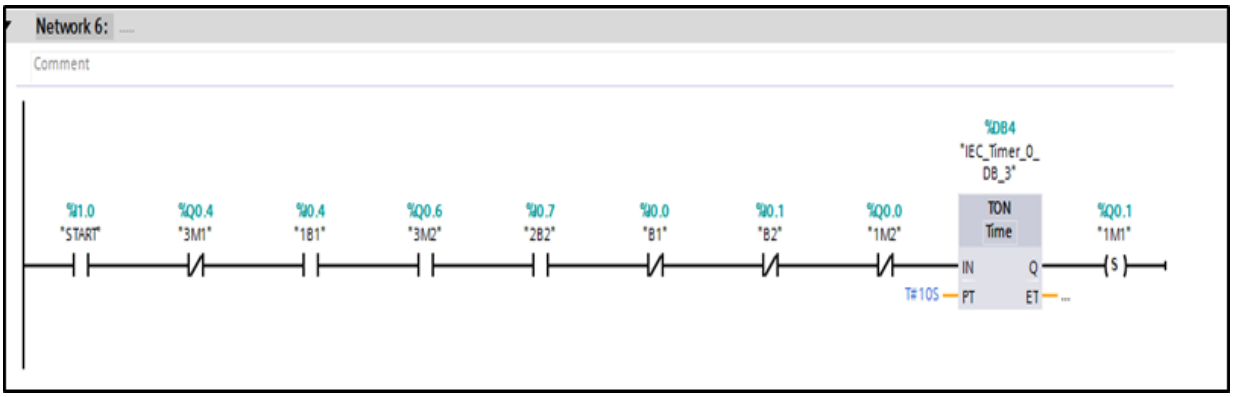
1M1, 1M2, 2M1, 2M2, 3M1, and 3M2 are solenoids'

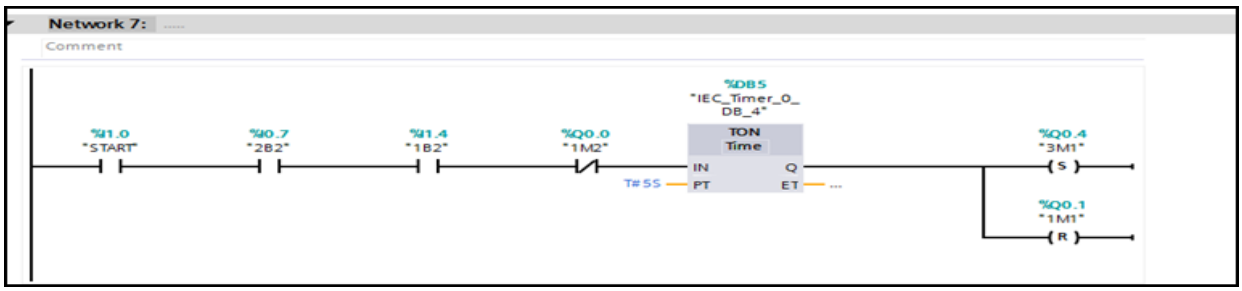



Network 7:
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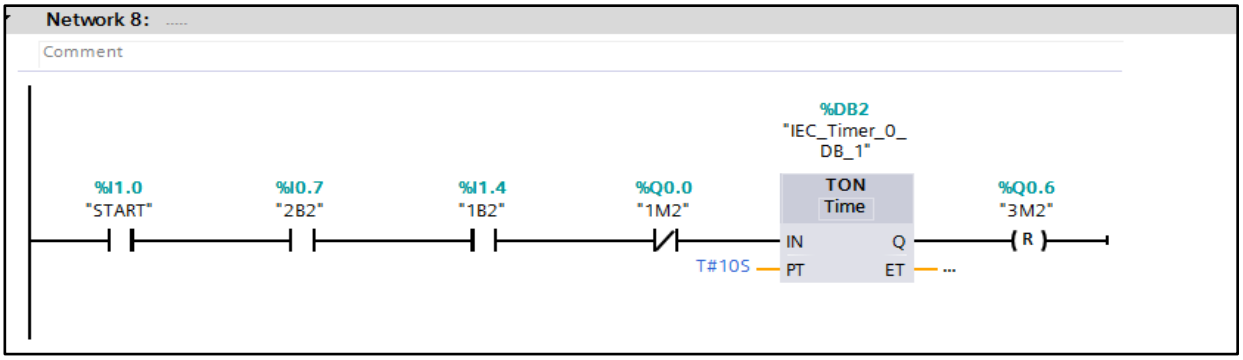
DB_4"
%I1.0
"START"
%I0.7
"2B2"
%I1.4
"1B2"
%Q0.0
"1M2"
TON
Time
IN
Q
T#5S
PT
ET
%Q0.4
"3M1"
S
%Q0.1
"1M1"
R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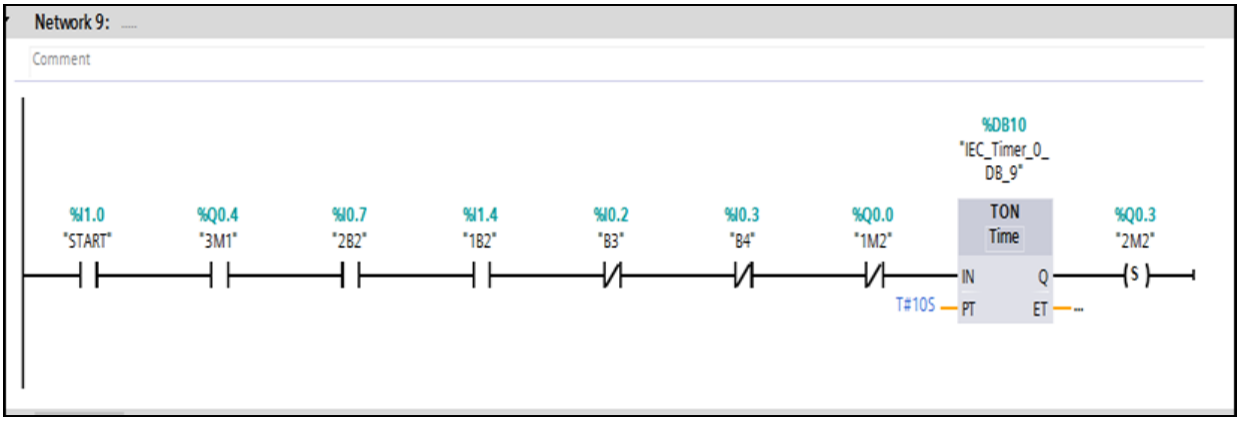
"IEC_Timer_0_
DB_1"
%I1.0
"START"
%I0.7
"2B2"
%I1.4
"1B2"
%Q0.0
"1M2"
TON
Time
IN
Q
T#10S
PT
ET
%Q0.6
"3M2"
R


Network 9:
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DB_9"
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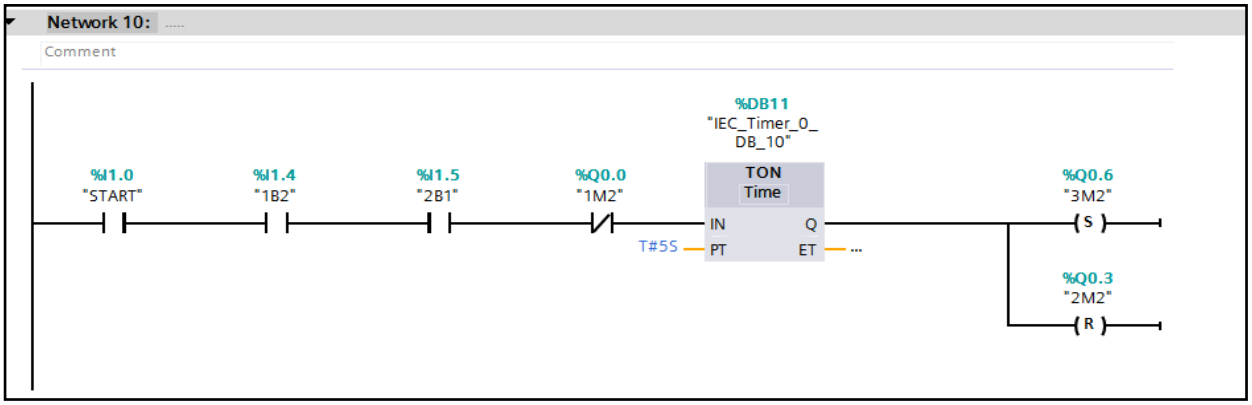
%Q0.4
"3M1"
%I0.7
"2B2"
%I1.4
"1B2"
%I0.2
"B3"
%I0.3
"B4"
%Q0.0
"1M2"
TON
Time
IN
Q
T#10S
PT
ET
%Q0.3
"2M2"
S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"START"
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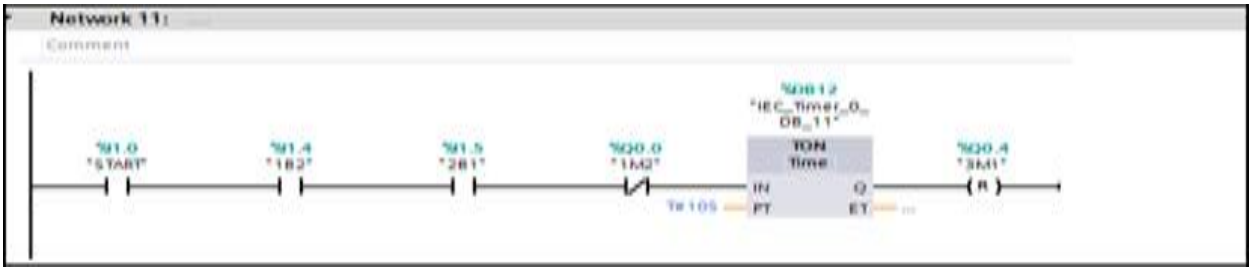
%I1.5
"2B1"
%Q0.0
"1M2"
TON
Time
IN
Q
T#5S
PT
ET
%Q0.6
"3M2"
S
%Q0.3
"2M2"
R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"1M2"
TON
Time
IN
Q
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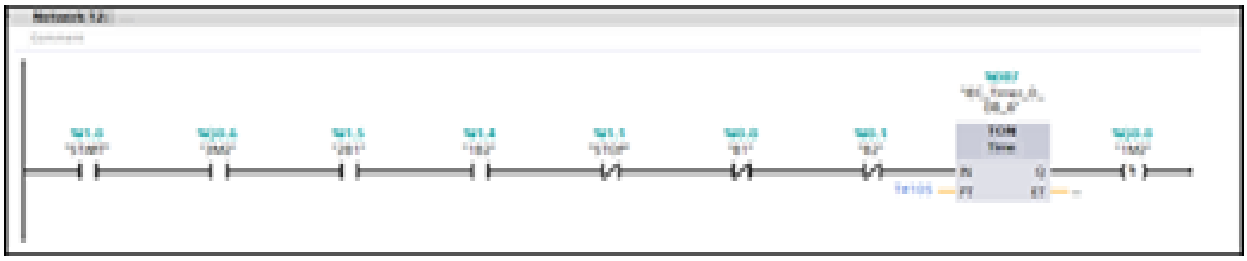
ET
%Q0.4
"3M1"
R



4) Areas of applications

i) Consumer applications (window cleaning and painting)

Window washing, is the cleaning of architectural glass used for structural, lighting, or attractive purposes. It can be done automatically, using many of tools for cleaning and access. But for safety of employee technology is also employed and increasingly, automation. Similarly, with the application of painting this robot can be used.

Fig .4 painting and cleaning application

ii) Inspections (building, aircraft & bridges, Pipes) etc

. Airlines and other commercial operators of large or turbine-powered aircraft follow a Continuous inspection program.

Turbo machinery inspection where there is inaccessibility for humans at high temperature

Fig .5

inspection of boilers and aircraft

## VII. CONCLUSION

As expected, the results of the project come out the satisfactory and the observations are as follows: The robot can be move as per PLC program that is upward, downward, left, and right along the glass of wall. It is facing the difficulty when mounted on the glass wall this cannot be sticks on glass wall due to high weight of the pneumatic cylinders, so that use low weight of the pneumatic cylinders for better to stick on glass wall.

## REFERENCES

[1] Bsail Mathew T, Jinto Matew, Abin T issac, Delvin Dominic,Mobin P Abraham, Sachin K S"Wall painting with wall climbing robo" International Journal of Advanced Research in Electrical, Electronics and Instrumentations Engineering.

[2] Sahil Bharti, S.R.Sadhave, H.Ramkumar, S.Ishwarya Lakshmi, G.Muralidharan" Design and Development of cleaning system". International Journal of Soft Computing and Artificial Intelligence.

[3] Ing.PeterTuleja, PhD. Ing.ĽuboslavaŠidlovskáTechnical University in Kosice, Faculty of Mechanical Engineering, Department of ProductionTechnique and Robotics, Nemcovej 32, Košice," Slovakia unilateral gripping with active vacuum suction cup: calculation of gripping force and number of suction cups.

[4] Michael Jackson, Robert Parkin," A Concept Selection Method for Designing Climbing Robots, EPSRC Centre for Innovative Manufacturing in Intelligent Automation,Loughborough University, Loughborough, UK.

[5] Tudor Catalin APOSTOLESCU1, Nicolae ALEXANDRESCU2, Constantin UDREA3, Lucian BOGATU4, Georgeta IONASCU5" study on vacuum attachment cups for a robot with vertical displacement.
[6] Research on the Vacuum Attachment System of a Cleaning Robot with Vertical Displacement,Nicolae Alexandrescu1,a, Constantin Udrea1,b, Despina Duminică1,c and Tud, Department of Mechanical Engineering and Mechatronics.
[7] International Journal of Advance Engineering and Resech Development Design of vacuum operated wall climbing robot Doshi Sachindra J. Asst. Prof.,Mechanical Engineering,Government Engineering College,Bhavnagar, India.
[8] SIEMENS S7 1200 PLC catlogue, DesignTech Systems Ltd.6, Kothrud, Pune – 411 038
[9] ]* SMC Catalog – Vacuum generators ZH10DS-06-06 (EJECTOR).