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Design and Analysis of Glass Climbing and Cleaning Robot

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ABSTRACT: This paper focuses on designing a compact wall cleaning robot. Nowadays, cleaning a scrapers window by using conventional methods is implemented widely. It is either via human involvement or by a machine. There are three types of conventional methods to clean scrapers window. First method is by using workers suspended in the air. Second method is by ground cleaning. In the ground cleaning, there are several ways that can be used. It can be done by washing technique using mobile elevated working platform or using scaffold or using a ladder. The third method is by using a customized window cleaning. The disadvantages of conventional methods by human can be described in four major points. First point is manual labour. Manual labours for conventional method undeniably gamble with high risk 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. 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 weather and daylight factor. This project is hoped to overcome the limitation of conventional methods. This will lead to a better and efficient way to do the cleaning instead of risking lives of people.

KEYWORDS: Wall climbing Robot, Suction cup, Arduino, Servo Motor, Vacuum Pump, Skyscraper.

I. INTRODUCTION

There exists increasing demand for the development of various service robots to relieve human beings from hazardous work, such as cleaning glass-surface of skyscrapers and fire rescue. Climbing robots are useful devices that can be adopted in a variety of applications like maintenance, building, inspection and safety in the process and construction industries. These systems are mainly adopted in places where direct access to human operator is very expensive, because of the need for scaffolding or very dangerous, due to the presence of hostile environment. Recently, there have been many demands for automatic cleaning system on outside surface of buildings such as window glass by increasing of modern architectures.

A glass climbing robot should be light and allow a large payload, reducing excessive adhesion forces and carrying instrumentations during navigation. Most of climbing robots developed at the present can be classified into two main functions: locomotion and adhesion with an adhesive mechanism, climbing robots can attach to the wall by using suction force, magnetic force, micro spines for interlocking. The other mechanisms used are negative pressure, propellers and grasping grippers. The robots with multiple- legs kinematics are too complex due to a lot of degrees of freedom. Suction pads are widely used for industrial purposes and the most currently applicable and robust compared to other adhesive mechanisms. Suction pads have high load carrying capacity and are flexible for all operating conditions, it can operate in low surface roughness, no ferromagnetic conditions. It is more reliable than most other mechanisms used for adhesion generation.

The purpose of the present study is to develop the glass climbing robot for cleaning, Glass window such as external glass of skyscrapers. It requires the following demands to apply the window cleaning robot for the practical use: 1. Adhere or stick the robot to glass surface with the help of suction cup vacuum. 2. Clean the glass surface of window with help of brush attached to the robot. 3. After cleaning off wiper & then climb (walk) the robot as per instruction to controller. The size of robot system will be design in such a way to allow the access on entirely cleaning surface of building's window; the robot is easy to handle by using automatic chips & programming. The robot is equipped with Bluetooth Arduino controlling chip. The robot is equipped with suction pads, vacuum pump, servomotors, brushes,

batteries, USB servo controller, Arduino Uno, jumping wires, connecting pipes, plastic chassis. This all will complete the whole assembly of our robot.

II. PROBLEM STATEMENT

The main problems encountered in the conventional external glass cleaning process are improper cleaning by conventional method. Cleaning is done by workers hanging on a platform rope, manual error may happen during cleaning. Difficult to clean complex areas where human is not feasible. Problem may also occur due to improper structure of the building. Cleaning manually is dangerous due to uneven natural conditions like wind. Cleaning at high height is difficult and risky. Therefore, the goal is to investigate selected materials, optimize mechanical design, and develop a device like robot which can be easily operated from any position, simplify the cleaning method and to reduce the human efforts by reducing the risk for doing the cleaning operation, reduce total cost of cleaning exterior glass surface by making it more efficient and user friendly.

III. METHODOLOGY

First of all, an acrylic board is pocketed and drilled according to assembly design. servo motors are mounted on four pockets with shaft vertically upward. A large U beam aluminium servo bracket is linked with metal horn for servo 25T by using four 3mm diameter stainless steel nut and bolt system, similarly 3 sets are prepared for other three arms. The U beam and metal horn assembly is mounted directly over the servo motor shaft by using a center screw, the same assembly is pivoted over the upper plate. The large U beam aluminium servo bracket with metal horn is linked with L shaped interconnected servo bracket by using four 3mm stainless steel nut and bolt system, similar more 3 sets are made. The L shaped bracket with large U beam bracket is linked with a short U shape aluminium servo bracket which is further linked with another short U shape aluminium servo bracket by four 3mm ss nut and bolt system, similar more 3 sets are made. The whole arm assembly is attached with another metal horn for servo 25T which is mounted on servo motor by using centre screw; the shaft position is perpendicular to first servo motor shaft which is linked with large U beam bracket. The servo is attached to suction cup by using long L shape bracket, the suction cup is attached with connectors of 8mm pipes. All the 8 servo motors are attached to 16 USB servo controller which is series with Arduino Uno, a battery supply is given to the respected controller. The suction cups are connected to a distributor which is attached to a 10mm pipe, the pipe is attached to a AC vacuum pump. A vacuum pressure gauge and control and regulating valve are attached between the cups and vacuum pump.

Following are the details of the parts –

Suction Cups- Selection of suction cup is based on number of suction cups and diameter of suction cups which are used to lift the object, our suction cups have function to just stick on the glass and give rigidity to body of robot. We have selected lifting suction cups of 50mm diameter that are used to lift glass for handling purpose & cutting purpose in glass industry.

Vacuum Pump- Vacuum pumps are equipment's used to generate vacuum, is similar to air compressors. It's even possible to generate compressed air or vacuum with the same machine, depending on how it is installed. Vacuum pumps generally can be considered as compressors in which the discharge, rather than the intake, is at atmospheric pressure. We have selected ¼ HP 1275 RPM 50 HZ AC motor. It operates on 230 V supply and has a rated power of 180 watts.

Servo Motor- This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package. The MG996R is essentially an upgraded version of the famous MG995 servo, and features upgraded shock-proofing and a redesigned PCB and IC control system that make it much more accurate than its predecessor. The gearing and motor have also been upgraded to improve dead bandwidth and centring.

Bluetooth + USB 16 Servo Controller- used to control up to 16 Hobby Servo motors or any other devices running on PPM signals from PC or any other device which have either serial or Bluetooth connectivity. This hardware is backed up by PC software which controls all servos and helps generating motion sequences. Once these sequences are generated one can control the motors with serial commands. Not only this but when you complete programming the

sequence and testing it, we can generate code for our Rhino Robot Control Board or any Arduino Board so that we can control all servos without PC and add sensors and controls.

Aluminium Brackets - This large 'U' shaped brackets is designed to fit most standard sized servos. This bracket is both lightweight and strong. Various holes are located on the bracket that fit most servo horns. Short U shape aluminium servo brackets are light in weight and strong. The bracket is made to support most of the servos. This bracket is used to make arms of various robots like pick and place robot etc. the bracket can be linked together using either 8mm nut and bolt system or four 3mm nut and bolt system. Metal horns are used to drive arm motor shaft is directly connected to horn which has internal gears and the horn has a central 3mm hole to mount motor and horn.

IV. ANALYTICAL RESULTS

Fig 1 shows the CAD Model; Fig. 2,4,6,8 shows Von misses stresses on various parts; Fig. 3,5,7,9 shows Displacement Analysis on various parts.

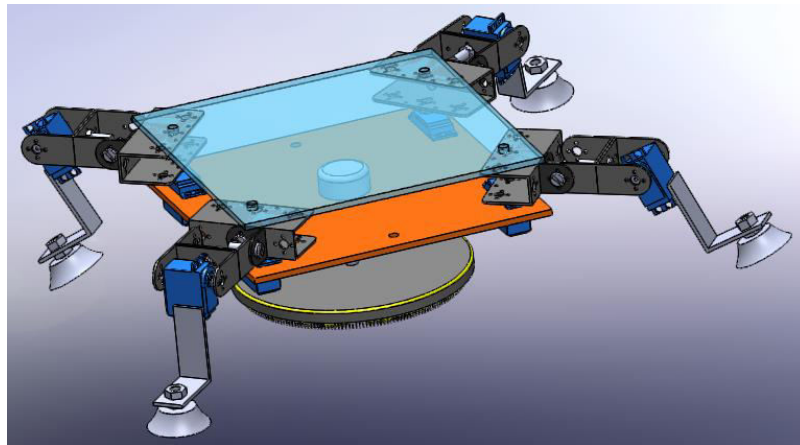


Fig. 1

Analysis of Various Parts –
Suction Cup –

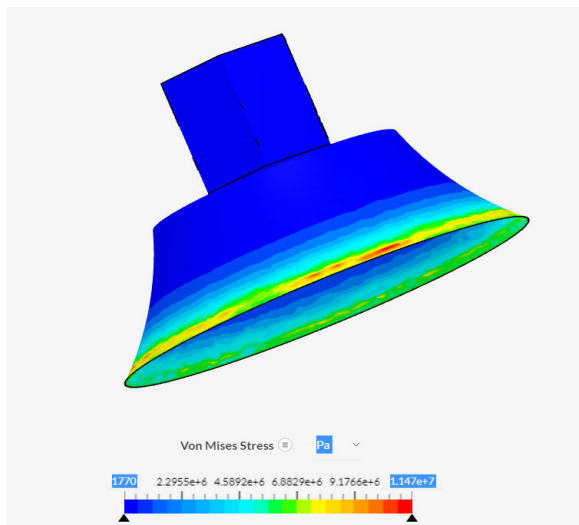


Fig. 2

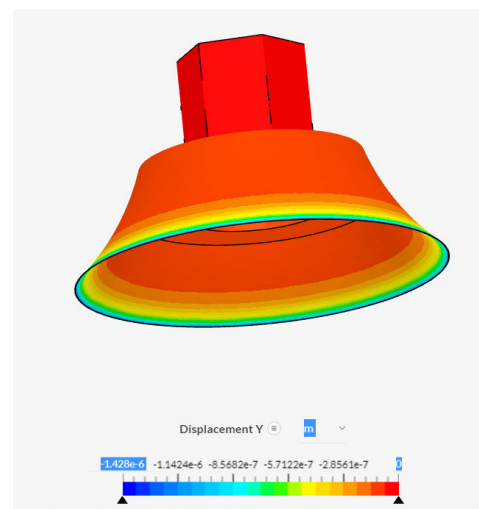


Fig. 3

U- Shaped Bracket –

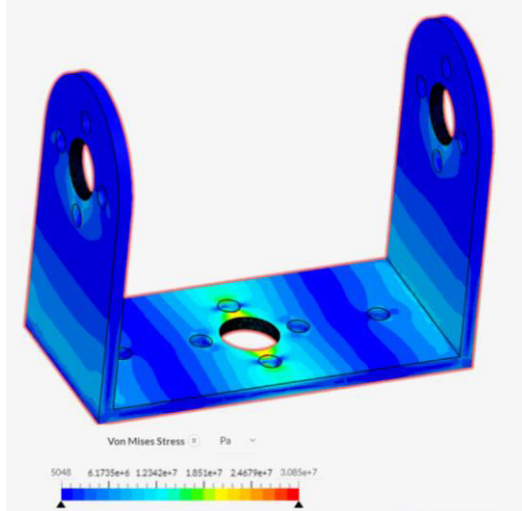


Fig. 4

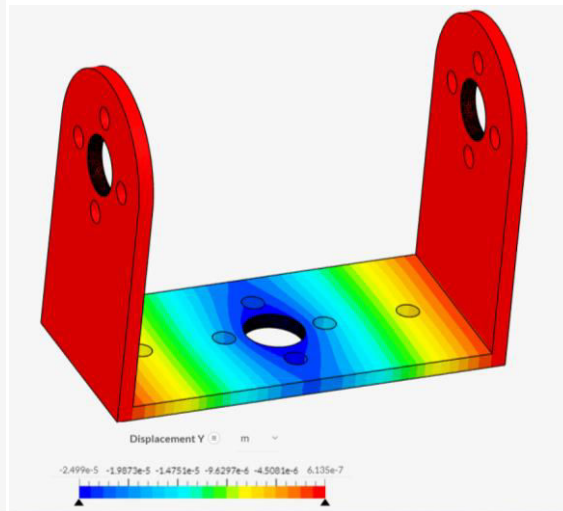


Fig. 5

L- Shaped Bracket –

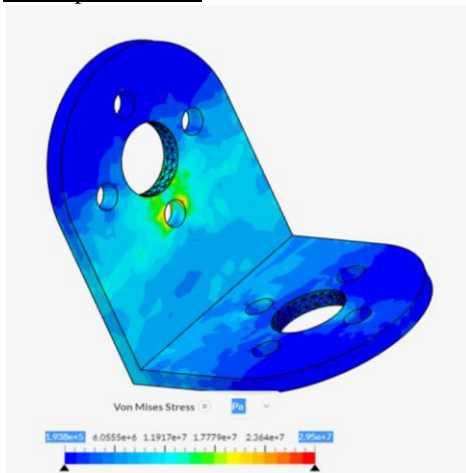


Fig. 6

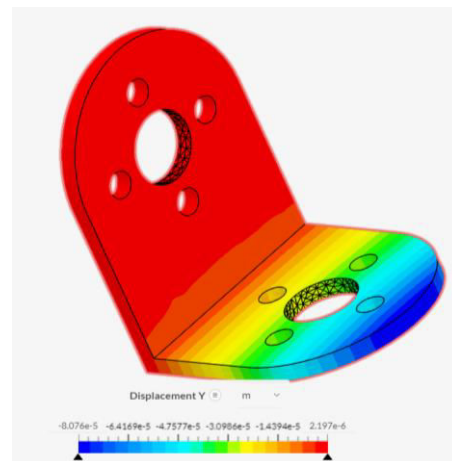


Fig. 7

Acrylic Board –

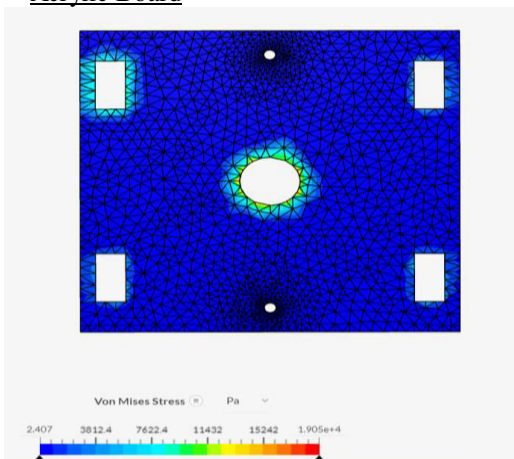


Fig. 8

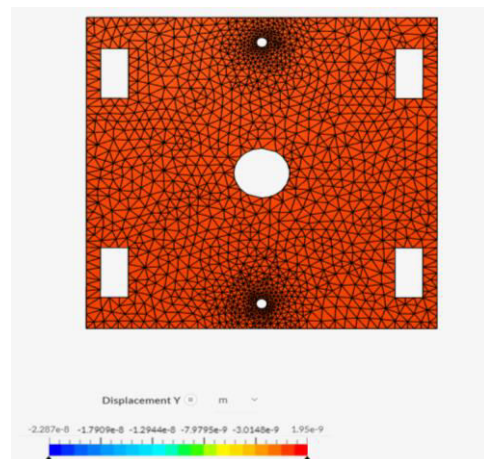


Fig. 9

V. CONCLUSION

From implemented analysis we can conclude that the robot will not break under designed load condition. This smaller and light weight mechanical device gives a protected and viable intends to manage unsafe obligation operations. Inside the mechanical zone our vigorous stage measuring more or less 3-5 Kg is created to get on generally smooth surfaces. The productive variation of climbing vacuum robot from administration field as cleaning mechanical operations of frontages of outer glass dividers, displayed in this paper, has the mean to substitute the human administrator from hard, threat and hazard's working. This vacuum robot introduced makes conceivable the robotized operations of washing.

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- [10] "Cleaning of Skyscrapers with help of Remote Controlled Electro-Pneumatical Climbing". By Mücahid Candan, in this work an electro-pneumatic robot considered for cleaning vertical surfaces like glass, chipboard or transparent plastic components is designed, controlled and implemented.



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