VACUUM ASSISTED WALL CLIMBER

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ABSTRACT: In this paper we have discussed and covered all the points that are required and essential for the manufacturing of vacuum assisted wall climber. We have also discussed various applications in which these vacuum assisted wall climber can be useful for human beings such as to perform the maintenance activities of high-rise building, fire rescue operation and for various evaluation and diagnostics applications etc. with the help of vacuum suction force. And we have also discussed various improvements which are applicable to make this system more reliable and comfortable.

***Keywords*: high-rise building, vacuum suction force**

1. INTRODUCTION

It has always been a dream of man to possess the power to walk up on vertical surfaces. Now vacuum assist wall climber will fulfill this dream to climb over a vertical surface against the gravity which may provide some super human abilities to normal human. This is a wall climbing machine which uses its vacuum pumps to produce a grip against the wall surfaces. It is worn like a backpack, on the back of human body to climb up on any surfaces- including glass, brick or plain surface without a rope. So we developed the vacuum wall climber, which is made from two suction pads and household vacuum pump. To have an air tight seal we used rubber material so that lip of the suction pad creates a friction against the wall surfaces. Larger the suction pads more weight it can hold or carry. These could also be used to carry the heavy loads with ease. But the object which we are lifting needs to have flat surface and it should be within the suction limit. If the air inside the cup is removed thus creating a perfect vacuum seal inside the cup whose pressure is very much lesser than atmospheric pressure. The method of using concept of vacuum to climb the walls is technique that has been developed in recent years.

2. MAIN COMPONENTS OF THE VACUUM ASSIST WALL CLIMBER

2.1 Vacuum Pump

2.2 Electric Source

2.3 Hoses

2.4 Suction Pads

3. CONSTRUCTION

3.1 Suction pad

The plywood of 20mm thick was selected due to its light weight and machinability. To create the suction pad, the plywood was cut to the required dimension of 400×300mm. The position of the holes for the handles, suction pipe, and valve release mechanism are marked and using a circular drill, the holes of the required dimensions are cut. The handles are attached to the plywood base using bolts. On the opposite side, the space required for the foam seal is marked and the surface is scored for better adhesive grip. Using rubber adhesive glue, the foam rubber is pasted on the scored surface. On top of the foam rubber, using rubber adhesive glue, high density polypropylene is pasted. The process is repeated to obtain alternate layers of foam and high density rubber. The connector hose is connected to the suction pad using epoxy and left to cure for a day, in order to make it an air tight seal. Finally, the suction pads are painted in metallic silver color using acrylic epoxy spray paint for better aesthetic look.

3.2 Pressure release mechanism

The pressure release mechanism enables the climber to remove the suction pads with ease. For comfortable pressure release mechanism we have used the switch button which is connected to the vacuum motor, through which we can comfortably release the pressure from one suction pad and adhere to a greater height. Due to such a type of mechanism it makes it more portable for the climber.

3.3 Backpack system

The plywood is cut to required dimensions and the edges are chamfered for better handling and aesthetic purpose. Then for better handling or carrying purpose, we used the bag according to the size of the plywood. And place the plywood inside the bag.

3.4 Foot support system

For stable and faster climbs, the foot support system was the optimal choice. Since it is exhausting to utilize only the upper body strength for climbing, a foot support system is provided so that the climber experiences less fatigue and better balance. The harness was more flexible, which allowed for easier and faster lateral movement. It should be light weight, and should posses moderate tensile strength. Interwoven polyester fabric is used to prepare the foot supporting harness. The polyester fabric is repeatedly woven to increase the thickness of the band and one end is attached to the suction pad handles.

3. WORKING

The working of the vacuum assisted wall climber simple. The climber who is going to carry out the climbing operation wears the backpack on his back , consisting of the two vacuum motor inside the backpack and these vacuum motors are been connected through the hoses to the suction pads. These suction pads are held on each hand and these vacuum motors are then turned ON. The climber uses the release mechanism to lock both the suction pads. After that the suction pad is placed over the plain surface or over any wall. And due to negative pressure created inside the vacuum pads these pads gets attach to the wall firmly. And after that the next vacuum pad is placed at some higher distance and similarly due to the negative pressure created inside the vacuum pads it gets attached to the wall firmly. For taking the next higher step the pressure release mechanism is been used, which allows the atmospheric air to enter into it. Due to which the climber is able to release the suction pad away from the wall. The climber then places the suction pad on the next higher step, by balancing his weight on the foot harness and handle. The climber releases the valve mechanism on the second suction pad, enabling him to lift the suction pad and place it over the next higher step. Theoretically, the climber can climb the vertical wall over the infinite distance. But for safety purpose, we have conducted the experiment to the limited height only.

4. DESIGN PARAMETER

In order to find the maximum normal load acting on the equipment, the vacuum pressure generated by the motor is measured. A vacuum gauge is used for finding the pressure at the suction end.

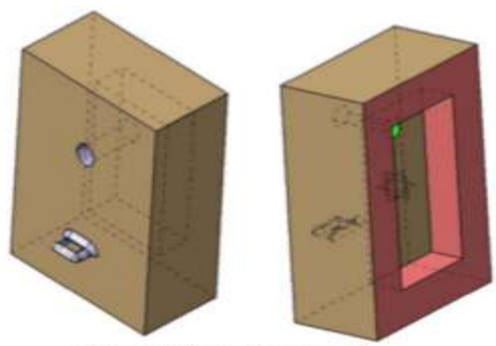

Figure 3D Design of suction pad

Vacuum pressure at the end of the suction line = 200 mm Hg (mm of mercury)

= 200 mm Hg

= 0.26675 bar

Standard atmospheric pressure (P.atm) = 1.013 bar

Absolute pressure at the end of suction line (Pab)

= (Standard atmospheric pressure) – (vacuum pressure at the end of suction line)

= (1.013 – 0.2667)

= 0.7462 bar.

Area of suction pad

Inside area = 0.3 x 0.25 m^2 = 0.075 m^2
Outside area = 0.4 x 0.3 m^2 = 0.120 m^2

Pressure Force

Pressure Force = Pout x Aout – Pin x Ain

= (1.013 x 0.12) – (0.7462 x 0.075)

= 0.12156 – 0.055965

= 0.065595 x 10^5

= 6559.5 N

Maximum normal load

Maximum normal load (in kg) = 6559.5/9.8

= 669.3

~670 kg

There is a safe altitude up to which the equipment can safely operate. Also it depends upon the load acting on equipment. Since the machine has an ultimate

5. APPLICATIONS

5.1 Military Applications

Military applications could include fighting environments where climbing over large obstructions was necessary. Stealthy operations might also be used for covert operations.

5.2 Recreational use

For recreational use, the obvious use would be at a local rock climbing facility or a carnival. The VWC could be sold to the public if proper standardized ASTM or OSHA tests were passed. Small-scale VWC systems could also be built for the young children or teenagers.

5.3 Rescue Operations

Rescue tasks could include firefighting situations where accessing the interior of a building is not viable option or could be life threatening to the fire fighter. Roofing operations could also use the VWC for a temporary anchor point if the surface cannot be fastened to. The window washing industry might even be able to use the VWC if it seemed feasible.

5.4 Household Use

The window washing industry might even be able to use the VAC if it seemed feasible. It can also be used for painting purpose, cleaning purpose.

6. FUTURE SCOPE

Since we live in an age where technology is constantly changing and improving, design modification could be made to greatly enhance the VAC system. Areas to consider for further improvements are:

- Rechargeable System
- Noise Reduction
- Weight Minimization
- Vacuum Motor Selection
- Conformable Pads

6.1 Rechargeable System

The use of batteries in the backpack system makes the VAC to scale any walls to the required height. LiPo batteries may be used, while considering its high energy density. For future systems, it would be nice to develop a VAC where the external power source charges the battery onboard. This would be useful in charging the batteries and would be convenient to climb up the wall part way with the power cords, then unplug and climb with batteries. The rechargeable system makes the VAC more compact.

6.2 Noise Reduction

Active noise reduction or passive noise reduction methods can be implemented. The active noise reduction method uses an electronic device to produce an anti-noise that is 180◦ out of phase with the original signal. Passive noise reduction involves providing a damping shell outside the vacuum motor, containing egg crate foam, to absorb the sound produced during operation.

6.3 Weight Minimization

In order to make climbing time more sustainable, a lighter weight VAC system was required. Several geometric modifications may improve ergonomics and ease of manufacturing. Next, materials were reanalyzed to see if better choices (lighter, less expensive) could replace the plywood material.

6.4 Vacuum Motor Selection

As manufacturing techniques continuously improve, new motors that are more lightweight, efficient and acoustically quieter will become available. This would greatly enhance the VAC performance, as the motors are a big contributor to weight and noise. Also, if the motor can work under varying speeds then VAC can be used to climb various types of walls.

7. CONCLUSION

From our work, we can conclude that vacuum assist wall climber is not only efficient but best option for the wall climbing. This assist wall climber gives chance to carry heavy work to the climb. We make the entire system with less weight and aesthetics and ergonomic consideration this assist wall climber reduce human efforts. This project is cheaper and its production cost will reduce more if it is produced in large scale.

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