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This device works on the vacuum to climb the vertical surfaces as its name indicate and this vacuum is utilized by two suction pads which are available in the hands of the climber and the suction pads are connected with the suction motor (vacuum pump) with the hoses.

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VACUUMASSISTEDCLIMBINGDEVICE

*Strictly as per the compliance and regulations of:*

# Vacuum Assisted Climbing Device

Shyam Lal Sharma [α] & Shahzad Ali [σ]

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This device works on the vacuum to climb the vertical surfaces as its name indicate and this vacuum is utilized by two suction pads which are available in the hands of the climber and the suction pads are connected with the suction motor (vacuum pump) with the hoses.

With the help of vacuum suction pad we can climb vertical surfaces like wall easily and without causing damage to the contact surface, their suction force should be designed by considering both external condition and the loads of working equipment.

In this project we performed a basic experiment on the vacuum suction force of suction pads attached to a vertical wall under various load condition.

This mechanism enables a person to climb up wall and remain suspended with no handholds.

*Keywords: suction pads, vacuum pressure (suction force), suction motor (vacuum motor).*

## I. Introduction

Vacuum Assisted Climbing Device is a wall climbing machine which uses vacuum as a source to climb the vertical surface through the suction which utilizes the vacuum, created by the vacuum pump (suction motor).

This is a wall climbing machine which uses its vacuum pumps (suction motor) to produce a grip against the wall surfaces. It can climb up to any height on any surface including glass, brick or without a rope. But the most important element was to come up with technology that can grip to any vertical surface.

So we developed this machine which is made from two pads and suction motor which are connected to each other with the hoses for air suction and wire for the electrical supply. The pads are made up of MDF (medium density fiber) board and the latex rubber.

The suction pads are designed after the pressure and force calculation which is done by using the pressure at the end of the suction line and the area of the suction pad (inner and outer area of the pads have to be measured) .

As we know in the many industries suction pads are used for material handling even in robotics the suction cups are used to hold the object and provide a complete grip to the user.

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Thus we design the suction pad which are connected to the suction motor which sucks the air from the pad's inner area and create the vacuum which enable the pad to stick on the wall without damaging it and provide a proper grip to the user.

The effectiveness of the pads are totally depend on the vacuum pump and the area of the pad and the material of the rubber which works as blocking agent or make the pad leakage free.

The rubber which we use to make the pad is latex rubber which has good water and temperature resistant property and is stronger than the natural rubber which also increases the life and the efficiency of the pad.

We have tried to make the complete device as light as it possible which allow the user to make irritation less effort to climb the vertical surfaces, and we use the synthetic plastic strips to make the leg linkage which is used to tow the heavy loads like vehicle and heavy containers as we need to carry all the load on a single pad with this linkage on hold position or while stepping upward.

We can climb the wall by using the ON/OFF switch which is provided near to the handle of the pad by active and inactive the pad with this switch along with the movement of the corresponding leg linkage.

## II. Methodology

After some research, a human climbing mechanism known as PVAC (Personnel Vacuum Assisted Climber) engineered by Utah University UG students was found. As papers about their work were not available, a from-the-scratch approach was adopted for designing.

To check the feasibility of the we perform an experiment with the suction pad which was made up of plywood and the home vacuum cleaner pump, which was enable to stick on the wall. The initial prototype system could bear a load of up to a 100kg, which was encouraging.

The dimension of the suction pads were obtained from design analysis and for this reverse engineering approach was adopted in designing the equipment.


*Fig. 2.1:* Front view of suction pad while looking from face and the rubber used in the suction pad.


*Fig. 2.2:* Picture of a suction pad while testing

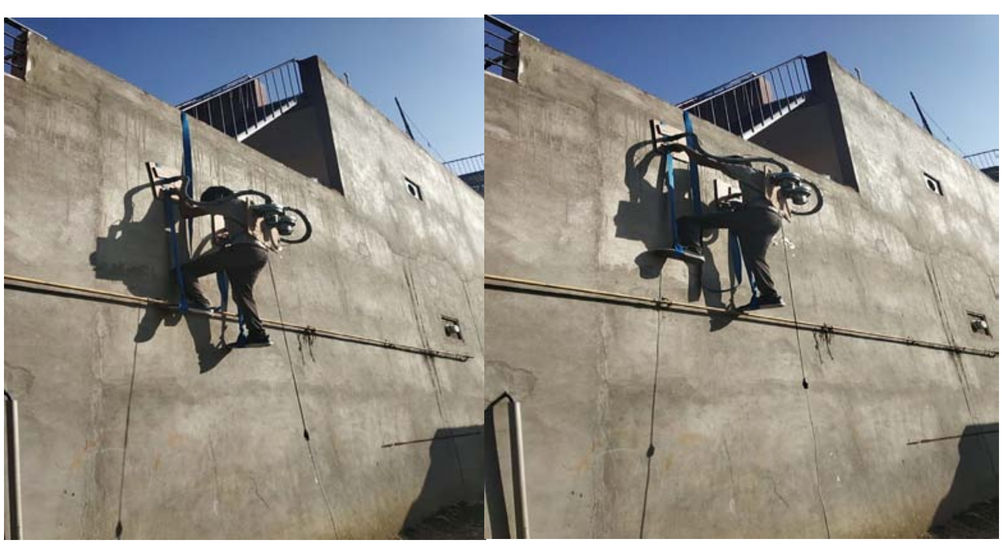

*Fig. 2.3:* Climbing with the help of VACD

## III. Components of Vacuum Pssisted Climbing Device

*a) Vacuum pump (Suction motor)*

It is the heart of the system which runs the complete system by creating the vacuum in the suction pad cavity, which allows the pads to stick on the surface of the wall with the help rubber.

*b) Electric source and wires*

An A.C power supply has to provide the system so that vacuum pump (suction motor) can run and whole system can start their function.

3. Hose pipelines

It creates the connection between vacuum pump and the suction pad which help and provide a path to the vacuum pump to suck the air from the pad cavity.

*c) Suction pads*

Suction pads are the second most important part of the system by which a climber can climb the wall and whole weight would be bear by the suction pad at halt position, thus it must be strong enough to bear a sustainable load of the climber and some objects that would be carried by the climber.

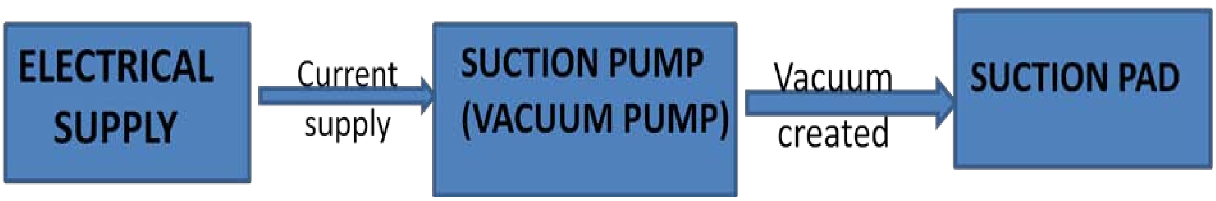


*Fig. 3.1:* Block diagram of a vacuum assisted climbing device working component

## IV. Designing Parameters

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.

Vacuum pressure at the end of the suction line

= 200mmHg (mm of mercury) (note 1mmHg= 0.00133bar)
= 200mmHg = 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).

$$=(1.013 - 0.2667)$$

$$= 0.7462 \text{ bar.}$$

*Area of suction pad*

Inside area = $0.2794 \times 0.2286$ m2 = 0.0638m2
Outside area = $0.3556 \times 0.3048$ m2 = 0.108 m2

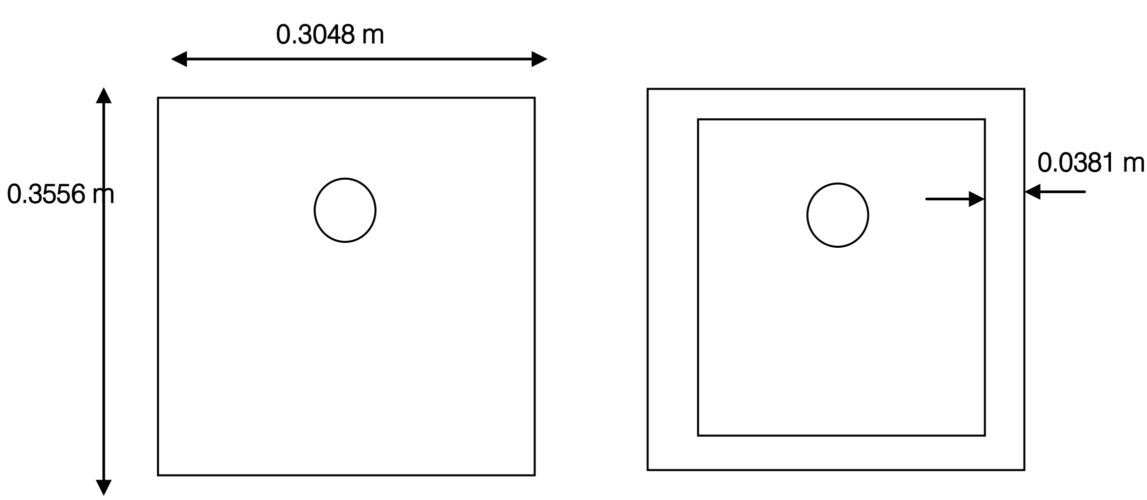


*Fig. 4.1:* Pads Dimensions Pressure Force

*Pressure Force*

Pressure Force = Pout × A out – Pin × A in

= (1.013 × 0.108 - 0.7462 × 0.0638)

= (10940.4-4760.76) N

= 6179.64 N~6000 N

*Maximum normal load*

Maximum normal load (in kg) = 6000/ 9.8

= 612.24 ~600 kg.

There is a safe altitude up to which the equipment can safely operate. Also it depends upon the load acting on equipment. Since he machine has an ultimate normal load capacity of 600 kg, margin of 200 kg is given. SO the ultimate is 400 kg.

*Safe load*

Assuming factor of safety= 3

Note:-As per standardization we need to take higher value of the fos for lifting device thus we take it 3.

Safe load = 400/3

=133.33~120 kg

= 120 Kg

## V. Fabrication

*a) The properties of the rubber used for pads*

1. Latex rubber is generally made up of around (55 to 65)% water and (30 to 40)% of rubber material.
2. It also contain sugar, resin, protein and ash, it undergoes exposure to sulfur, carbon black and oil which make the latex stronger.
3. The most ideal working temperature range is between -55 degrees Celsius and 82 degree Celsius.
4. It is water resistant and stronger than natural rubber.

*b) Procedure to make pads and the complete device*

- Firstly cut the MDF (Mean Density Fiber) board in the desired dimensions.
- Then cut the latex rubber in the desired dimensions.
- Then drilled a hole of 0.0508m in the board to fix the hoses.
- Then remove some material from the MDF board where the rubber needs to be fixed, with the help of emery paper.
- Then paste the latex rubber with the help of araldite and clamp them for overnight and let it dry.
- Once the rubber is pasted on the board then make the wire and hose connection with the vacuum motor (suction motor).
- Add an ON/OFF switch on the each pad.
- In this device two vacuum pump and two pads are used.

## VI. Conclusion

Firstly we have tested the pad with suction motor having the capacity of 600W but there was some leakage in the pad thus test was failed then we had glued the rubber on the plywood pad again to remove the leakage.

Second time we used the suction motor having capacity of 1500W and we used MDF (Medium Density Fiber) board which is light in weight and has good strength to carry load and design the pads as per the calculation after the final test we conclude this vacuum assisted climber is the best option for the wall climbing. This vacuum assist wall climber gives chance to carry heavy work to the climb and its bonding would withstand 100kg load.

We make the entire system with less weighted and aesthetics and ergonomic consideration this assist wall climber reduce the human efforts. The equipment provides high load carrying capacity. The designing and testing stages were successful and performance of the equipment was found excellent.

The future scope of the equipment includes addition of the individual sensors in each suction pad and addition of the compact batteries.

Each time suction pad and adhere to surface, the pressure inside the suction pad varies. It is necessary to ensure that the suction created is sufficient for holding the weight.

Another scope is addition of compact high power batteries. This will increase the flexibility of the operation. Also addition of battery level sensor is a need to indicate battery level.

In the future the mechanism can be automated with the help of sensors and the artificial intelligence which may increase its durability and the life of the machine.

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