Study on the wall climbing robot driven by the caterpillar tracks

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Abstract: With the development of economy and various techniques, the development of the wall climbing robot is getting more and more attention. This is because various jobs are not appropriate for human beings, such as some tasks in some special or dangerous environments, wall cleaning of high building, etc. In view of such problems, it is necessary to develop a wall climbing robot moving in various working conditions. In this paper, we developed a wall climbing robot driven by the caterpillar tracks. It can pass some simple obstacles. At the same time it can capture the environment pictures with a CCD camera and send the image data directly to the server. Moreover, we analysis its structures and some functions.

Keywords: Wall climbing robot, caterpillar track**.**

I. INTRODUCTION

Climbing robots can attach to the wall and move with carrying capacity of the working tool. And work in some special or dangerous circumstances to substitute humans to complete the relevant tasks. Xiaodong Chen et al [1]. shows that they are used primarily for wall cleaning, maintenance of nuclear power stations, hull painting, sand blasting, anti-terrorism and testing of petrochemical oil tank. In recent years, with the developing of the railway, bridge inspection becomes a new direction of climbing robots.

They can be classified by the type of moving. There are wheel-type, crawler-type and sucker-type.

Robots with sucker-type can go across small obstacles, but slowly. And they have lest two suckers and legs for movement. Then not only the weight will increase by setting more legs and suckers, but the system of control maybe more complex. It is bad for stability.

Wheel-type provides a faster, flexibility-control means. But it is difficult to holding a continued adsorptive power. And robots need a big sucker to provide absorptive power. When robots are working on some bumpy plane, it is a little trouble of control. We can't ensure the wheels have rolled the same distant. If we add some system to correct routes, the energy consumption will be raised.

Caterpillar haves strong adaptability to wall and its landing area is large, but not easily turn. To work on the wall or under bridges, sucker devices are necessary. The caterpillar is heavier than wheel-type structure. It is mean that caterpillar expends more energy. But it can work on different planes.

Compared with these three types, we find they use the same way to against the gravity—some mechanical devices. Consequently, a big part of energy was used by these devices.

Because of the technology development, people have higher requirements of climbing robots. Small size, mobility, environmental adaptability, low noise, low energy consumption and long cruising time become the further goals.

Because of the traditional climbing robot has many shortcomings, therefore the future climbing robot structure should towards practical direction.

Xuming Cui, Yingfei Sun, Fujun He [2]. shows that in this few years, scientists discovered the secret of how does gecko walk on the wall. The secret is the Van der Waals force. It is weak electromagnetic attraction produced by neutral molecules, when they are extremely close. This means can be used into developing a new kind of adsorption device. And the energy problem has been considered. We need a battery with high-capacity and light, or by remote control approach for robots to provide energy and signal control.

To solve the problems above, we discovered a easy means of using helium balloon. We can use the buoyancy of the helium balloon to against the gravity. Then we can save a lot of energy to lengthen the robots working time. And it is safe for robot, because we don't need worry about it drop from the wall or the bottom of bridges when it power off suddenly.

Helium is one of the six inert gasses. When some helium leak from balloon and mixed with air, it results in blast or fire. So helium is very safe for practical using.

II. ELEMENTS AND FUNCTIONS

Most of climbing robots must be working with some mechanical parts to provide the power to against the gravity. But when we are designing a climbing robot, decreasing the weight is an important qualification. As we know that more weight consumes more energy. So we have to balance the two aspects----using more mechanical parts to provide more power and diminishing more structure to lengthen the working time.

Now we present a new means to against the gravity. It is the helium.

Helium is a very light colorless gas that is one of the six inert gasses; the most difficult gas to liquefy; occurs in economically extractable amounts in certain natural gases. And the helium balloon was used for aviation in the primary period. Now it can play the same role in climbing robot field to provide buoyancy.

We use the buoyancy in two ways, some part of buoyancy to counteract the weight of the robot. And the other part is used to create enough pressure for friction. Then the friction can transform into the impetus of plane motion under the bridge.

Here are some basic equations.

$$F_b = M \times g + F_p \quad (1)$$

F_b ——the buoyancy;
M ——the weight of whole robot;
F_p ——the pressure;
g —— the gravity acceleration;

$$F_m = F_f = \mu \times F_p \quad (2)$$

F_m —— the impetus of plane motion;
μ —— the coefficient of friction;
F_f —— the friction between the travelling mechanism and the bottom of bridge;

Here are some figures to show the structure.

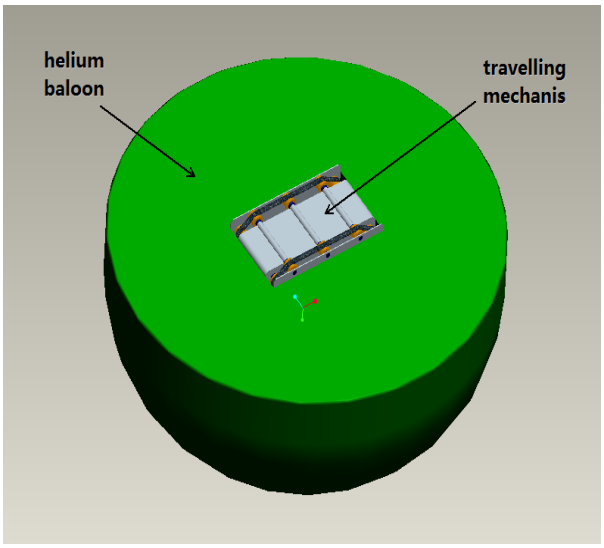

Fig.1.The illustration of the structure

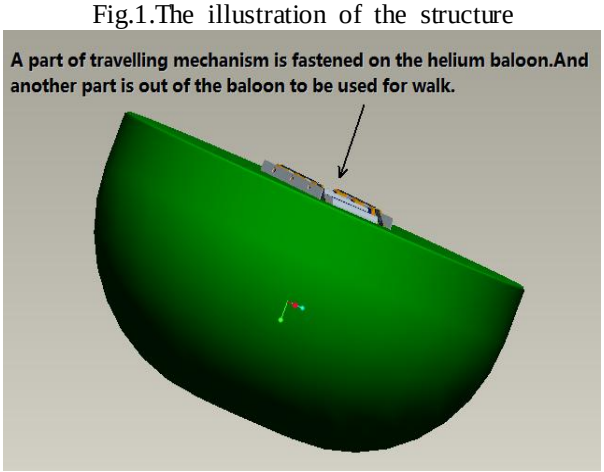

Fig.2.The detail of the structure

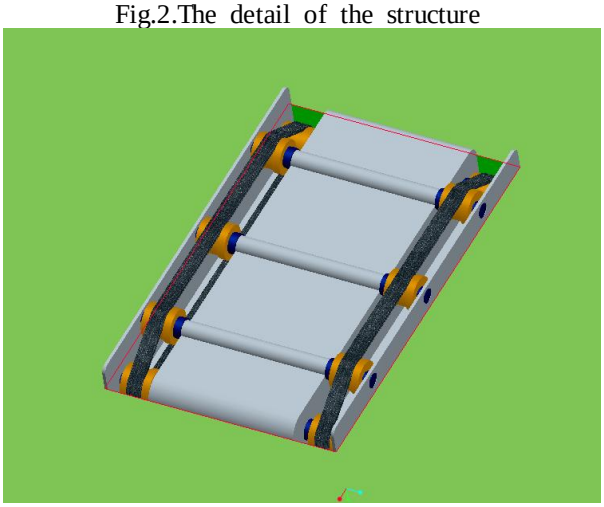

Fig.3.The walking structure

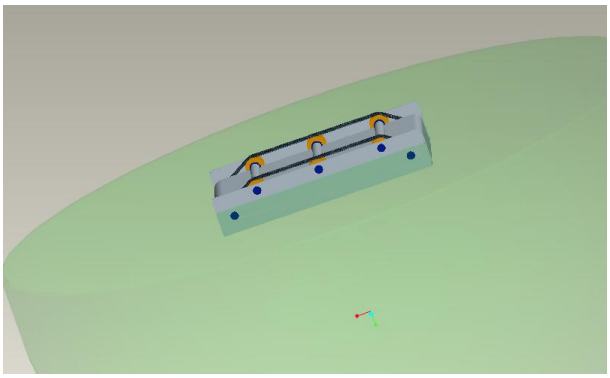

Fig.4.Inset a part of walk structure in balloon

III. ANALYSIS AND EXPERIENCES

For proving the means can be used into reality, we made some analysis about it.

According to the equations below, we drew the curves to describe the relation between volume of helium and buoyancy.

The density of helium is 0.1786g/L (0℃, 1atm).

1. Equations

We assumed the shape of balloon is cube. Then we set three thickness of balloon. They were 0.0005m, 0.0007m and 0.001m.

$$F_{\mathrm{b}} = \left(\rho_a \times V_a - \rho_h \times V_{\mathrm{h}} - \rho_{\mathrm{b}} \times \left(V_a - V_{\mathrm{h}}\right)\right) \quad (3)$$

F_{b} ——the buoyancy (kg);

ρ_{a} —— the density of air (kg/m^3);

ρ_{h} —— the density of helium (kg/m^3);

V_a —— the volume of helium (m^3);

ρ_{b} —— the density of balloon (kg/m^3);

V_{b} —— the volume of balloon (m^3);

$$V_{\mathrm{a}} - V_h = \left(r_a{}^3 - r_{\mathrm{h}}{}^3\right) \quad (4)$$

r_{a} —— the radius of the volume of balloon replaced air (m);

r_{h} —— the radius of the volume of helium (m);

$$r_a - r_h = h_b \quad (5)$$

h_b —— the thickness of balloon (m);

2. Figures

After we did some calculation, we draw the curves between volume and the buoyancy.

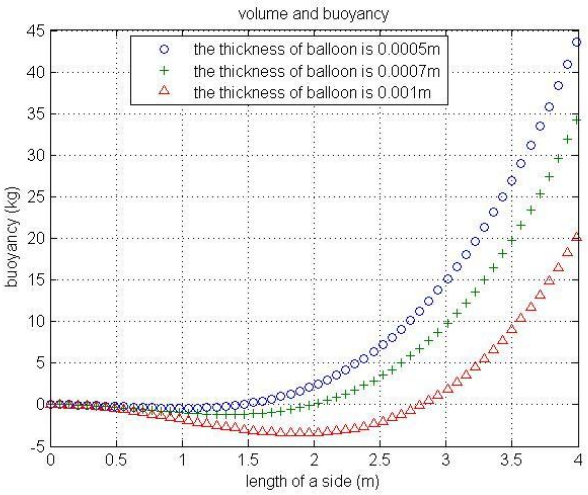

Fig.3.The relation between volume and buoyancy

IV. CONCLUSION

After analysis, we can see that this means can be used in some robots which have a big body type. And when the length of a side is above 3m, the helium balloon can provide appreciable buoyancy. And the power is clear, without any energy consumption. What's more, this means can avoid some accident. Such as, when the robot shut down suddenly or power off in working time, the helium balloon can protect the robot from crashed. Consequently, this means is safety and energy-saving. But we find that wind bring a bad effect on the big balloon. Now we are working on finding a way to decrease the bad effect.

REFERENCES

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