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Design and Fabrication of Staircase Climbing Robot

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Abstract – *Staircase climbing robot are important for conducting scientific analysis of objectives. Current mobility designs are complex, using many wheels or legs. An eight wheeled rover capable of traversing rough terrain using an efficient high degree of mobility suspension system. The primary mechanical feature of the stair case climbing mechanism design is its simplicity. Which is accomplish by using only two motors for mobility. Both motors are located inside the body where thermal variations and disturbance is kept to minimum, increasing the reliability and efficiency. Eight wheels' stair case climbing design robot is used because stability purpose.*

Key Words: Stair case climbing robot, suspension system, mobility, climbing.

1. INTRODUCTION

Robotics is the area of automation which integrates the technology in various field like mechanism, sensors and electronics control system, artificial intelligence and embedded system. The synthesis of mechanism is the very first step in any robot design depending upon its application. According to a locomotive mechanism to achieve the desired mobility, mobile robots may be split into following categories: leg-type, track-type and wheel-type mobile robot consumption is also the important matter of developing. Stair climbing robot is one of the attractive performance of robot in legged and wheeled. Developments have been made in various kind of stair climbers, considering how to make it climbing ability higher and its mechanical complexity reasonable and practical. We introduce some solutions to realize stair climbing machines that we developed. Each of them has good performance as in a category of their kind, e.g. various numbers of wheeled shapes. Then, we discuss a development of adjustable high grip mover, which we think one of the best solutions as the stair climber.

1.1 Problem Statement

To make staircase climbing robot which can climb the step of given height without interrupted in step with maximum stability. The main objective of project is making of staircase climbing robot which climb step while do not get trap between step, another is stability of robot during climbing. The chassis plays important role to maintain the average pitch angle of both rockers by allowing both rockers to move as per the situation. As per the acute design, one end is fitted with a drive wheel and the other end is pivoted to a links which provides required motion and degree of freedom.

2. WORKING PRINCIPLE

2.1 Locomotion

Locomotion is a process, which moves a rigid body. There is a mobile robot's most important part is its locomotion system which determines the stability. The difference of robotic locomotion is distinct from traditional types in that it has to be more reliable without human interaction. While constructing a robot, designer must have decided on the terrain requirements like stability criteria, obstacle height, and surface friction. There is no only one exact solution while comparing the mobility systems.

2.2 Wheel Motion

While driving on a flat surface, if there is no slipping, wheel center will move on a line parallel to the surface with constant velocity. Although, obstacle geometries can be different, most difficult geometry which be can climbed by wheel is stair type rectangular obstacle. In figure, height of the obstacle is same or less than the half diameter of the wheel. For this condition, the wheel's instant center of rotation (IC1) is located at the contact point of the obstacle and wheel Trajectory of the wheel centers' during motion generates a soft curve, thus, horizontal motion of the wheel center does not break. Since in figure height of the obstacle is more than the half diameter of wheel, this condition can be classified as *climbing*. Climbing motion consist of two sub

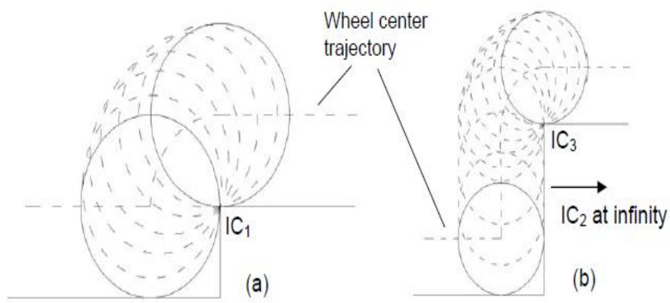

Figure -1 Wheel Motion

motions. First one is a vertical motion, which causes a horizontal reaction force on wheel center . This vertical motion's instant center (IC2) is at infinity. Second one is a soft rotation similar to figure with instant center of rotation (IC3) at the corner.

3. WORKING OF ROBOT

3.1 Initial position of robot

Consider initially the robot is at rest condition. When it start moving the first wheel starts climbing on the stairs for that it get required power from the other three wheels which are at ground. For climbing first step wheel should have minimum torque for vertical motion against gravity. The remaining three wheels provide sufficient amount of force for upward motion. While driving on a flat surface, if there is no slipping, wheel center will move on a line parallel to the surface with constant velocity.

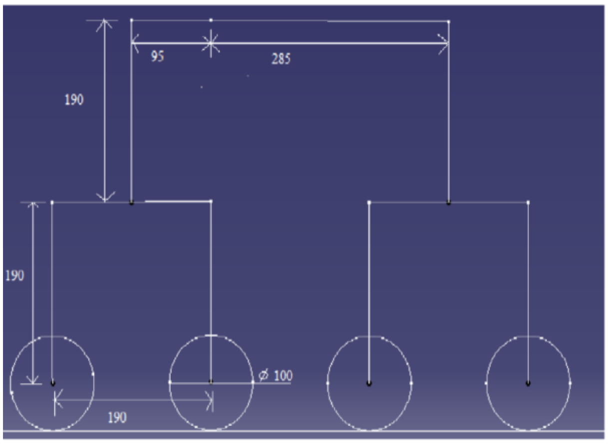

Figure-2 Initial position of robot

3.2 Second position of robot

When first wheel going to complete its motion at reach to the floor of the step one at that time second wheel starts climbing the step and get required power from front wheel and also by that rear two wheels to complete the rising position. As per objective second wheel should not get trap at lowest bottom side of step. To overcome this problem second wheel should start vertical motion against vertical height of step. For this as soon as first wheel finish vertical climbing second should start vertical motion. This is main strategy to find distance between first two wheels while climbing the step. Similarly as position one, remaining three wheels possess horizontal transverse motion.

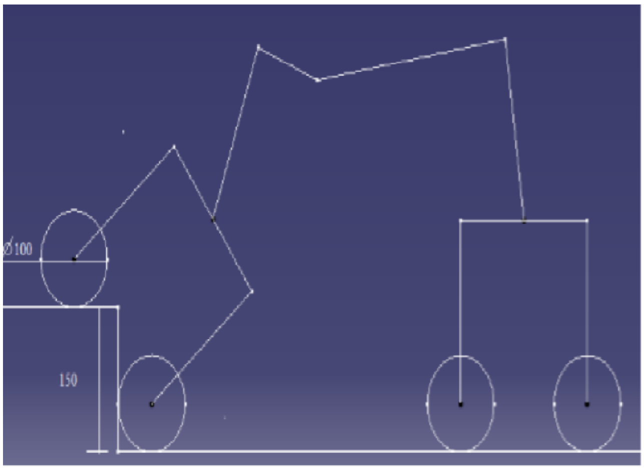

Figure-3 Second position of robot

3.3 Third position of robot

When second wheel completes its rising position at same time the first wheel and third of the robot starts its climbing step, the required torque for the step climbing is power take from a side wheel which is present.

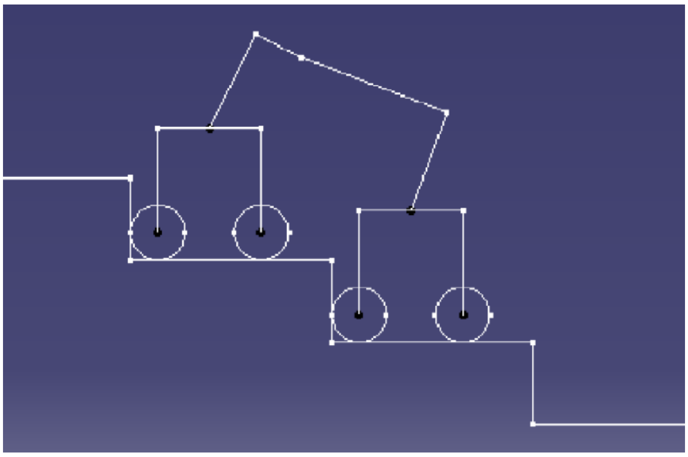

Figure- 4 Third position of robot

3.4 Final position of robot

When the first and third wheel of the robot is going to complete its rising position or on the way of floor position. At the same time second and fourth wheel of the robot are coming the rising position which gets the required support and power from the first and third wheel which are at same position.

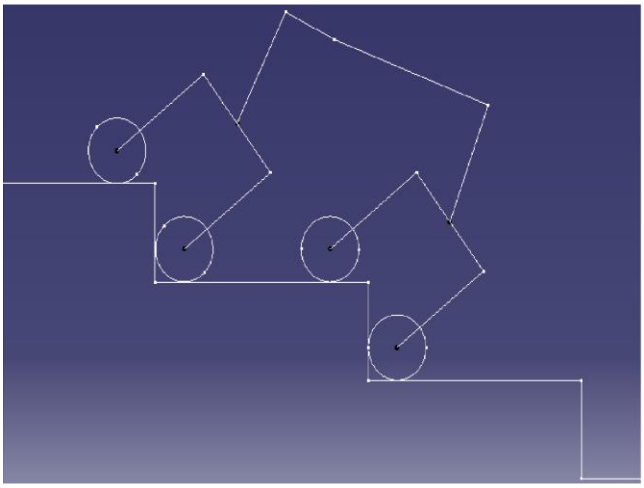

Figure-5 Fourth position of robot

4. DESIGN CALCULATION

The objective of the research work is stair climbing. To achieve proper stair climbing the diameter of linkage should be proper. Assume the stair height and length 150mm& 370mm respectively. To climb the stair with higher stability, it is required that maximum two wheels should be in rising position at a time. Now we need to obtain distance between 1st & 2nd wheel through CAD software (190mm)

4.1 Dimensions of wheel

Wheel diameter= 100mm
As wheel diameter is greater the half of stair height then it can climb stair easily and with more stability.

i.e. (wheel diameter) > (step height)

Hence (100) > (150/2)

4.2 Velocity

As we consider the diameter of robot wheel is greater than half of step height.

Wheel diameter = 100mm

rpm of Motor = 60 rpm

Speed of robot can be calculate by following formula

$$V = R \times \omega$$

$$V = \frac{D}{2} * \frac{2\pi n}{60}$$

$$V = \frac{100*2*\pi*60}{2*60}$$

V = 0.3141 m/s

4.3 Acceleration

Acceleration of incliners is given by following equation.

$$\frac{9.81*\sin(\text{angle of inclination})*\pi}{180}$$

=0.121m\s^2

5. COMPONENT DETAILS

5.1 Wheel

The wheel is the most common moving element among other possibilities including legs, flying, swimming and rolling. A wheel provides at least speed, accuracy and stability for a robot, three characteristics very important in designing and build robots. Depending on the design and requirements, oriental and ball wheels user for balancing a robot.

5.1.1 Wheel dimensions

- 10cm diameter
- 5cm width
- Hole diameter 6 mm
- Screw for fastening on motor shaft
- Made from virgin plastic
- Plastic Wheel, GE White 4 "Double Tyre (10 cm x 5 cm)

5.2 Motor

The motor is screwed to the gear box from inside. Although motor gives 60 RPM at 12V but motor runs smoothly from 4V to 12V and gives wide range of RPM, and torque. Tables below gives fairly good idea of the motor's performance in terms of RPM and no load current as a function of voltage and stall torque, stall current as a function of voltage.

5.2.1 Specifications

- DC supply: 4 to 12V
- RPM: 60 at 12V
- Total length: 46mm
- Motor diameter: 36mm
- Motor length: 25mm
- Brush type: Precious metal
- Gear head diameter: 37mm
- Gear head length: 21mm
- Output shaft: Centered
- Shaft diameter: 6mm
- Shaft length: 22mm
- Gear assembly: Spur
- Motor weight: 100gms

5.3 Battery

5.3.1 Specification of Battery

12 Volt-8 AH

5.4 Lead screw

A lead screw also known as a power screw or translation screw is a screw used as a linkage in a machine, to translate turning motion into linear motion. Because of the large area of sliding contact between their male and female members, screw threads have larger frictional energy losses compared to other linkages. They are not typically used to carry high power, but more for intermittent use in low power actuator and positioned mechanisms.

5.5 Bolt

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten multiple parts together. The two partners are kept together by a combination of their threads' friction (with slight elastic deformation), a slight stretching of the bolt, and compression of the parts to be held together. In applications where vibration or rotation may work a nut loose, various locking mechanisms may be employed: lock washers, jam nuts, specialist adhesive thread-locking fluid such as safety pins (split pins) or lock wire in conjunction with castellated nuts, nylon inserts or slightly oval-shaped threads.

5.6 Links

5.6.1 Link-1

Dimensions-

- Length of Link 1 is 230mm.
- Height of Link 1 is 230mm.
- Drill at downward side is of 14mm.
- Drill at upwards side is of 8mm.

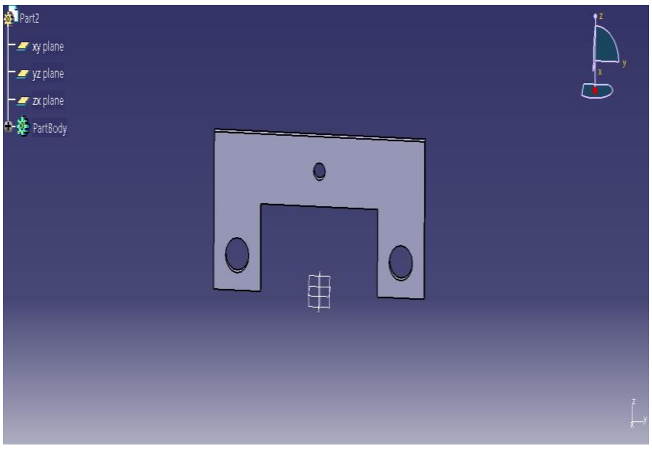

Figure- 6 Link 1

5.6.2 Link-2

Dimensions-

- Length of Link is 325mm.
- Height of Link is 230mm.
- Drill of 8mm.

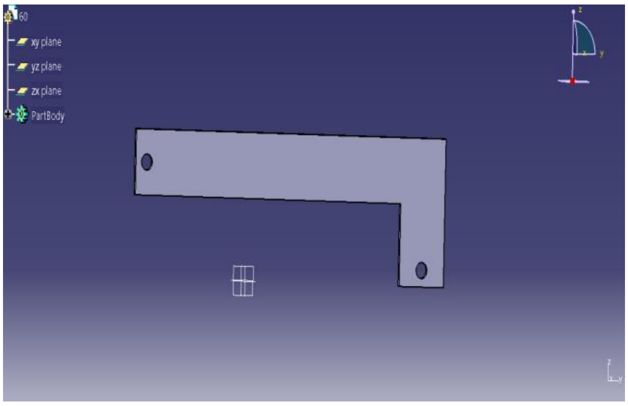

Figure-7 Link 2

5.6.3 Link-3

Dimension-

- Length of Link3 is 135mm.
- Height of Link is 230mm.
- Drill of 8mm.

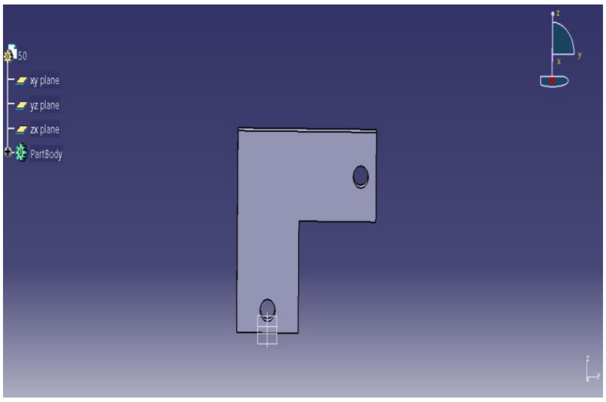

Figure- 8 Link 3

6. MATERIAL SELECTION

6.1 Width of link

As robot links are of wooden material and it is easy to machining on this material. It should have suitable for machining that is it should be sustain drilling, finishing operations. Hence, width of the link is 40mm.

6.2 Thickness of link

Thickness of robot link is 4mmThis thickness links are more suitable for the drilling and finishing operations.

6.3 Link

Material used for link is wood. For following reason.

6.3.1 Density

The density of wood is also influenced by structure of wood. Latewood is made of cells which have thicker walls and smaller cavities in comparison to early wood. This results in higher density of latewood as compared with early wood and explains why the density of wood increases with increasing proportion of latewood.

7. WORKING MODEL

7.1 Side view of robot

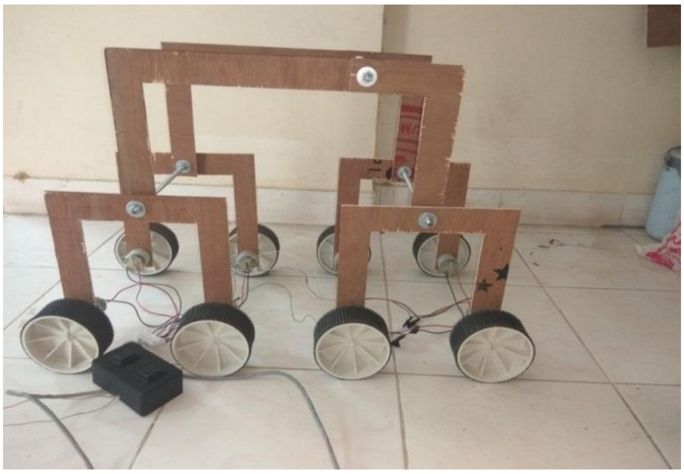

Figure- 9 side view of robot

7.2 Top view of robot

Figure- 10 Top view of robot

8. RESULT

In the robot we use motors and gearbox that the robot capable to run the robot at the speed of 0.314m/s. This robot is capable to climb the steps of height of 150mm and length of 370mm as per consider while designing. The robot gets the stability because of the center of gravity of the model is close to be stair.

9. CONCLUSIONS

This work shows how eight-wheel robot works on different surfaces. As per the different weight acting on link determines torque applied on it. By assuming accurate stair dimensions, accurately dimensioned eight robots can climb the stair with great stability. Also we tested for the Web cam with AV recording mounted on eight-wheel system and found satisfactorily performance obtains during this test camera has rotated around 360˚. During stair climbing test for length less than 375 mm system cannot climb the stair. It can be possible to develop new models of eight wheel which can climb the stairs having low lengths

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