Design and Developement of Pipe Climbing Robot for Leak Detection

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ABSTRACT

The project describes the design and prototype implementation of a wheeled pipe climbing robot. Pipe climbing robots have become an interesting area for research in the current last years. Some robots have been developed for solution of problem. Each construction has its own advantages and disadvantages. The aim of this work was to design another pipe climbing robot that uses a another clamping principle. Pipe climbing robot has many applications in industries as we know in chemical industry, there are chemicals that are harmful to human health and the pipelines of which are needed to be inspected after certain period of time. Humans cannot be allowed to perform such operations, therefore this robot can be very helpful in such tasks of inspection. In thermal power plants boilers also have the similar situation, as pressure and temperature inside the boilers is very high. Long pipes carrying water and steam can also be inspected for leakages which occurs due to environmental factors .

Keywords*: Robot, DC motor, Spring, Sensors, Micro-controller.*

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1. INTRODUCTION:

The design is inspired by the human-climber's action which relies on a strap around his waist. A climber may push his weight back to provide more torque around his waist to create higher force on his foot. The principle of the construction is that the centre of mass has a fix distance to the pipe, representing the body of the climbing man, which has the effect that the normal force between the wheel and the pipe is high enough to drive upwards. Robots that can climb pipes are under development and are expected to be used in the inside/outside maintenance of buildings, observations of disaster scenes from a height, pruning trees, and more. As an alternative, we developed and analyzed a climbing method. Based on this definition a very flexible walking machine, which can walk on very rough and steep terrain should not belong to the class of climbing robots. In the following climbing robots will be distinguished into 3 classes based on their locomotion ability:

(1) wheeled-driven or chain-driven machines, (2)

Legged locomotion,

(3) Locomotion based on arms and grippers.

Since the end of the 80ties climbing robots are examined for different types of application scenarios all over the world. E.g. at the end of the 80ties and begin of the 90ties in Japan several national projects concerning climbing robots for specific application scenarios have been developed. At the end of the 90ties mainly in Europe several different prototype machine have been developed for different types of applications like the inspection of pipes and ducts in the petrochemical industry, maintenance and inspection work in the construction and nuclear industry or cleaning robots for huge class walls.

ISSN: 2321-8169
908 – 913

1.1 PROBLEM STATEMENT:

Design and develop a prototype model of showing the concept of automatic pipe climbing robot which will show the working of application of robot climbing vertically over a pipe. Also fabricate the model of the same which will show the working desired by pipe climbing robot.

1.3 LITERATURE REVIEW:

Tim Bret et.al. [1] Says in the paper "toward autonomous free-climbing automatons" that the goal of this analysis is to change a multi-limbed robot to climb vertical rock exploitation techniques the same as those developed by human climbers. The automaton consists of atiny low variety of articulated limbs. solely the limb end-points will build contact with the environment—a surface with tiny, arbitrarily distributed features called holds. A path through this environment is a sequence of one-step climbing moves in which the robot brings a limb end-point to a new hold. The robot maintains balance during each move by pushing and/or pulling at other holds, exploiting contact and friction at these holds while adjusting internal degrees of freedom to avoid sliding. The paper first considers a planar three-limbed robot, then a 3-D four-limbed robot model after a real hardware system. It proposes an efficient test of the quasi-static equilibrium of these robots and describes a fast planner based on this test to compute one -step climbing moves. This planner is demonstrated in simulation for both robots.

Salice Peter et.al. [2] Says in the paper "design and construction of a tree climbing robot" that The project presented here, focuses on designing a tree climbing robot. Our prime consideration in designing tree cli mbing robot is of the motion planning and method of gripping. With arms involving four legs and sharp end as feet. The mechanical structure is designed to move the structure upwards against the gravitational forces in successive upper body and lower body movements similar to a tree climber. The gripping is designed in a way to dig the upper or lower part of the structure in to the tree facilitating the upward movement. The results shows that it can successfully climb the trees. Tree climbing robot has the potential to be applied to various pursuits, such as harvesting, tree maintenance, and observation of tree dwelling animals.

2. SYSTEM ARCHITECTURE:

The paradigm model carries with it six wheels mounted in 2 rows, every wheel has its separate motor for driving purpose. conjointly the spring arrangement is provided for fascinating the pipes having totally different diameters. The toggle switches are provided that management the motion of the wheels either forward or backward. The frame has hinge joint for gap and shutting the model. When we fix the mechanism over any pipe and press the on-off switch the all the six motors begin operating and moves the mechanism in forward or reverse direction per the input. The forward or backward motion of the motor is depend upon the polarity of the motor, that is modified with the assistance of toggle switches.

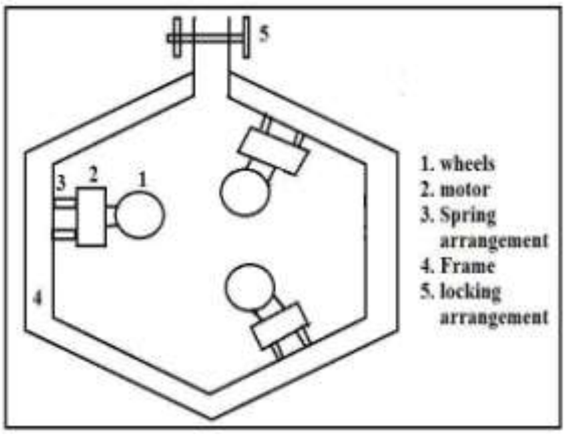

Fig.1 Schematic model

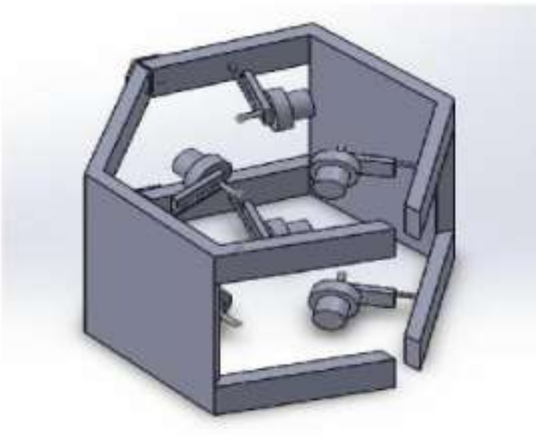

Fig.2 Proposed model using SOLIDWORKS

3.SYSTEM DESIGN:

3.1 DC MOTOR:

Almost each mechanical movement that we have a tendency to see around America is accomplished by an electrical motor. electrical machines square measure a way of changing energy. Motors take current and manufacture energy. electrical motors square measure wont to power many devices we have a tendency to use in standard of living. Motors are available in numerous sizes. large motors that may take many 1000's of HP square measure usually employed in the trade. Some samples of massive motor applications embody elevators, electrical trains, hoists, and serious metal rolling mills. samples of tiny motor applications embody motors employed in vehicles, robots, hand power tools and food blenders. Micro-machines square measure electrical machines with components the dimensions of red blood cells, and notice several applications in drugs.

Here we have a tendency to square measure mistreatment three DC motors one for clamping purpose i.e. for vice, second for linear movement the pipe and therefore the third for driving the cutter blade.

Features: RPM=100 rate

5 weight unit torque-DC motor, Voltage-12v

3.2 WHEELS:

A wheel may be a circular element that's supposed to rotate on Associate in Nursing shaft bearing. The wheel is one in all the most parts of the wheel and shaft that is one in all the six straightforward machines. Wheels, in conjunction with axles, permit significant objects to be stirred simply facilitating movement or transportation whereas supporting a load, or acting labor in machines. Wheels also are used for different functions, like a ship's wheel, wheel, wheel and regulator.

3.3 SPRING ARRANGEMENT:

Springs area unit versatile machine parts used for controlled application of force (or torque) or for storing and unleash of energy. Flexibility is enabled owing to smartly designed pure mathematics or by mistreatment of versatile material. These springs holds the automaton weight hooked up to the pipe to stop from slippery down.

3.4 TOGGLE SWITCH:

For use in several applications from vehicles to industrial machinery, toggle switches area unit a reasonably easy device. electrical toggle switches management the present to power instrumentality. From basic toggle switches to industrial toggle switches, AN electrical switch may be a straightforward single-pipe single-throw (SPST) device, or a additional concerned double-pipe double-throw (DPDT) configuration. it would facilitate to find out switches basics so as to understand what form of electrical toggle switch you wish for your explicit instrumentality. you will soon notice you'll opt for something from AN electronic switch to lighted electrical toggle switches.

3.5 FASTENERS (NUT AND BOLT):

A nut could be a style of fastener with a rib hole. bats ar nearly always employed in conjunction with a conjugation bolt to lock 2 or additional components along. the 2 partners ar unbroken along by a mixture of their threads' friction, a small stretching of the bolt, and compression of the components to be control along.Bolts use a good type of head styles, as do screws.

These ar designed to interact with the tool accustomed tighten them. Some bolt heads instead lock the bolt in situ, so it doesn't move and a tool is just required for the nut finish.The first bolts had sq. heads, fashioned by shaping. These ar still found, though far more common these days is that the polygon head. These ar control and turned by a wrench or wrench, of that there ar several forms. Most ar control from the facet, some from in-line with the bolt.

ISSN: 2321-8169
908 – 913

3.6 LIQUID DETECTION SENSORS:

The liquid sensor module is an easy tool for leak detection. It can be used as a switch when fluid drop falls through the board and also for measuring intensity.
The module features, a liquid board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer.

Fig.3 Microcontroller and Leak Detection Sensor

4.CALCULATIONS:

DC motor selection Specifications Voltage =12V, Current=7.5 amp

- Voltage=current*resistance, $12=7.5*R$

$R=12/7.5$ $R=1.62$ ohm

From paper FAVLHABER

The major constraint on motor operation is thermal $Pdis=I^2*R$

- Heat Heat dissipated= current through the motor squared, multiplied by the terminal resistance

$Pdis= (7.5)^2*1.6$

$Pdis= 90$

- Force required to move weight on motors assume 10 kg

$F=10*9.81$

$=98.1$ N

ISSN: 2321-8169
908 – 913

- Torque required for motor T=f*r

Assuming wheel radius 40 mm T=98.1*0.04

T=3.924 Nm Power p=2*π*N*T/60

P=V^2/R (where v= 12 volt, and R= resistance 1.62) =12^2/1.62

P=88.8888watt P=90 watt

- To find RPM of motor,

90=2π*N*3.924/60 N=219 rpm…..maximum

- Specifications

RPM=100 rpm,

5 kg torque-DC motor, Voltage-12v

4.1 SPRING CALCULATION:

The outer diameter of coil is, D=10mm. Because, The outer diameter of shaft is 8-10 mm.

Allowable shear stress is=z=315 MPa ,Modulus of rigidity,G=80kN/m2,Modulus of elasticity,E=210kN/mm2

- Spring index:-C=D/d=10/4=2.5

Spring rate:- δ=15%max

δ=15/100*34.78=5kw/f K=1.746

- Stresses on helical spring;

Torsional shear stress,
τ1=(8*58*10)/(π*4^3)=23.07N/mm2.

Torsional shear stress τ 1=23.07N/mm2

Twisting moment T=w*D/2=588.6*10/2

T=2943Nmm

Direct shear stressτ2=588.6/(π/4*(4)^2) Direct shear

stress τ2=46.83N/mm2.

- We know that resultant shear stress induced,

= τ1+τ2

τ =69.9 N/mm2

5. CONCLUSION

We developed a pipe climbing robot which can move in upward and downward direction. Also it can remain stationary based on its own weight. So we have really made a nice experience with this work and have learned a lot of new things in this section, which were unknown for me at the beginning. I have the knowledge to design and produce a mechanical construction for research and also for my interests in the free time. From this point of view the goal is attained.
There is large scope for further development in the robot we designed, we have discussed some of the points below:

1. Obstacle detection and path finding can be integrated in the project prototype.
2. Further improvements like appropriate mechanism for turning the robot, performing lateral motion can be implemented.

ACKNOWLEDGEMENT

This research was supported by Mechanical Department of Smt. Kashibai Navale College of Engineering. We thank our guide Mr. G.S.DAVE who provided insight and expertise that greatly assisted the research.

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