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Design and Fabrication of Pipe Inspection Robot

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ABSTRACT:

Our Project aims to design and fabricate the Pipe Inspection Robot. The mechanism involves a translational element which is connected to the three frames with links at 120 deg.It has also a central frame to which on the top the camera is attached and is used to support the central element and the camera. To the links the Wheels and Dc motors are attached .This robot model is used for relatively small diameters. A bidirectional switch is attached with the motors to make the robot move to and fro. The robot allows for detection of cracks, buckles etc.

INTRODUCTION:

Pipeline structures go to pot steadily over time. Corrosion hurries up steadily and long time deterioration will increase the opportunity of failure (fatigue cracking). Limiting normal examining sports to the "scrap" a part of the pipelines best, consequences in the long run right into a pipeline machine with questionable integrity. The self assurance degree in integrity will drop beneath attractiveness levels. Inspection of currently uninspected sections of the pipeline machine will become a must. This mission gives statistics on the "robot inspection technology".

Pipelines are validated to be the most secure manner to move and distribute Gases and Liquids. Regular inspection is needed to preserve that reputation. The large a part of the pipelines machine is available via way of means of In-Line Inspection Tools however this get admission to is restricted to the segment in among the launching and receiving traps best.

Unfortunately, corrosion does now no longer have this limitation. The enterprise appears for way of examining those in-available stress keeping piping structures, preferably, with out interrupting the operations. It is a truth that sufficiently dependable and correct inspection consequences can best be acquired via way of means of direct pipe wall contact/get admission to. If that isn't always viable from the outside, we must move inside. Since enhancing pipeline structures for In-Line Inspection is specially now no longer practical, PIPE INSPECTION ROBOT pursues improvement of ROBOTIC inspection offerings for currently in-available pipeline structures.

INSPECTION METHODS:

1. Video Inspection:

Robots for video inspection of piping systems have a movable head that can rotate 360° and tilt 90°. Video photos can even be taken right next to the pipe wall. Video recording at the checkpoint, separate from online video data, allows the operator to monitor, receive and annotate footage. The camera was specially designed for use in pipeline systems and, in addition to excellent resolution, has a 10x optical zoom function as well as auto and manual focus and adjustable lighting. With highly specialized CCTV cameras, we can visually inspect any pipe system from as little as 6 millimeters or 1/4 inch in diameter to any size. Our industrial cameras are the most reliable and efficient way to detect leaks and inspect welds in piping systems. We are experts at solving tough challenges - if possible, Alfonso Group can do it. We have conducted video inspections of sewage systems, domestic and commercial wastewater treatment plants, water systems, refineries and offshore facilities.

2. Visual Inspection

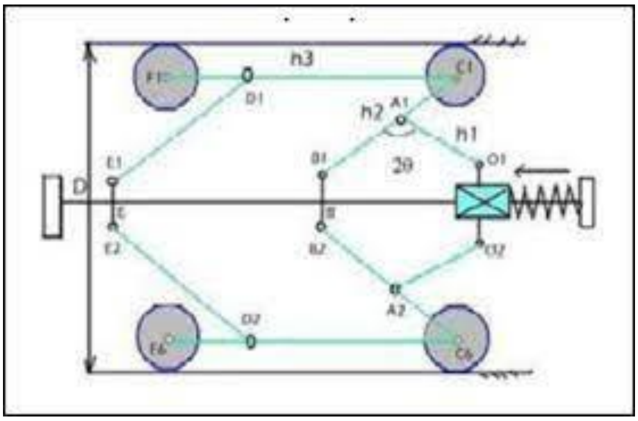
3. Ultrasonic inspection

4. Infrared method

COMPONENTS OF PIPE INSPECTION ROBOT:

1. Central Frame

2. Translational element
3. Compression spring
4. Links
5. Actuators
6. Batteries
7. Camera



Schematic Diagram of PIR

DESIGN OF PIPE INSPECTION ROBOT

Selection of materials:

This machine is made of lightweight, strong materials. Different elements of the robot can be made of various materials. The materials chosen should be light and robust to provide the best possible usage of electricity. Although wood is lightweight, it will wear out if utilised for this machine. Metals are the best materials for the robot because most polymers can't hold a candle to metals in terms of strength. The material should have a high magnetic susceptibility, be ductile, less brittle, and malleable. For the links and the common rod, which is hollow to save weight, aluminium was used as the material. For the engine, various materials are picked though.

The materials selected for the motor should be highly magnetically susceptible and excellent electrical conductors. Materials include copper and other things. However, because to its highly desired properties, aluminium was chosen as the material for the connections and central body. Aluminium is strong and lightweight, making it suitable for a wide range of uses.

Engineering buildings utilise aluminium alloys with a variety of characteristics.Aluminium alloys' strength and durability can vary significantly depending on the alloy's constituents, heat treatments, and production processes. The sensitivity to heat of aluminium alloys is another crucial characteristic.

The fact that aluminium, unlike steel, will melt without first flaming red complicates heating-related work shop practises. Like other structural alloys, aluminium alloys are prone to internal stresses during heating processes like welding and casting. Due to their low melting point, aluminium alloys are problematic in this aspect since they are more prone to distortions from thermally induced stress release.

Mechanism:

The mechanism in question is a four-bar mechanism with three revolute joints and one prismatic joint, as shown in the illustration.

H equals 2r, 2d, and 2h2cosθ. Where (h1 = OA, h2 = BC = D, h3 = CF) h1 = 30 mm, h2 = 85 mm, and h3 = 105 mm

$H=2\times36+2\times28+2\times85\times$ H=248.20mm

Where D is the pipe's diameter in mm and d is the distance between EE' in mm.The connection lengths are given in millimetres as h1, h2, and h3. r is the wheel's radius, and H is the robot's height outside the pipe. 18 for a consistent diameter

Assume that D = 2r + 2d + 2h2 where D = 237.27 mm.

Kinematics of Mechanism:

The linking structure can be shown as in the illustration. This device has four bars. consisting, as shown, of one prismatic and three revolute joints. Therefore, the displacement db may be used to characterise the motion of all revolute joints.

Static Analysis:

Static analysis must be done in order to determine the actuator size. Assume that Fcx and Fcz in (Figure 4) represent, respectively, the reaction force and the traction force applied to the fourbar by the driving wheel. Now, using the free-body diagram with the virtual work principle results in

$\delta W = Fcz\ \delta z - Fbx\ \delta x = 0$

where the spring force Fbx is. Because only Fcz and Fbx carry out work, this is.

z = 2.33/ sin, x = 2.33/ cos, and

W = Fcz (2.33l sin) - Fbx (-2.33l cos) are the equivalent coordinates of these forces in relation to the coordinate situated at the A hinge, and they are written as follows:

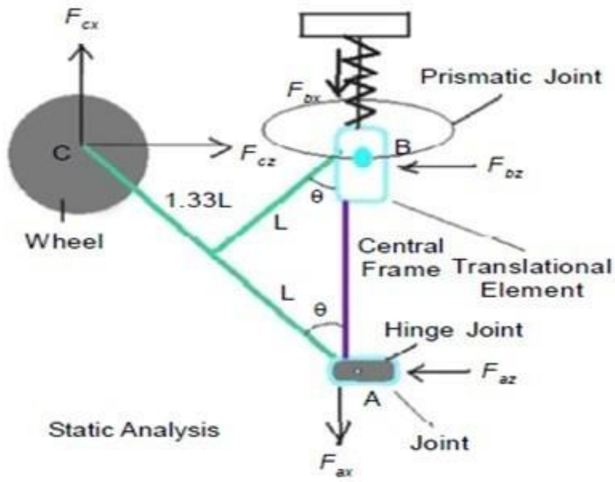
Fcz*2.333/ cos - Fbx*2.33/ sin . = 0.

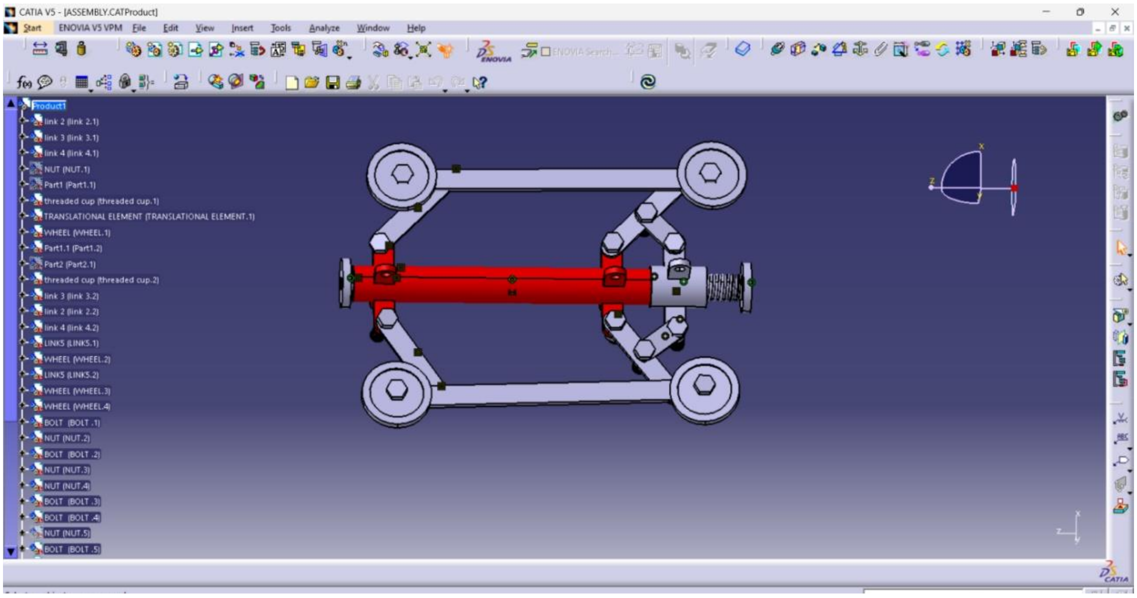
The result of rearranging is: Fbx = Fcz*cos/sin

Fbx = Fcz*tan relates the spring force at the prismatic joint B to the normal force Fcz.

The six traction forces applied to the belt add up to the robot's overall weight, W. Each traction force Fcx is therefore equal to 0.6 of the total weight of the robot frame.

Consequently, the following formula is used to determine the actuator's size: = Fcx*R = WR/6 R is the wheel radius. The huge weight of the robot does not affect the linkage's ability to fold, according to the static study mentioned above. The spring force is determined to be 4.5 and the spring stiffness is found to be 0.9 N/mm. Thus, we deduced that the actuator must have at least 3 kg of torque. Thus, we employed three 1.5 kg torque actuators for a total of 4.5 kg torque. Utilising an actuator with greater torque than necessary is safe.





The PIR is designed in the CATIA V5 software

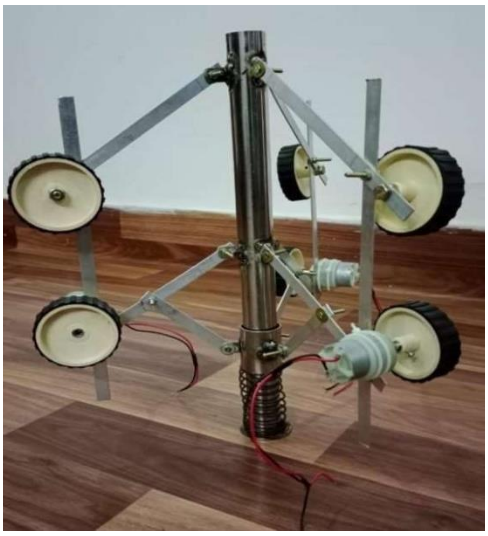
WORKING OF PIR:

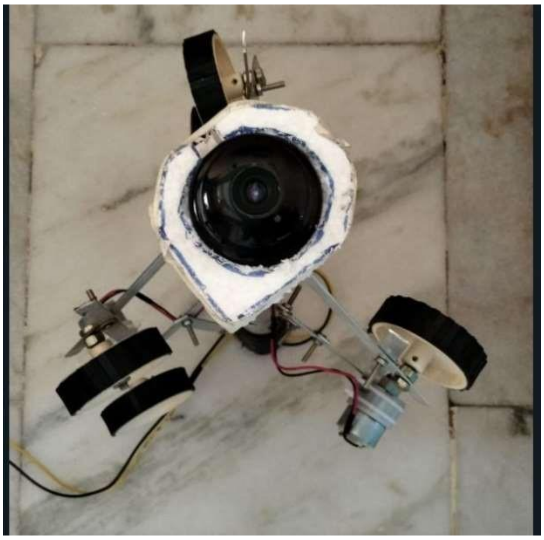
Since the pipe inspection robot is mainly designed for round pipes, it can navigate in pipes with any hole diameter between 203 mm and 254 mm (8 inches and 10 inches). Appropriate mechanisms were used, thanks to which it acquires the ability to move in arcs and narrow the pipes. PIRs have the ability to see down dark pipes that the human eye cannot see. This was made possible by installing a surveillance camera and LEDs on the head of the PIACR.

The output is sent to an external display where a high quality digital image can be received. The perfect fit between pipe and robot is only established after the robot has been placed in the pipe. Then the 12V DC power is turned on to make the robot work and the camera starts. The three-button robot controller makes it easy to control the operation of the robot, with one button for moving forward and backward and two more for moving and tilting the camera head mounted in front of the robot. Inspection so you can photos and videos inside the tube.

Operation of the PIR begins upon insertion into the tube. The front three arms are pushed in by hand and then inserted into the tube, and then the rear three arms are inserted by pressing the PIR.The drive motors are the first six arms mentioned here that pull the entire system. The PIR is about 175 cm long and in order to be able to move freely inside the arc tubes, there are 2 degrees of freedom of connection inside, which facilitate its rotation. When the switch is turned on and current flows through the wires, the wheels will start moving, forcing the PIR to move forward. Friction between the wheels and the tube allows the wheels to Move.

FABRICATION:

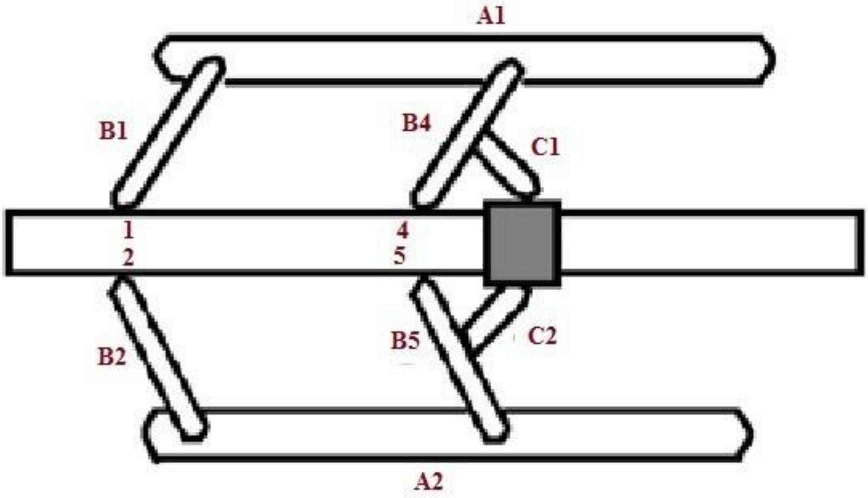




The core element of apipe inspection robot is 12.7 mm in diameter, 3 mm thick, and 176 mm long. One translational element is 15 mm in diameter. 20mm long and 3mm in thickness. There are 12 links total, 3 of which are 105mm (A1, A2, A3), 6 of which are 85mm (B1, B2, B3, B4, B5, B6), and 3 of which are 30mm (C1, C2, C3).The spring length is of 90mm.

The 6 links, each measuring 28 mm in length, are linked to the central component. Links on the central element are joined to the fulcrum using pin joints at the locations 1, 2, and 3 respectively, as indicated in fig.. similarly to the preceding point. The three links, each of which has a 30mm diameter, are attached to the translation element's fulcrum on the outside using pin joints that have a 120° lateral spacing, and the other end is attached to links B4, B5, and B6 at a point To the ends of the links (B1,B2,B3,B4,B5,B6), a second link with length (A1,A2,A3) is attached at the distance indicated in fig. As indicated in fig., the motor and wheels are positioned on links A1, A2, and A3.The swivelling and turning head with a camera and a BO Motor is connected to the front of the construction.

The cylindrical body is attached to a swivelling head with a camera and lights fixed on it. The swivelling head is built into the kind of LED illumination that is frequently utilised. The pipe line's interior is illuminated by the LED. The camera is remotely pannable and tiltable. The motor wiring as depicted in Fig. is powered by a 12 volt DC adaptor. The camera's BO motor receives 3 volts of DC power. Use the robot remote to turn the motor wheel The camera is attached to the output device (display equipment) via a lengthy cable looped around a winch. There are 6 wheels, each with a 72mm diameter.There are six 10 rpm, 12 volt D.C. motors.Two BO motors each with a 60 rpm and 3-9 v motor.The camera and light are controlled by the BO motor, which is mounted to the robot's front side. The spring, which is connected to the robot's end, uses a translational element to give the links expand and compression action.



PROTOTYPE RESULTS

Pipe used for the demonstration is made of a plastic bucket with 240 mm in diameter. The footpads are made of rubber grip just for the demonstration, but it may be need to use high friction footpads for real application. Both spring loaded arms are partially expanded at the initial position.

The robot is subjected to the speed test. It is done by measuring time while the robot moves along the predetermined distance. It is shown that the average speed ranges 0.6~ 0.79 m/minand fifty percent decrease in speed . By using camera clear view of cracks and holes is shown on mobile and holes are visible on pipe from outside.

ADVANTAGES OF PIPE INSPECTION ROBOT

- Pipe inspection robot defects inside the pipe are recorded and displayed on the monitor screen, helping the working members to observe, detect, quickly analyze and diagnose. .
- Save the total investment, improve work efficiency, more accurate detection.
- Reduce the input frequency in the test environment.
- Running cost related to other method is low.
- The production costs of this robot are relatively low.

DISADVANTAGES OF PIPE INSPECTION ROBOT

- Pipe inspection robots have limitations such as. the ability to rotate a T-shaped tube or move through a plug valve.
- Another disadvantage of earlier robots is that the friction between the hose and the communication and power cables makes it difficult to move over long distances. The fiber optic communication system can reduce friction.
- This robot does not work in water.
- This robot only works in empty pipe.

CONCLUSION:

Robots play an important role in maintaining internal pipeline networks. Some are designed to perform specific tasks on a fixed diameter(240mm) pipe, while others can adapt the design function to the variation of the pipe being tested. This project results in a modular robotic system in a tube. The design goal of these robotic systems is to identify adaptable tubes. The prototype presented allows the use of a mini-camera for viewing pipe inspections or other devices for detecting damage inside pipes (measuring systems with lasers, sensors, etc. The modular design has proven to be easily adaptable to new environments with minor modifications. Pipeline blockages are a difficult issue. The mechanism solves the problem by driving the spring and increasing the flexibility of the mechanism. The robot is designed to climb horizontal and vertical pipes. Various module types for the mini pipe inspection robot were presented. Many pipeline inspection robot projects have been fully realized.

Books

Theory of Machine -Prof. R. S. Khurmi & Prof. J. K. Gupta.

Automation production systems, and Computer-Integrated Manufacturing - Prof. M. P.Groover

Links:

http://www.ulcrobotics.com/products

http://www.piacr.tk/Introduction to Pipe Inspection and Cleaning Robot

http://www.sciencedirect.com/science/article/pii/S0094114X06002254

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