

Design & Fabrication of Pipe Inspection Robot

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Abstract

A pipe inspection robot is device that is inserted into pipes to check for obstruction or damage. These robots are traditionally manufactured offshore, are extremely expensive, and are often not adequately supported in the event or malfunction. This had resulted in associated environmental services limited. A New Zealand utilize of this equipment, facing significant periods of down time as they wait for their robots to be the repaired. Recently, they were informing that several robots were no longer supported. This project was conceived to redesign the electronics control systems one of these PIR, utilizing the existing mechanical platform. Requirements for the robot were that it must operate reliably in confined, dark and wet environments and provides a human wears with a digital video feed of the internal status of the pipes. There robot should as much as possible incorporate off the shaft components, cheap, and potentially onsite repair. This project details the redesign and constructions of such robots.

Keywords: - *Inspection robots, Compression Spring, Mechanism, Actuators, Transmitter*

INTRODUCTION

Inspection robots are used in many fields of industry. One application is monitoring the inside of the pipes and channels, recognizing and solving problems through the interior of pipes or channels.

Automated inspection of the inner surface of a pipe can be achieved by a mobile robot. Because pipelines are typically buried underground, they are in contact with the soil and subject to corrosion, where the steel pipe wall oxidizes, and

effectively reducing wall thickness. Although it's less common, corrosion also can occur on the inside surface of the pipe and reduces the strength of the pipe. If crack goes undetected and becomes severe, the pipe can leak and, in rare cases, fail catastrophically. Extensive efforts are made to mitigate corrosion. Pipe inspection is necessary to locate defects due to corrosion and wear while the pipe is transporting fluids. This ability is necessary especially when one should inspect an underground pipe. In this work, Pipe Inspection Robot (PIR) with ability to move inside horizontal and vertical pipes has been designed and fabricated.

The robot consists of a motor for driving and camera for monitoring station to the contrary. Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labor intensive or dangerous work and also to act in inaccessible environment. The use of robots is more common today than ever before and it is no longer exclusively used by the heavy production industries the inspection of pipes may be relevant for improving security and efficiency in industrial plants. These specific operations as inspection, maintenance, cleaning etc. are expensive, thus the application of the robots appears

to be one of the most attractive solutions. Pipelines which are tools for transporting oils, gases and other fluids such as chemicals, have been employed as major utilities in a number of countries for long time. Recently, many troubles occur in pipelines, and most of them are caused by aging, corrosion, cracks, and mechanical damages from the third parties. Currently, the applications of robots for the maintenance of the pipeline utilities are considered as one of the most attractive solutions available should have high magnetic susceptibility and should be good conductor of electricity. The materials are copper and so on. But aluminum is chosen as the materials for the linkages and central body because of its much-desired properties.

A. Problem Statement

- Now a day's many of industries used different diameter pipes for different application like to carry chemicals, high pressure steam and gases hence there may be chances of problems like corrosion, leakages.
- It is not possible to avoid all these problems manually.
- The mud inside the pipe can reduce the efficiency of the water flow.
- The conventional method is very difficult and tiring.

B. Objectives

- To traverse a robot inside a pipe with forward and backward motion and should also do vertical climbing in pipe.
- It should be able to move in various diameters of pipe.
- To build a fully autonomous pipeline cleaning robot.
- To design a robot that can move horizontally and vertically inside the pipe.
- To construct a robot that can minimize the mud and scale inside the pipe.

C. Scope

- The reason of scoping the project work to a boundary is to ensure the project will be done in a systematic manner and prevent overlapping of work occurs. This project focuses on cleaning the inner of the pipeline water system.
- In industrial pipe lines and gas pipe lines it is applicable to detect crack & leakages.
- It's applicable for to detect the problem of blockage in pipe.
- It's applicable for long and different diameter of pipes, cleaning and spray painting.

D. Methodology

The principle of this project is to inspect various pipes and provide its actual footage to operator. Robot works on four bar mechanism. The mechanism involved here is a four bar mechanism consisting of three revolute joints and one prismatic joint as depicted. Robot is designed in such a way that it reduces human efforts while inspecting the industrial pipes. Various steps are carried out to reduce weight of robot. Hence inspection of pipes is done by robot to get required.

LITERATURE REVIEW

From the research paper of Atul Gargade, robots are used to remove human being from laborious and dangerous work. This project describes an in- pipe inspection robot. This robot consist of a fore leg system, a rear leg system and a body. The fore and rear leg systems are constructed by using three worm gear system that are arranged at an angle of 120 degree with respect to each other to operate inside a pipe of different diameters. The springs are attached to each leg and the robot body to operate in pipes of 140mm to 200mm diameter range. Here, all major components of robot are designed. This robot is used for offline visual inspection of gas pipelines, water pipelines and drain pipes etc. This robot also has wide

applications in chemical industries as well as in gulf countries for inspection of oil and gas pipelines. From the research paper of E. Navin Prasad, Inspection robots are used in many fields of industry. One application is monitoring the inside of the pipes and channels, recognizing and solving problems through the interior of pipes or channels. Automated inspection of the inner surface of a pipe can be achieved by a mobile robot. Because pipelines are typically buried underground, they are in contact with the soil and subject to corrosion, where the steel pipe wall oxidizes, and effectively reducing wall thickness. Although it's less common, corrosion also can occur on the inside surface of the pipe and reduces the strength of the pipe. If crack goes undetected and becomes severe, the pipe can leak and, in rare cases, fail catastrophically.

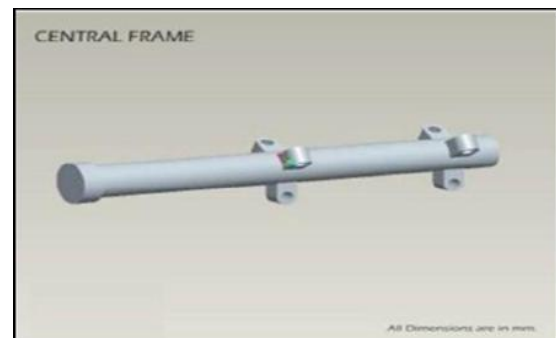
Extensive efforts are made to mitigate corrosion. Pipe inspection is necessary to locate defects due to corrosion and wear while the pipe is transporting fluids. This ability is necessary especially when one should inspect an underground pipe. In this work, Pipe Inspection Robot (PIR) with ability to move inside horizontal and vertical pipes has been designed and fabricated. The robot consists of a motor

for driving and camera for monitoring. He has given advantages of his model. He has also performed kinematic and dynamic analysis on it and finally concluded that its behavior is good. His model gives 90% accuracy in crack detection and can tilt in range of -30° to $+20^\circ$. The research of Kentarou. Nishijima, in pipe inspection robot which analyses image data and he has tested his robot in various pipe materials to calculate losses in microwave signals.

FABRICATION & DESIGN

Central Frame:-

Central body is the frame of the robot. It supports all other components and holds batteries at the centre of the body. The joints are brazed on the central frame at 120 degrees. The central body is drilled and its ends are threaded internally for the insertion of pencil batteries and closing with externally threaded caps. Wireless camera is fixed at one end of the frame.



Hollow

Inner diameter – 15 mm

Outer diameter– 20 mm

Length – 220 mm

Material – Mild steel

Translational Element:-

Translational Element is the movable part in the robot which slides along the central body for repositioning in case of pipe diameter variation. This element is drilled at the center for the translating along the central body. This will restrict the links to some extreme angles beyond which it could not be translated. The extreme angles are found to be 15 degrees and 60 degrees. The joints are brazed on the translational element at 120 degrees for the links to be fixed onto it.



Inner diameter – 18 mm

Outer diameter – 23mm

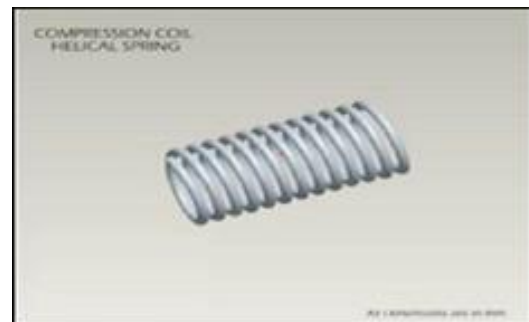
Length of the element – 25 mm

Material – Mild steel

Compression Spring

A spring is an elastic object used to store mechanical Energy. Spring used here is made out of hardened steel. Compression spring is mainly used to exert tension. The purpose of spring is as follows: The force that the mini robot mechanism exercises on the pipe walls is generated with the help of an extensible spring.

The helical spring disposed on the central axis assures the repositioning of the structure, in the case of the pipe diameters variation.



Diameter – 18 mm

Outer diameter – 20 mm

Pitch – 5mm

Length of the spring – 60 mm

Material – Stainless steel

Wheel

Diameter – 72 mm

Link:

Each resistant body in a machine which moves relative to another resistant body is called Kinematic link or element. A resistant body is which do not go under deformation while transmitting the force. Links are the major part of the robot which translates motion. Links are connected to form a linkage. The mechanism involved here is a 4 bar mechanism which has 3 revolute pairs and 1 single prismatic pairs as depicted. Links holds the receiver, switch, and 9v battery for the camera. Also it supports the actuator.



Drilled Holes (Figure)

Link 1 – 30 mm

Link2 – 85 mm

Link3 – 105 mm

Thickness – 3mm

Drilled holes – 12 and 6 mm

Material –Acrylic

Actuators

Actuators are the drive for the robot. Since we have chosen aluminum material for fabrication, the weight is comparatively

less. So the motor should have 2 kg torque to travel inside the pipe. We used 3 motors which has 1 kg torque to make the robot in motion. The supply for the motor is 6v which is from the central body. The 3 motors are placed at 120 degrees and are supported on the links by a tag.



Batteries

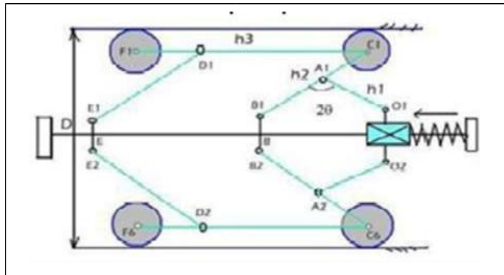
Batteries give supply for a motor and wireless camera. Motor and radio frequency gets 6v supply from the central body and wireless camera gets supply from a 9vbattery. And 3v batteries for transmitter which has two toggle switch. One is for motor forward and reverse control and the other one is for glowing LED's.

Transmitter

The extension cable which attached the camera with output device transmits the video and picture.

MECHANISM

The mechanism involved here is a four bar mechanism consisting of three revolute joints and one prismatic joint as depicted



Kinematics of Mechanism

This is a four-bar mechanism consisting of three revolute and one prismatic joints as Depicted. Ran thus, the motion of all joints revolute can be described in terms of the displacement d_b .

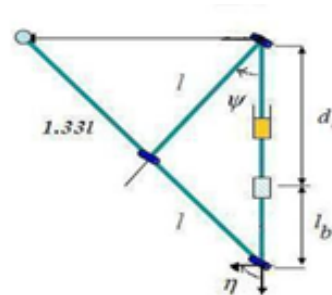
$$H = 2r + 2d + 2h_2 \times \cos\theta, \text{ Where,}$$

$$h_1 = 30 \text{ mm, } h_2 = 85 \text{ mm, } h_3 = 105 \text{ mm}$$

$$(h_1 = OA, h_2 = BC = D, h_3 = CF)$$

$$H = 2 \times 36 + 2 \times 28 + 2 \times 85 \times \cos 45$$

$$H = 248.20 \text{ mm}$$



Where D-Diameter of the pipe in mm, d-Distance between EE' in mm. h_1, h_2, h_3 are the length of the links in mm. r-Radius of the wheel, H=Height of robot outside the pipe.

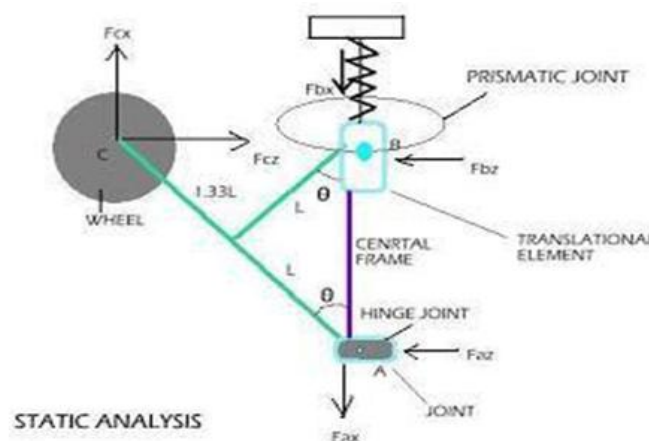
STATIC ANALYSIS

In order to decide the actuator size, it is Necessary to perform the static analysis. Assume did in Figure, F_{cx} and F_{cz} denote the reaction force and the traction force exerted on the four-bar by the driving wheel, respectively. Now applying the virtual work principle to the free-body diagram gives

For uniform Diameter, Assume $D = 2r + 2d + 2h_2$

$$D = 2 \times 36 + 2 \times 28 + 2 \times 85 \times$$

$$D = 237.27 \text{ mm}$$



CONCLUSION

Robots play an important role in inside pipe-network maintenance and their repairing. Some of them were designed to realize specific tasks for pipes with constant diameters, and other may adapt the structure function of the variation of the inspected pipe.

In this research paper, inside pipe modular robotic system are proposed. An important design goal of these robotic systems is the adaptability to the inner diameters of the pipes. The given prototype permits the usage of a mini-cam for visualization of the in-pipe inspection or other devices needed for failure detection that appear in the inner part of pipes (measuring systems with laser, sensor setc).

The major advantage is that it could be used in case of pipe diameter variation with the simple mechanism. We developed a pipe inspection robot that can be applied to 203mm- 254mm pipeline. A real prototype was developed to test the feasibility of this robot for inspection of in-house pipelines.

The types of inspection tasks are very different. A modular design was considered for easily adapted to new environments with small changes.

Presence of obstacles within the pipelines is a difficult issue. In the proposed mechanism the problem is solved by a spring actuation and increasing the flexibility of the mechanism. The robot is designed to be able to traverse horizontal and vertical pipes. Several types of modules for pipe inspection mini-robot have been presented. Many of the design goals of the Pipe inspection robot have been completely fulfilled.

REFERENCES

Books

- I. Theory of Machine -Prof. R. S. Khurmi & Prof. J. K. Gupta.
- II. Automation production systems, and Computer-Integrated Manufacturing - Prof. M. P. Groover

Links:

- I. <http://www.ulcrobotics.com/products>
- II. <http://www.piacr.tk/Introduction to Pipe Inspection and Cleaning Robot>
- III. <http://www.sciencedirect.com/science/article/pii/S0094114X06002254>

- IV. <http://capitalpipeliners.com/cctv-pipe-inspection-method-applicability>
- V. <http://www.google.co.in/patents?hl=en&lr=&vid=USPAT5084764&id=tislAAAAEBAJ&oi=fnd&dq=+of+pipe+inspection&printsec=abstract#v=onepage&q=of%20pipe%20inspection&f=false>
- VI. <http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=3951>
- VII. <http://www.faadooengineers.com/tube/2012/06/11/mechanical-engineering-project-pipe-inspection-robot/>