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Non Destructive Inspection of Pipe using Pipe Inspection Robot

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Abstract: *In today's scenario natural reservoirs of fossil fuel are keeping on depleting and on the other side the use of these resources are increasing. The transportation industry consumes a major portion of these resources, so we need to optimize the use of these resources. Transportation through pipe is among one of the ways in which large quantity of material is supplied from one place to another in an economical manner. As the flow from pipe is continues and in certain cases it cannot be stop, due to this continuous flow, wear and tear, corrosion, etc. in pipe takes place. So we need certain methods to inspect the pipe, so that future problem can be mitigated at early stage, which saves time and money both (if inspection is not done than, failure result in huge loss of money and time). To do such pipe inspection flexile robot are required. In this research paper the designing of such a pipe inspection robot (six wheel robot) is explained, having fore leg system, rear leg system and a central element. Each wheel of robot is at an angle of 120^o with each other and the wireless camera is used for inspection of pipe. In the designing of the robot, static analysis is done. This robot can inspect any pipe within the range of 48-60 cm of diameter.*

I. Introduction

Inspection of pipeline is an important task so as to ensure there are no defects that may eventually lead to problems such as leakage, which in the worst case scenario may lead to a fatal hazard such as an explosion. Primarily robots are designed in such way that they reduce human intervention from labor intensive and hazardous work environment; sometimes it is also used to discover inaccessible work place which is generally impossible to access by humans.

The complex internal geometry and hazard content constraints of pipes require robots for inspection purpose. With these constraints, inspection of pipe becomes so more necessary that, tolerating it may lead to some serious industrial accidents which contaminate environment and loss of human lives also. For inspection of such pipes, robot requirement is must especially in order to check corrosion level of pipe, recovery of usable parts from pipe interior, for sampling of sludge and scale formation on pipe internal surface etc.

On other hand many researcher have a research on pipe inspection robot, in these research they have taken the different criteria or different pipe diameter for the inspection of the pipelines. A Two specific mechanisms in the robot are important for successful locomotion: the Adaptable Quad Arm Mechanism (AQAM) and the Swivel Hand Mechanism (SHM) [1]. The second project is robot is design using only two wheel chains and inspection pipe is 80 to 100mm [2]. Used screw drive chain and inspection of pipe is curved [3]. In a robot, using worm gear, the pipe of diameter 180 to 200mm were inspected [4]. Inspection and repair robots for waste water pipes, a challenge to sensory and locomotion and design issues [5]. The works deals with the design and prototyping of an apparatus to traverse piping systems for inspection, cleaning and or examination of the piping systems and using nondestructive technique [6].

All pipe lines become old after several years use e.g. steel pipes in factories, steel pipe carrying water or gas, ceramic pipes, concrete pipes and plastic pipes. In order to inspect and repair these pipes, a flexible automatic inspection robot is needed. In addition, in order to control the inspection robot and transmit the collected data to the terminal, which is located at the pipe inlet, a wireless communication system for life time Maintenance was developed and its performance was analyzed.

II. Mechanism Of PIR

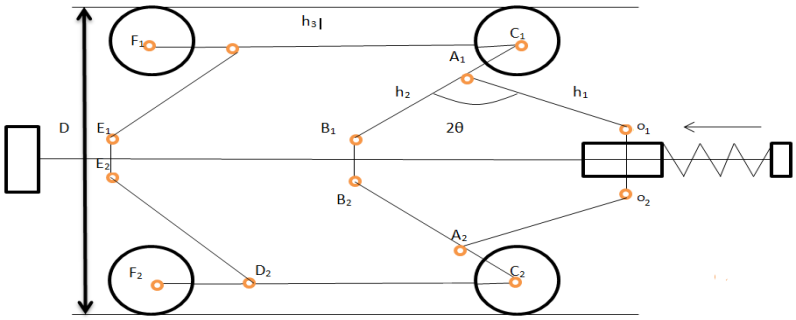

Fig 1

III. Details Of Mechanism

This system consist of a fore leg system, a rear leg system and a central body. The fore and rear leg system are spring loaded systems and constructed by using kinematics links. Both the fore leg and the rear leg system contain three leg each and the three leg of each system are arranged in such a manner that they make an angle of 120 degree with each other, so that the robot can operate inside pipes of different diameters. In this robot there are three revolute joint and one prismatic joint. In mechanism having spring for the variation of the diameter.

The head of the robot is fitted with camera and LED, whereas the sensor is on the central body and remote is available for the forward and backward movement of robot. In mechanism actuator are attached on all the six wheels. Camera is connected to the receiver and receiver gives all photos and videos on monitor.

Variable used in mechanism are:-

D= Pipe diameter

h_1= First link

h_2= Second link

h_3= Third link

E_1E_2 &B_1B_2= fixed hinges on central frame.

O_1O_2= Hinges on prismatic joint.

To calculate the diameter of pipe the formula is:

$D = 2r+2d+2h_2\cos\theta$

Where, r= radius of robot wheel

D= distance between E_1& E_2

h_2= length of the link h

θ= angle between h_2& h_1.

IV. Degrees of Freedom

"Minimum number of independent variables required to define the position or motion of system is known as degree of freedom of system."

This mechanism has got 3 revolute pairs and a prismatic pair, so the mechanism involved here is a four links mechanism.

Number of links, n- 4

Number of joints, j- 4

Number of higher pair, h = 0

The kutzback's equation for the degrees of freedom is:

$$F = 3 (n – 1) – 2 j - h. \quad \text{…… (1)}$$

Therefore,

$$F= 3 (4- 1) – 2* 4 – 0$$

$$F= 3*3 – 2*4$$

$$F= 9 – 8=1 \quad \text{…… (2)}$$

If F = 1, degree of freedom is one. The mechanism has fully constrained motion and this represents a working mechanism which has practical utility. All the working mechanisms have single degree of freedom.

V. Advantages of PIR

- Can adapt various pipe diameters.
- Able to provide screw type motion.
- Less friction force.
- High speed mobility.

VI. Disadvantages of PIR

- Require bigger radius of curvature to turn.
- Less efficient on uneven surface.
- Less flexibility.
- Not work in under water pipe line.

VII. Range of Operation

Robot should also be designed according to the range of operation. Long and medium range robots are controlled by the wireless means and they must have provision of long life onboard battery. On the other hand small and micro robots can be controlled by cable, by wireless means or by mini batteries.

In-pipe inspection robots can be classified on the basis of range of operation as follows

1. Less than 10mm- micro robot
2. 10mm to 100m- small robot
3. 100mm to 500mm- medium robot
4. 500mm or more - large robot

VIII. Conclusion

In this research paper designing of pipe inspection robot has been done. Many types of pipe inspection robots are available in the market, but our focus is on the importance of six wheel robot This robot consist of four link mechanism having degree of freedom one, which means it is a working machine. The maximum diameter of pipe which can be inspected by the robot is 60cm and can inspected in a tolerance of -10 to -12cm i.e. 48cm to 60cm pipe can be inspected with this robot. As of now, design calculation of pipe inspection robot has been done and all the parameters needed for the modeling of robot is fixed.

The above observations can be utilized as a guideline while designing six wheels PIR for a particular application.

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