"Design and Construct of Internal Pipe Inspection Robot"

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ABSTRACT
Pipelines have proven to be safest way to transport and distribute gases and liquid. In pipeline regular inspection is required to safety of pipe. An IPIR is a device that is insert into pipe to check for obstruction and various defects like hole, dent marks, cracks, and material loss due to any chemical reaction. Most of the pipeline have small internal diameter which finish up inaccessible. This analysis objective to design and manufacture IPIR using different sensors like Aurdino Nano, Infrared Sensor, and Gas Sensors (MQ-135). Furthermore Boroscopic Camera was also used for optical examination. This IPIR robot adjust simply to the spherical shape of a pipe and works on DC motor that supply the sufficient torque to robot. The robot is designed to be able to traverse horizontal and vertical pipes and has capability to report and display the view.
Keywords: *Internal Pipe Inspection Robot, Non-Destructive Test*

INTRODUCTION

Robotics has arisen as of the rapidly expanding engineering fields in current technology. Robots are directed to eliminate the involvement of mortals in hazardous workstations. Pipelines have proven to be the safest way to transport and distribute gases and liquids. In the pipeline, regular inspection is required to ensure the safety of the pipe. Usually, it is impractical to modify piping systems for internal pipeline inspection, so internal pipe inspection robots are developing robotic inspection services for pipeline systems. As it is generally impractical to modify piping systems for in-line inspection, pipe inspection robots continue to develop robotic inspection services for pipeline systems that are currently inaccessible. Primarily robots are designed in such a way that they reduce human intervention in labor intensive and hazardous work environment; sometimes it is also used to discover inaccessible workplace which is generally impossible to access by humans.

Many types of pipes are used to transport important lifelines like water and gas supply in our modern society. But newly many problems are happening in the pipelines because of natural climate and mechanical damages. If the damages in the pipe are caused due to corrosion then it is tough to check out the defects and the exact place of the defects. This examination must be required. If we decide to do this examination manually then a great amount of time, effort and labor are needed.

PROBLEM STATEMENT

- As it is generally impractical to modify piping systems for in-line inspection, pipe inspection robots continue to develop robotic inspection services for pipeline systems that are currently inaccessible.
- Recently, many industries use various diameter pipes for different applications, Hence there may be chances of problems like corrosion, cracking, dents, metal losses and leakages. These problems are unavoidable. The conventional method is very complicated, boring and costly. These problems are in industry, houses and power plants.

OBJECTIVES

1. To ensure the safety in pipeline industry.
2. To build a semi-autonomous internal pipeline inspection robot.
3. To design a robot that can move inside the pipeline.
4. To move the robot inside the pipe and inspect the area with minimum possible time.
5. It should be able to move in various diameters of pipe. (Range- 250mm to 350mm)
6. To detect hazardous gases.
7. To find location of defects such as cracks, blowholes, dent marks, damage at joints or at weld and blockage

LITERATURE REVIEW

M .N. Mohammed [1] Robots are devised in such way to dispose of human intervention from labour extensive and hazardous work environment. At times they are also used to travel to unreachable workplaces that are typically not possible to access by

human. Pipe inspections fall in the same category due to the fact that they carry toxic chemicals and fluids. This research aims to design and develop a pipeline inspection robot using an autonomous mobile robot with ultrasound sensors and connected via GSM and GPS. In addition, IP camera was also used for visual inspection, integration of wireless capability for easy viewing of acquired data and images.

A.Rahal[2] Pipeline or mass transport line are the chief applications which are typically involved in the oil and gas industries. Hence, inspection and maintenance must be done frequently to ensure the pipeline can be used in an excellent working state. The inspection on pipeline must be done before and after its maintenance. However, it is difficult to inspect within the pipe to ensure it is in good condition. Currently, various new types of technology are used for inspection purposes specifically by means of the Non-Destructive Testing, but it highly costly. Thus, this project focuses on the design and development of an inspection robot to perform a pipeline inspection

Ankita Nayak[3] Basically robots are designed in such way that they remove human intervention from labour intensive and hazardous work environment, sometimes they are also used to explore inaccessible work places which are generally impossible to access by humans. The inspection of pipe comes in same category because they carry toxic chemicals, fluids and most of the time has small internal diameter or bends which become inaccessible to human. The complex internal geometry and hazard content constraints of pipes demand robots for inspection of such pipes in order to check corrosion level of pipe, recovery of usable parts from pipe interior, sampling of sludge and scale formation on pipe internal surface etc.

Apoorva Vikram Singh[4]In recent years, robotics has become an important domain in the field of engineering. It plays a crucial role in various fields, one of them being inspection purpose. In-pipe inspection robots are necessary for the safe and smooth running of industries. Problems arising in the piping network may lead to loss of the transported medium and leakage of which often affect the environment. Hence, it must be continuously inspected which involves large amount of labour. Also, the working environment usually involves possible exposure to hazardous chemicals or gases, humid and low oxygen content air, zones inaccessible to human hands, etc.

EXPERIMENTAL SETUP

COMPOENTS:

1. **Linkages**

The linkages we are using are total 3 different dimensional linkages. In that we have used four bar chain mechanism to adjust the range of robot and also to balance within the movementof robot in the pipeline.

1.1 Link 1 - 80mm
1.2 Link 2 - 140m
1.3 Link 3 - 245mm

Fig 1. Linkages

2. Main Body Frame

Central body is the frame of the robot. It supports all other components and holds batteriesat the Centre of the body. The joints are brazed on the central frame at 120 degrees. Wired camera is fixed at one end of the frame.

2.1 Inner diameter- 21 mm
2.2 Outer diameter- 25 mm
2.3 Length of frame- 240 m
2.4 Material- Mild Steel (M.S.)

Fig 2. Main centre body

3. Compression Spring

A spring is an elastic object used to store mechanical Energy. Spring used here is made out of hardened steel. 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 axisassures the repositioning of the structure, in the case of the pipe diameters variation.

3.1 Outer diameter – 35 mm
3.2 Pitch – 20 mm
3.3 Length of the spring – 130 mm
3.4 Material – Stainless steel

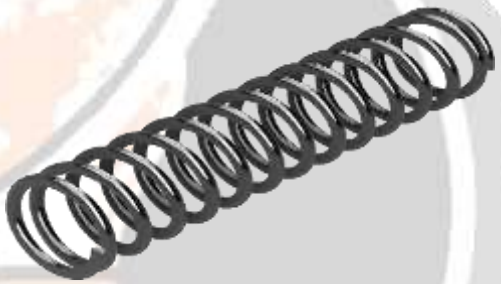

Fig 3. Compression Spring

4. Sleeve

A sleeve we are used is metal sleeve of MS material. This is used for a linear movement to compress the compression spring to adjust the range of the robot. It plays vital role in adjusting the diameter of robot according to the testing pipe within its range.

4.1 Outer Diameter – 25mm
4.2 Inner Diameter – 20mm
4.3 Length – 45mm

Fig 4. Sliding Sleeve

5 .Dc motor

The 12V DC Geared Motor can be used in variety of robotics applications and isavailable with wide range of RPM and Torque.

- Length: 80mm
- Torque: 1.5 kg.cm
- Shaft Diameter: 6mm
- Weight: 130.00 gm
- Speed: 30 RPM

Fig 5. DC Motor (30 RPM)

6. Display

LCD 16x2 is a 16-pin device that has 2 rows that can accommodate 16 characters each. LCD 16x2 can be used in 4-bit mode or 8-bit mode. It is also possible to create custom characters. It has 8 data lines and 3 control lines that can be used for control purposes.

Fig 6. Display

7. Boroscopic Camera

- A baroscopic is an optical device consisting of a rigid or flexible tube with an eyepiece or display on one end, an objective lens or camera on the other linked together by an optical or electrical system in between. The optical system in some instances is surrounded by optical fibers used for illumination of the remote object.

- Resolution: HD: 640*480(On Android) and 1280*720 (On PC).
- View Angle: 66
- Focal Length: 4cm –infinite
- With 6 adjustable brightness LED light source.
- Size: diameter: 7 mm
- Length: 5 M
- Temperature: -20 ~ 84 C
- Waterproof

Fig 7. Boroscopic Camera

8. Aurdino Nano

The aurdino we have used is Aurdino Nano. It is used to produce a clock of precise frequency using constant voltage. The Arduino Nano is a small, complete, and breadboard- friendly board based on the ATmega328P released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor.

Fig 8. Aurdino Nano

9. Infrared Sensor

An infrared sensor (IR sensor) is a radiation-sensitive optoelectronic component with a spectral sensitivity in the infrared wavelength range 780 nm … 50 µm. In a defined angle range, the sensor elements detect the heat radiation (infrared radiation) that changes over time and space due to the movement of people.

- Main Chip: LM393
- Operating Voltage (VDC): 3.6 - 5
- Distance Measuring Range (CM): 2 – 30cm
- Dimensions: 48 x 14 x 8 mm
- Weight: 15 grams

Fig 9. IR Sensor

10. Gas Sensor

The MQ-135 Gas sensor can detect gases like Ammonia (NH3), sulfur (S), Benzene (C6H6), CO2, and other harmful gases and smoke. Similar to other MQ series gas sensor, thissensor also has a digital and analog output pin. When the level of these gases go beyond a threshold limit in the air the digital pin goes high

- Operating Voltage: 2.5V to 5.0V
- Power consumption: 150mA
- Detect/Measure: NH3, Nox, CO2, Alcohol, Benzene, Smoke
- Typical operating Voltage: 5V
- Digital Output: 0V to 5V (TTL Logic) @ 5V Vcc
- Analog Output: 0-5V @ 5V Vcc

Fig 10. Gas Sensor (MQ 135)

WORKING

The four bar link mechanism used in Internal Pipe Inspection Robot can be compatible in the pipes with the diameter ranges from 260mm to 340mm.we had to provide auto adjusting mechanism that can expand and contact as PIR moves inside the pipe. Spring of suitable stiffness is mounted on base rod, as seen in figure, so that as arms gets contracted due to load of compression against pipe PIR wheel motion is provided with 10 rpm, 12 V DC motors hence its speed is 30 rpm. The power provided to motors is from single 12V dc adapter hence load on each motor will be minimum that expected. Expansive leg mechanism has the motion repeating retraction and extension by sliding action of legs attached to the sleeve with compression spring. If expansive leg mechanism extends, robot hold out by the frictional force between the pipe and supports. Robot must be able to move smoothly in the pipe.

The robot is enabled with electronic circuit with the IR sensor and gas sensor to inspect internal area of pipeline. We have used two Aurdino Nano in that first aurdino is used for the inspection purpose in which IR sensor and Gas sensor is controlled and the result is displayed on the 16X2 LCD Display. Another aurdino Nano is used for the servo motor to actuate the IR Sensor mounted on it with the 180 degree rotation. The IR sensors are mounted on the Servo motor on the opposite direction with each other. The 180 rotation of servo motor gives 360 degree inspection inside the pipeline. For the visual inspection to view the obstacle inside the pipeline, detected hole and also to see the smoke or any other visible gas inside the pipeline. The all the results is displayed to the inspector through display with the buzzer warning when hole and hazardous gas is detected.

Fig 11. Internal Pipe Inspection Robot

CONCLUSION

In this paper construction and working of in –pipe inspection robot is discussed .This internal pipe inspection robot able to move freely inside the straight pipe of different diameter pipe. We developed a pipe inspection robot that can be applied to 250 mm-350 mm pipeline. The types of inspection tasks are very different. 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. As a conclusion, all objectives for this project were managed to achieve. y. The objective of this research is to build a robot that can be operated in different modes such as obstacle detection, crack detection, Dent mark, holes, corrosion etc. The robot is designed to be able to travel in forward and backward directions. Obstacles are detected using IR sensors.

FUTURE SCOPE

1. Use of lighter material for the links to reduce the weight.
2. Infrared/Ultrasonic inspection for better detection of defects.
3. Implementation of long range sensors. Implementation as a bore well rescue robot.
4. Alternate design without links to facilitate better motion.
5. Use of better Ultra High Definition camera for clear and better view of internal area of pipe.
6. Can be used to measure distance of pipe for underground or unreachable area pipelines.
7. Usage of high quality materials for longer lifespan of robot.
8. Adapting a 360 degree rotating camera.

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