PIPE INSPECTION ROBOT

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Abstract – *Pipelines are very significant tool as they are used in many different industries for various applications such as transportation of gas, water, fuel, oils, etc. Over time, they are prone to aging, corrosion, cracks, mechanical damage etc and ignorance of these problems leads to accidents which incurs huge losses in terms of both economy and lives. This highlights the inevitable need to inspect pipes at a regular interval for the purpose of security and improved efficiency in industrial plants. Now there is many ways of inspecting pipes such as X-rays, magnetic particle inspection method etc, but these methods do not give a full proper internal inspection of pipes. This pipe inspection robot aims at detecting the exact location of leakage and clearing the blockages and thus removing human factor from labour intensive and dangerous work, thereby reducing the number of accidents that happen due to the lack of regular inspection.*

***Key Words*: Pipelines, Pipe Inspection Robot, Leak Detection, Pipe Leakage, Water Distribution System.**

1. INTRODUCTION

The growth of robots is tremendous in this technologically advanced era. Robots are conceptualized to eliminate the human factor from labour intensive or dangerous and inaccessible work environment. The use of robots is very common in this age of automation and it is no longer exclusively used by manufacturing industries. Since the dawn of industries, pipelines are tools for transporting oils, gases and other fluids. Many defects occur in pipelines and a majority of them are caused by aging, corrosion, cracks, mechanical damages due to improper installations. If ignored, these troubles translate into major chemical disasters which harm both human life and environment equally. Thus, the inspection of pipes is extremely important for improving the reliability and security of the industries. The pipelines are the major tools for the transportation of drinkable water, effluent water, fuel oils and gas. A lot of troubles caused by piping networks aging, corrosion, cracks, and mechanical damages are possible.

A significant amount of water is lost in the water supply system. Water leakage is been a major problem for many regions around the world. In some areas water loss due to water leakages in the supply network exceeds 40% of water in supply system. Leaks from pipes, plumbing fixtures and fittings are a significant source of water waste for many households. Research has shown that the typical home can lose 2,000 to 20,000 gallons (7.6 m^3 to 76 m^3) of water per year due to leaks. Some leaks are obvious, such as dripping faucets and leaking water heaters.

In many water distribution systems, a significant percentage of water is lost while in transit from treatment plants to consumers. According to an inquiry made in 1991 by the International Water Supply Association (IWSA), the amount of lost or "unaccounted for water" (UFW) is typically in the range of 20–30% of production (Cheong 1991). In the case of some systems, mostly older ones, the percentage of lost water could be as high as 50% (AWWA 1987).Leaks in pipelines, whether for oil, gas, or water, are a frequently occurring problem in infrastructure worldwide. Unfortunately, many leaks go undetected for years because the source of the leak is not visible. Currently, one of the most viable solution for inspection of pipelines are robots.

Pipe Inspection Robots are widely used in petrochemical, water supply and fluid transportation industries. Many researchers have done work to develop new pipe inspection robots to enhance various aspects of in pipe inspection robot like vision, control and motion of robot. Research work of these researchers are reviewed to find the design philosophy, capabilities and limitation of different types of robots. The inspection of pipes is crucial for improving the security in industrial plants. These specific operations such as cleaning, maintenance etc are expensive. Also, if ignored they lead to chemical catastrophes. However, using manual labour to inspect these pipelines is risky as there may be presence of toxic gases or insufficient amount of oxygen. Geometrical constraints may render those areas inaccessible. A design for a visual inspection system for the interior of pipelines with minimal service interruption is presented.

2. PROPOSED METHODOLOGY

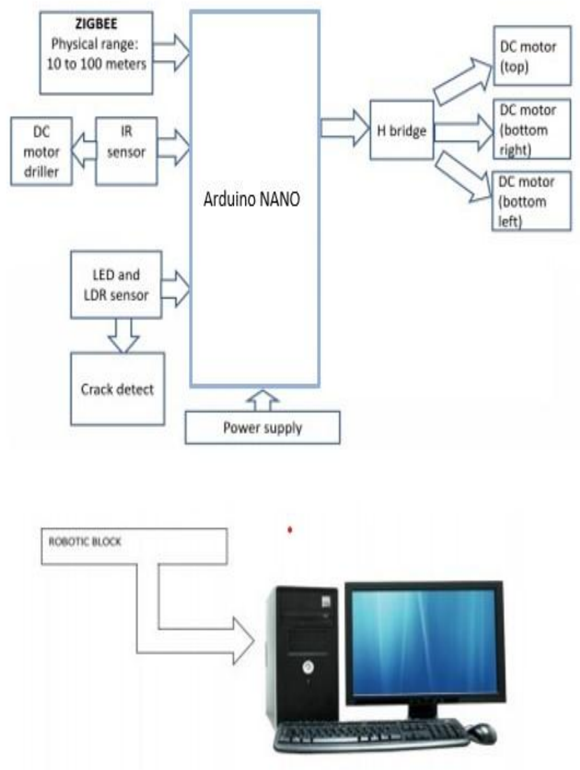

Fig-1: Block diagram of the proposed system

The robot is designed in such a way that it can detect the exact location where the leakage has occurred in the pipe. The crack detection is done with the help of LDR sensor. IR sensor is used to detect the obstacles and a driller is used to remove them. The codes required to detect cracks and obstacle were written and dumped on an Arduino Nano.

The controlling system consisting of microcontroller, motor driver, different sensors and wireless camera was mounted on the model and synchronized with the mechanical part. Wireless transfer of information of the conditions inside the pipe is done with the help of ZigBee module connected to both the robot and laptop. A PVC pipe of six inches diameter was used for testing the pipeline inspection robot.

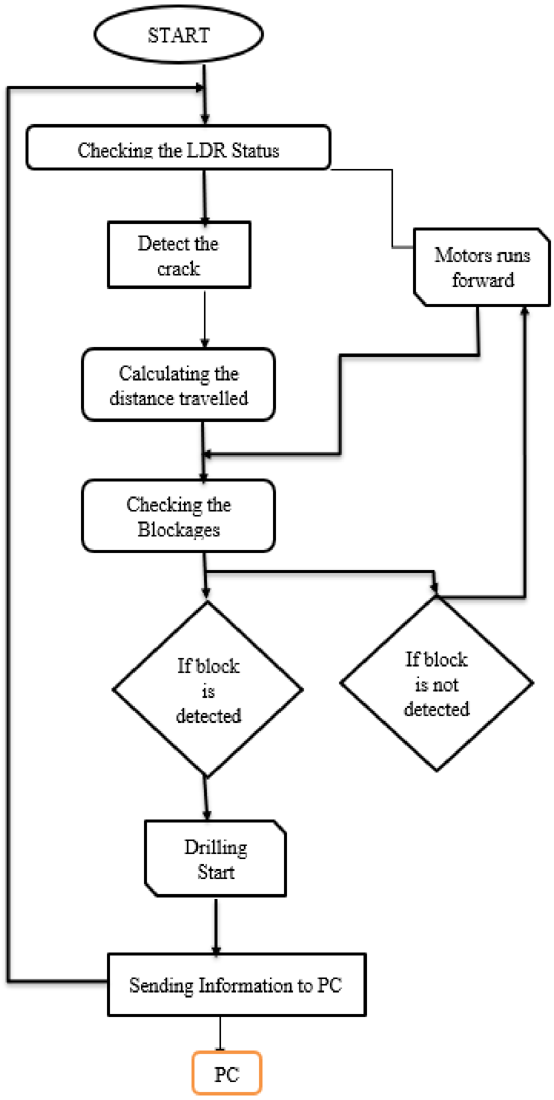

Fig-2: Flowchart of the proposed system

Once the robot is placed inside the pipe, led which is attached to the robot glows throughout and the pipe and LDR would monitor the values. Where ever the variation is seen that particular place will be identified as crack detected and we would be calculating distance. As the robot moves forward it also checks for blockage, if blockage is present then drilling operation would start, information of the conditions inside the pipe is communicated wirelessly with the help of ZigBee module connected to both the robot and laptop.

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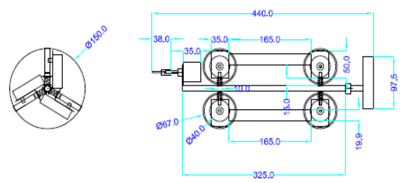
3. DIMENSION OF PI ROBOT

Hardware Specifications of Pipe spy Robot

It deals with the CATIA designs of each component of the Pipe spy Robot and the dimensions of each of them as well. It also mentions the specification of the robot. The robot is modeled on CATIA software.



SPECIFICATIONS

1.MOTOR -	3NOS	10RPM SPEED
2.COMPRESSON SPRINGS -	6NOS	DIA10X15MM LENGTH
3.WHEEL-	6NOS	DIA 67X20MM WIDTH
4.DRILLER MOTOR	1NO	500 RPM

Fig-3: Design and fabrication of PI robot

The pipe inspection robotic block consists of a central cylindrical body on which sensors and actuators are placed. It is a 6-wheel robot. Front Three wheels are for motion and are connected to DC motor. Behind three wheels are dummy wheels which are used for supporting the entire model for a smooth forward movement. The front part of robot consists of DC motor with driller. Compression coil helical springs are mounted around the wheels. While inserting the robot inside the pipe it is compressed manually. Once it is inside the pipe the spring near the wheel decompresses and have a strong grip along the diameter of the pipe.

Dimensions of components of the PI Robot

I) DIMENSION OF LINK

CATIA prototype of link is shown in figure-4.

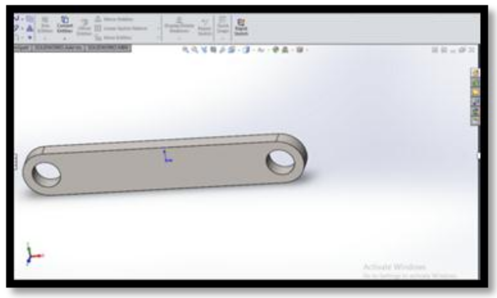


Fig-4: Links which are used PI robot

Link 1 – 30 mm
Thickness – 3 mm
Link2 – 85 mm
Drilled holes – 12 and 6 mm
Link3 – 105 mm
Material – Stainless Steel

II) DIMENSION OF CENTRAL BODY

CATIA prototype of the central body is shown in Fig.

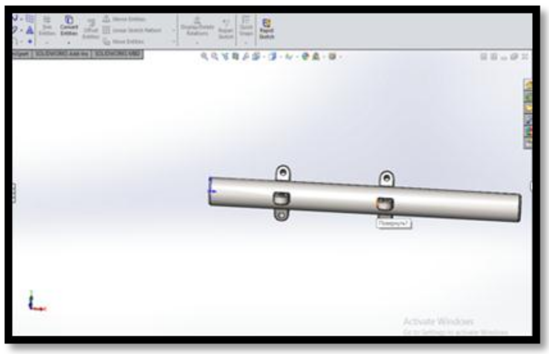


Fig-5: Central shaft on which the body of the PI Robot rests

Hollow
Length – 220 mm
Inner diameter – 15 mm
Material – Mild steel
Outer diameter – 20 mm

III) DIMENSION OF TRANSLATIONAL ELEMENT

CATIA prototype of the translational element is shown in Figure-6.

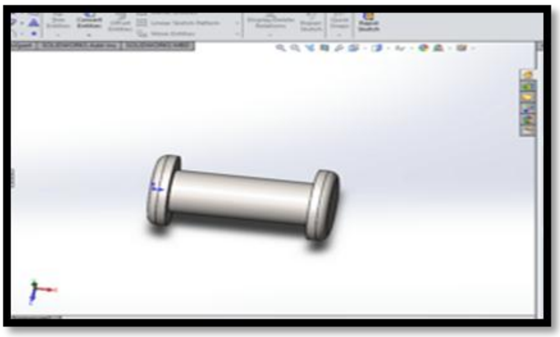


Fig-6: Translational element for movement of the links

Inner diameter – 18 mm
Length of the element – 25 mm
Outer diameter – 23 mm
Material – Mild steel

IV) DIMENSION OF SPRING

CATIA prototype of the spring is shown in Figure-7.

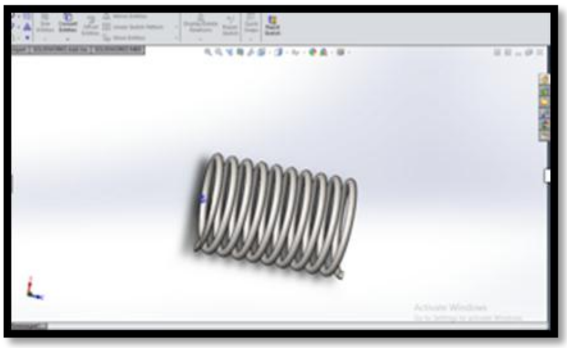


Fig-7: Spring

Inner diameter – 18 mm
Length of the spring – 60 mm
Outer diameter – 20 mm
Material – Stainless steel
Pitch – 5 mm

4. CONTROLLING OF PI ROBOT

This deals with all the paraphernalia related to the controlling of the inspection robot consisting of microcontroller, sensors, actuators and motor driver.

4.1 DC Motor Control and H bridge:

H bridges are generally used to control DC Motor and the design consists of four switches labelled A1, A2, B1, and B2 as shown in Fig. Switches A1 and B2 connect motor to the high voltage supply whereas switches A2 and B1 connect the motor to the low voltage supply. This allows the motor to be controlled in either direction by connecting one set of switches either A1 and A2 or B1 and B2 [16].

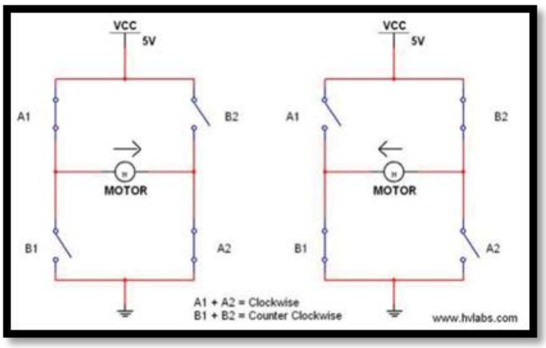


Fig-8: H Bridge Working

4.2 IR Sensor

The IR Sensor-Single is a general-purpose proximity sensor. The module consists of a IR emitter and IR receiver pair. The module which is shown by Fig consists of 358 comparator IC. The output of sensor is high whenever it does not detect IR frequency and low otherwise. The on-board LED indicator helps user to check status of the sensor without using any additional hardware.

The output of IR receiver goes low when it receives IR signal. Hence the output pin is normally low because, though the IR LED is continuously transmitting, due to no obstacle, nothing is reflected back to the IR receiver. The indication LED is off. When an obstacle is encountered, the output of IR receiver goes low, IR signal is reflected from the obstacle surface. This drives the output of the comparator low. This output is connected to the cathode of the LED, which then turns ON [17].

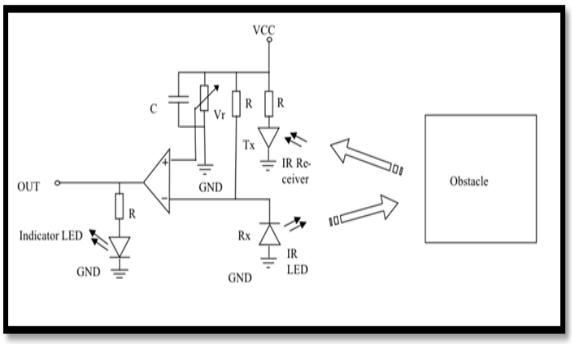


Fig-9: Functional Block Diagram of IR Sensor

4.3 LDR Sensor

An LDR sensor (*Light Dependent Resistor)* is basically a photo resistor and its resistivity is a function of the incident electromagnetic radiation. Symbolic representation of LDR Sensor is shown in figure-10.

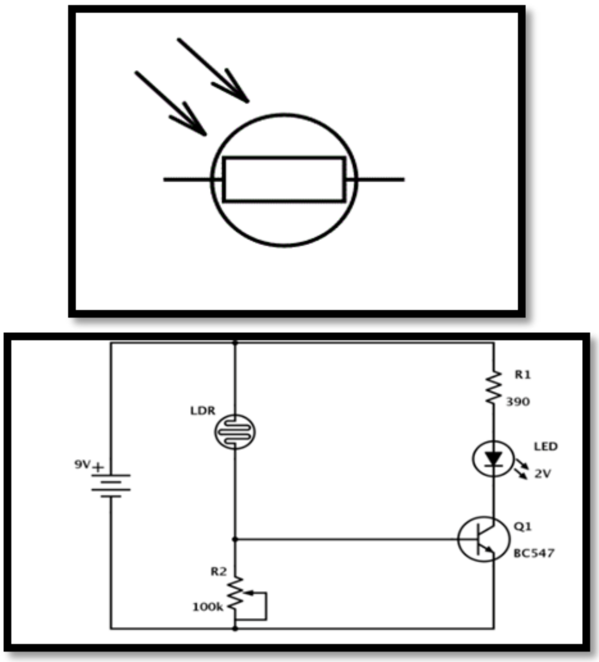


Fig-10: Symbolic Representation of LDR Sensor and Circuit diagram of LDR Sensor

4.4 ZigBee Module

ZigBee communication is a PAN technology that is specially built for control and sensor networks and it is based on IEEE 802.15.4 standard for wireless personal area networks (WPANs). This communication standard defines physical and Media Access Control (MAC) layers so as to handle many devices at low-data rates. Thus, Zigbee's WPANs operate at 868 MHz, 902-928MHz and 2.4 GHz frequencies. The date rate of 250 kbps is best suited for periodic as well as intermediate two-way transmission of data between sensors and controllers [18].

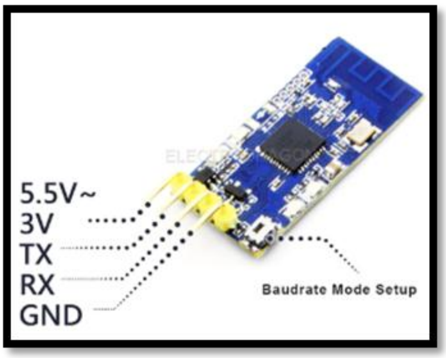


Fig-11: Zigbee Module

5. RESULT

A pipeline inspection robot has been designed and developed. Flash Magic was used to give the inputs and get corresponding output. It displayed the output according to conditions mentioned in the code which is tabulated in Table.

Table -1: Output at Flash Magic Terminal

INPUT	OUTPUT
Character 'f'	forward
Character 's'	stop
Character 'r'	Reverse
When crack is present	Crack detected
When obstacle is present	Obstacle found

1) Upon giving the character 'f' as input, the robot moves forward. Upon giving character 'r' as input, the robot moves in the backward direction. Upon giving the character 's', the robot stops.

2) If light falls on any of the LDR sensor, it detects crack and the output signal is given on the terminal. The robot stops at the moment it detects crack. The output is shown by figure-12 below.

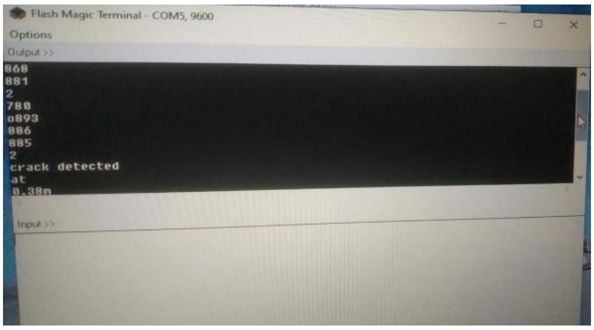


Fig-12: Crack detected

3) When the IR sensor senses any obstacle, the drill bit at the top of the robot starts rotating and an error signal is sent on the terminal stating an obstacle is detected. The output is shown by figure-13 below.

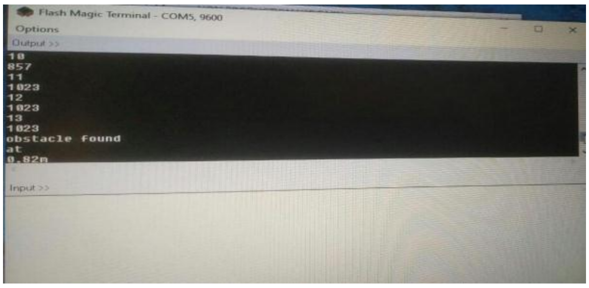


Fig-13: Obstacle Detection

4) The images of the Pipeline Inspection robot that has been developed is shown in Figure-14 and figure-15 below.

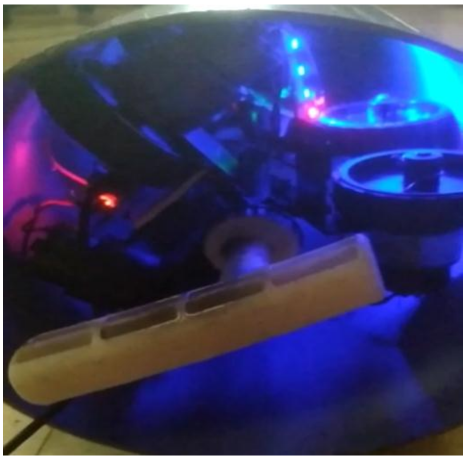


Fig-14: PI Robot inside the pipe

Fig-15: PI Robot top view

6. CONCLUSION

A very important design goal of the robotic systems is the adaptability to the inner diameters of the pipes. The major advantage of this robot is that it could be used in case of pipe diameter variation with the simple mechanism. A pipe inspection robot that can be applied to 6-8inch diameter pipeline was developed to test the feasibility of this robot for inspection of pipelines. We used a Arduino Nano board for the controlling of the DC motor along with a couple of sensors.

7. PROJECT OUTCOMES

A great deal was learnt in the process of implementing this project.

- There was a requirement of knowledge in other fields that are not Electrical and Electronics related, such as Mechanics and Robotic, to be fully able to comprehend the problems encountered so as to model practical solutions.
- Numerous glitches in the code helped us in honing our programming skills.
- The proper placement of all the components on the pipe keeping all the constraints in mind helped us in tackling problems at a better way.

Moreover, good team work and time management skills have helped us obtain the required project objectives.

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