e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:03/March-2025 Impact Factor- 8.187 www.irjmets.com

PIPELINE INSPECTION ROBOT

Prof. A.D Kulkarni*1, Y.D. Bhange*2, D.M Shinde*3, S.S Samson*4, A.D. Gawale*5
*1,2,3,4,5Jayawantrao Sawant Polytechnic, Hadapsar Pune, India.
DOI: https://www.doi.org/10.56726/IRJMETS68435

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.

Keywords: Pipelines, Pipeline Inspection Robot Leak Detection, Pipe Leakage, Water Distribution System.

I. 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. Pipe line inspection robots are remotely operated vehicles used to inspect the internal condition of pipelines. These robots are equipped with sensors and cameras to detect corrosion, cracks, and other defects. Pipeline inspection robots are advanced technological tools designed to inspect and maintain pipelines that transport various substances, such as water, oil, or gas. These robots are essential for ensuring the integrity and safety of pipeline systems.

II. LITERATURE REVIEW

In their research article, Jong-Hoon Kim, Gokarna Sharma, and S. Sitharama Iyengar have proposed the design and execution of a single module fully autonomous mobile pipeline exploration robot that they have dubbed FAMPER. This robot is capable of inspecting pipelines that are 150 millimeters in diameter. This particular robot is made up of four wall-press caterpillars, each of which gets its power from two DC motors. In order to give steering capacity that allows the vehicle to go between 45-degree elbows, 90-degree elbows, T-branches, and Y branches, the pace of each caterpillar is regulated individually. The fact that this research is the first of its kind is that it demonstrates the possibility of employing a fourcaterpillar structure that offers improved performance in all kinds of elaborate pipeline networks. The robotic system has been created and tested in a variety of pipeline configurations prior to its implementation. In addition, this robot has a wide range of uses in the chemical industry, as well as in Gulf member states for the purpose of inspecting oil and gas pipelines. (1)
[1] Based on the findings of the study paper written by Atul Gargade1, Dhanraj Tambuskar, and Gajanan Thokal, it has been postulated that a robot is made up of a body, a foreleg system, and a rear leg system. There are three worm gear systems that are used in the construction of the fore and rear leg systems. These gear systems are positioned at an angle of 120 degrees with respect to each other in order to let them to function

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inside of pipes of varying sizes. In order for the robot to function in pipes with diameters ranging from 140mm to 200mm, the springs are linked to each leg as well as the body of the robot. 2 [2] Palwinder Kaur's research article, which can be found (1) Gurpreet Singh and Ravinder Kaur have collaborated on the development of a novel concept that will allow them to manage bore well rescue operations without the need for human intervention and to inspect any form of leakage in the pipe. There is a system that utilizes wheeled legs in this design so that it may go within the pipe. A circumferential and symmetrical distance of 120 degrees is maintained between each pair of legs. The legs of the robot are able to be adjusted in accordance with the size of the pipeline because it has been made adaptive. Having an adaptable structure that can be adapted to the diameter of the pipe and having an attracting force that can be adjusted in the direction of the walls of the pipe are both made feasible by this structural design.[3]: Binti Nur Afiqah binti There have been explanations provided by Haji Yahya, Negin Ashrafi, and Ali Hussein Humod regarding the application of robotics in a variety of industries, mostly in pipeline inspection. The purpose of this review paper was to satisfy the requirement of the evaluation section for the Automation and Robotics module. These are the goals of this review paper: to observe various robotics applications in pipeline inspection; to learn about the various designs of robots used in pipeline inspection; to outline the difficulties and adaptation improvements in the robotics application that was applied; and to learn about the different designs of robots used in pipeline inspection. It was stated at the end of this review paper that there were certain improvements that were found in a few designs of the robot example, such as the Parallelogram Wheel Leg [4]. for the purpose of inspection, a hybrid locomotion mechanism is proposed. There is a guarding method and an optimal guarding algorithm that are proposed in the research article that was written by Xin Li [5].

III. METHODOLOGY

1. Design

Develop a lightweight, modular robot design that Can navigate through various pipeline configurations and environments.

2. Sensor Integration

Incorporate advanced sensors, including cameras, ultrasonic sensors, and pressure sensors, to gather comprehensive data on the pipelines condition.

3. Data Processing

Implement robust data processing algorithms to analyze the collected information and identify potential issues or detects in the pipeline.

4. Wireless Communication

Establish a reliable wireless communication system to transmit data from the robot to a centralized control station in real-time

5. User Interface

Develop a user-friendly interface that allows operators to monitor the robot's progress, view inspection data, and make informed decisions.

6. Field Testing

Conduct rigorous field testing to evaluate the robot's performance, identify and address any technical challenges, and ensure the reliability of the system.

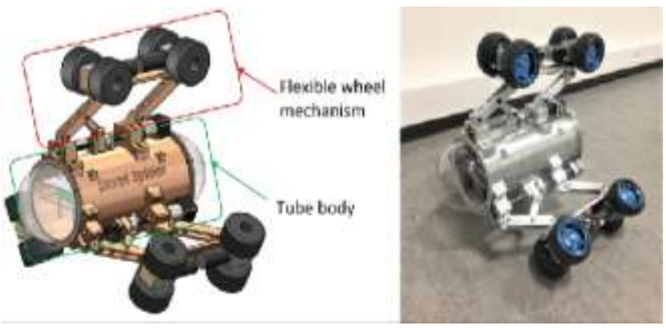

Fig 1:

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Fig 2:

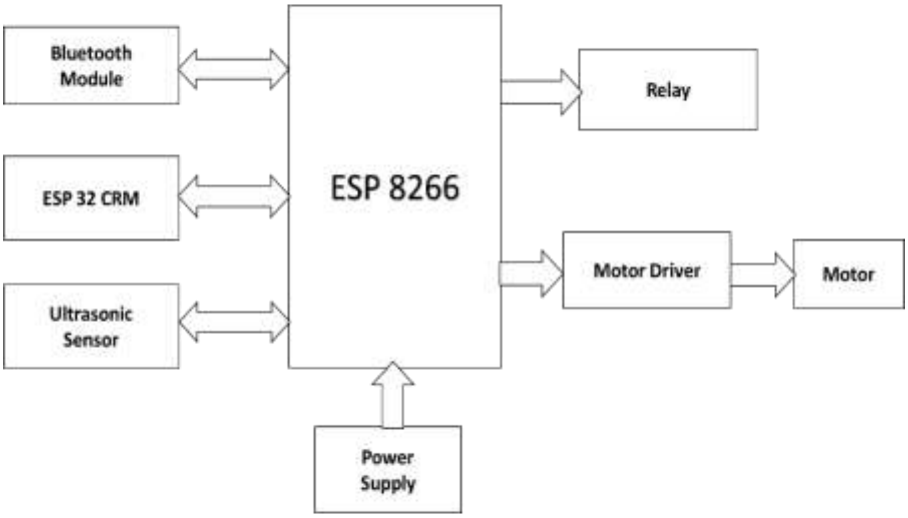

Fig 3: Block diagram of proposed system

The construction of the robot is done in such an manner 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. An ultrasonic sensor is utilized in order to identify the obstructions and a driller is used to remove them. The codes required to detect cracks and obstacle were written and dumped on an Node MCU.

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 accomplished with the assistance of an ESP8266 module that is connected to both the laptop and the robot. A PVC pipe of four inches diameter. was used for testing the pipeline in sopection robot.

FLOWCHART

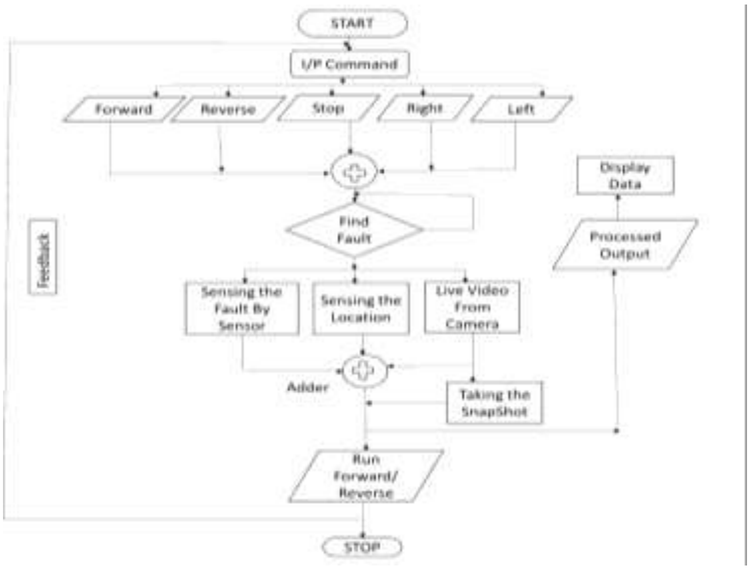

Fig 4: Flowchart of the proposed system

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Pipeline inspection robot, designed to navigate pipelines autonomously, detect faults, and document them. It begins with directional input commands (forward, reverse, stop, right, left) to control movement, followed by continuous fault detection using onboard sensors. Upon finding a fault, the robot identifies its location and activates a live video feed for visual inspection, capturing snapshots for further analysis. The data from both sensors and the camera are processed and displayed, providing real-time feedback on pipeline conditions. A feedback loop adjusts the robot's movement based on the fault detection, ensuring thorough inspection and efficient navigation.

IV. DESIGN

Fig 5: Design of robot

Design Constraints

Size and Dimension: The robot should have a compact size and dimensions to fit and navigate through pipes of varying diameters and configurations.

Maneuverability : The robot should be able to navigate through tight spaces, bends, and obstacles within the pipe network.

Robustness and Durability: The robot should be built with materials and components that can withstand harsh and corrosive environments found in pipes, ensuring long-term reliability.

Power and Energy Efficiency:

The robot should.

This model is created using the blender Software. It's a 3D model of robot . Here we created three The pipe leak detection and localization robot consists of a mechanism of nine-legged 120 – degree apart rotor based traction tire set-up whichis docked into multiple transition element which is welded into the main central frame, additional push element with spring loaded risers are inserted to eliminate the change arising within external walls of pipe and the tire sub- clearance be designed to operate using efficient power sources, such as batteries, to provide sufficient runtime for inspections without frequent recharging or replacement.

Sensing and Detection Capabilities: The robot should incorporate sensors and detection systems capable of accurately identifying cracks, leaks, blockages,and other pipe abnormalities.

Communication and Data Transmission: The robot should be equipped with reliable communication systems to transmit inspection data, video feedback, and control signals in real- time to operators or monitoring systems outside the pipes

V. ADVANTAGES

1. Enhanced Safety

Reduces the need for human inspectors to enter potentially hazardous environments, minimizing safety risks associated with confined spaces.

2. Improved Accuracy

High-resolution cameras and advanced sensors provide precise data on pipeline conditions, enabling accurate detection of leaks, corrosion, and blockages.

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3. Cost Efficiency

Reduces labor costs and downtime associated with manual inspections, leading to significant savings in maintenance and operational expenses.

4. Real-Time Monitoring

Provides real-time data collection and analysis, allowing for immediate identification of issues and faster decision- making.

5. Non-Invasive Inspection

Inspects pipelines without the need for excavation or disruption to the water supply, maintaining

VI. CONCLUSION

The development and deployment of pipeline inspection robots represent a significant advancement in the maintenance and monitoring of pipeline infrastructure. These robots enhance safety by reducing the need for human entry into hazardous environments, improve efficiency through real-time data collection, and lower operational costs by minimizing downtime.

In conclusion, the development of an advanced pipeline leakage detection and localization robot represents a significant step forward in the maintenance and monitoring of critical pipeline infrastructure. By integrating multiple sensing technologies such as acoustic, ultrasonic, and gas detection systems, the robot can effectively identify and locate pipeline leaks with high accuracy. The autonomous nature of the robot, combined with advanced algorithms for navigation and leak localization, reduces the need for manual inspections, minimizing operational downtime and human exposure to hazardous environments.

The experimental findings demonstrated that the proposed system is capable of detecting leaks under various conditions, including pipelines with different diameters, materials, and operational environments.

VII. FUTURE SCOPE

1. Autonomous navigation:

Future developments may focus on autonomous navigation, enabling the robot to inspect pipelines without human intervention.

2. Advanced sensor technologies:

Future developments may incorporate advanced sensor technologies, such as acoustic sensors or electromagnetic sensors, to enhance defect detection and classification.

3. Integration with other technologies:

Future developments may integrate the robot with other technologies, such as drones or satellite imaging, to provide a more comprehensive pipeline inspection solution.

VIII. REFERENCES

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