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Pipeline Cleaning Robot

Prof. Sowmya M, Vismitha V, Shreya G, Suhana Hussian,
Vijeta Reddy V

a Professor, Vidya Vikas Institute of Engineering and Technology,Dept. of ECE,Mysore,India 570011, bStudent,Vidya Vikas Institute of Engineering and Technology,Dept. of ECE,Mysore,India 570011, cStudent, Vidya Vikas Institute of Engineering and Technology,,Dept. of ECE,Mysore,India 570011, dStudent, Vidya Vikas Institute of Engineering and Technology,,Dept. of ECE,Mysore,India 570011, eStudent, Vidya Vikas Institute of Engineering and Technology,,Dept. of ECE,Mysore,India 570011.

Abstract: *The name of our project is pipe the pipe inspecting and cleaning robot (PIAC); in a nutshell it is a robot that will be used to clean the interior of the pipes using a brushing mechanism. One of the critical areas of the oil and gas industry is the transport of oil and other fluids through a network of pipes. Over time these pipes have accumulated amount of slug and other deposits; this leads to decrease in pipeline carrying capacity, reduced reliability, loss of power due to higher pumping pressure required and irregular flow. In the light of the problems mentioned above we have decided to attempt to solve this problem using our project. This will not only clean the interior of the pipe but also be able to send live video feedback to the personnel on the ground depicting the kind of residues found in the pipes. The robot can also be added with additional sensors to relay any other critical information. The pipeline cleaning robot is one of the most important system developed for a proper maintenance of underground pipes. Due to large development and increase in usage of fuel, oil, gas and the pipes used for such process need to be maintained properly. There are many ways to do that so but biggest problem arises with such maintenance machine are heavy cost and durability to work in and out of the pipes. 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*

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I. Introduction

Pipeline cleaning robot is used to clean the interior of the pipes using a brushing mechanism. One of the critical areas of the oil and gas industry is the transport of oil and other fluids through a network of pipes.

Over time these pipes have accumulated amount of slug and other deposits, this leads to decrease in pipeline carrying capacity, reduced reliability, loss of power due to higher pumping pressure required and irregular flow. In the light of the problems mentioned above we have decided to attempt to solve this problem using our project. This will not only clean the interior of the pipe but also be able to send live video feedback to the personnel on the ground depicting the kind of residues found in the pipes. The robot can also be added with additional sensors to relay any other critical information. 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.

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

II. Literature Survey

The purpose of this literature survey is to study the Pipeline cleaning robot. To know more about the alternative solutions that are implemented instead of our proposed model related literature review and to get the knowledge about the different technologies that are implemented to design a system.

[1] In-pipe Cleaning Mechanical System for DeWaLoP Robot - Developing WaterLoss Prevention The work presented.Describes the design and development of a mechanism used forpipe-joint redevelopment from the Developing Water Loss Prevention (DeWaLoP) project. The project objective is to redevelop the cast-iron pipes of the over 100 years old fresh water supply systems of Vienna and Bratislava, by building a robot that crawls into water canals of about one meter in diameter and that is able to clean and apply a restoration material to repair the pipe-joint gaps. This proposed redevelopment pipe-joint method is more complex than conventional ones, which superficially clean the in-pipe surface with a rotating tool located at the front of the robot without cleaning in detail the area of application.

[2] Oil Pipelines/Water Pipeline Crawling Robot for Leakage Drive control system plays important roles in pipeline robot. In order to inspect the flaw and corrosion of seabed crude oil pipeline, an original mobile pipeline robot with crawler drive unit, power and monitor unit, central control unit, and ultrasonic wave inspection device is developed. Considering the limited space, a compact hardware system is designed based on an ARM processor with controllers. With made-to-order protocol for the crawl robot, an intelligent drive control system is developed. The implementation of the crawl robot demonstrates that the presented drive control scheme can meet the motion control requirements of the underwater pipeline crawl robot.

[3] Fully Autonomous Pipeline Cleaning Robot Fully Autonomous Pipeline Cleaning Robot is used to clean the mud or dirt inside the pipe. The autonomous pipe cleaning robot has four tracks to make a smooth mobility inside the pipe. The track was attached with foldable linkage. The foldable linkages give the ability to the robot to move horizontally or vertically inside the pipe. The compress and track design was combined together to maximize the efficiency of the robot. Furthermore, the track wheel will give more friction between robot and the pipe. Thus it can prevent the robot from slipping or spinning inside the pipe. The wire brushes are an effective way to remove the mud inside the pipe. This gives the idea of combining the robot technology with the wire brushes cleaning technology. The brushes are attached behind the robot. The brushes will rotate to clean the mud.The cleaning process will start if the sensors detect the mud. If the sensors do not detect the mud, the cleaning process will not happen. By using this method the life span of battery can last longer due to power saving. The dsPIC30F4011 is used as the microcontroller for the robot to control the movement of the robot. The sensor used in this project is infrared sensor. Infra-red sensor is used to detect the obstacle in front of the robot. If there are any obstacles the robot will reverse automatically until the robot come up from the pipe.

[4] Design of a Fully Autonomous Mobile Pipeline Exploration Robot (Famper) This thesis presents the design and implementation of a robot based on novel idea we call “caterpillar navigational mechanism”. A Fully Autonomous Mobile Pipeline Exploration Robot (FAMPER), for exploring pipeline structures autonomously has been built and its performance has been evaluated. FAMPER has been designed for 6 inch sewer pipes, which are predominantly used in urban constructions. The proposed design enables FAMPER to display formidable mobility and controllability in most of the existing structure of pipeline, and provides a spacious body for housing various electronic devices. Specifically, FAMPER is equipped with several sensors, and a high performance processor for autonomous navigation.

[5] Advanced pipe inspection robot Recently many plants' pipes and drains became old and many robots to inspect these pipes were developed in the past. Wired robots were put to practical use, but they had a heavy power supply and a signal wire. Therefore, new inspection robots using wireless radio communication system are considered useful for long complex pipes and long distance pipes including straight, vertical and bend line. But sending wireless radio signals isn't practical because the properties of the radio wave are affected by the shape and material of the pipes

Summary of the Literature survey

The outcome for the literature survey are as follows:

1. By outlining the problems and adaptability improvements in the robotics application that were applied, it can be concluded that improvements in few designs of the robot example the Parallelogram Wheel Leg which proposes a hybrid locomotion system for inspection. This ensures the movement of the robot inside the pipe without flipping and providing grip to the robot inside the pipe.
2. Confirmation of pipe condition and flow integrity, by using Live video streaming to monitor the condition of the pipe and to make sure that the cleaning is done.

3. It is found from the previous projects that there's a need to work on power savings by reducing pump pressure which has to be the outcome of cleaning.
4. The brushing mechanism to be in an appropriate manner to ensure effective cleaning of the pipeline interiors
5. Robot to have fast response reaction to bring out appropriate action.

III. Methodology

The robot has 4 wheels and 1 cleaning brush as shown in figure 3.1 below. The cleaning brush is significantly large because it snugly fits into the pipe diameter and also can comprehensively clean the top and the bottom.

1 **Mobility system**: The mobility system consists of the motors that control the motion of the robot with the pipe. There are 2 motors that are connected to 4 wheels 2 in the front and 2 at the back.

2 **Cleaning system**: the cleaning system consist of the powerful cleaning motor that is connected to the from of the robot.

3 **Wireless control**: Wireless control system is responsible for the wireless communication between the robot.

4 **Video feedback**: This sub system connects the camera to the rest of the robot.

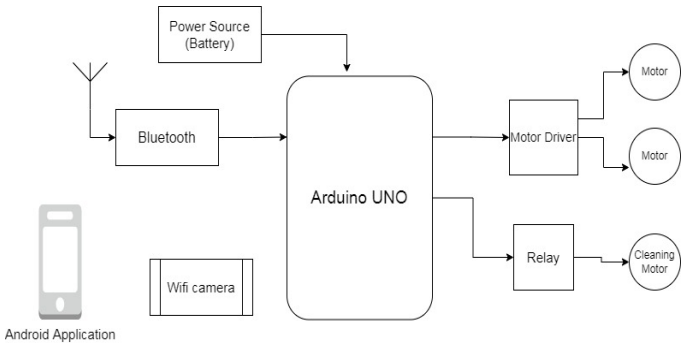

Figure 2. Block diagram of Pipeline cleaning robot

1. Robot Design and Construction: The first step is to design and construct the pipeline cleaning robot. This involves selecting the appropriate size, shape, and materials to ensure compatibility with the pipeline being cleaned. The robot should be equipped with necessary cleaning tools, sensors, and cameras to perform its tasks effectively.

2. Navigation and Propulsion: Pipeline cleaning robots need to navigate through the pipeline system autonomously or under remote control. They are equipped with propulsion mechanisms such as wheels, tracks, or even crawling mechanisms to move through the pipeline. Navigation systems may utilize sensors, cameras, or mapping technologies to help the robot navigate and identify its location within the pipeline.

3. Cleaning Mechanism: Pipeline cleaning robots use various cleaning mechanisms depending on the type of deposits or contaminants they are designed to remove. Some common cleaning mechanisms include brushes, scrapers, water jets, vacuum suction, or high-pressure air systems. These mechanisms are designed to effectively dislodge and remove debris, sediment, scale, or other contaminants from the pipeline walls.

4. Sensing and Inspection: Pipeline cleaning robots often incorporate sensors and cameras to monitor and inspect the pipeline's condition. These sensors may include proximity sensors, pressure sensors, or corrosion sensors to detect abnormalities or damage in the pipeline. Cameras and imaging systems provide visual inspection capabilities, allowing the robot to identify cracks, leaks, or other structural issues.

5. Data Collection and Analysis: The robot collects data during the cleaning and inspection process. This data includes information on cleaning progress, pipeline conditions, and any detected anomalies. The collected data can be analyzed in real-time or later to assess the pipeline's integrity, identify maintenance needs, or generate reports for further action.

6. Communication and Control: Pipeline cleaning robots may require communication capabilities to receive commands, transmit data, or provide status updates. This can be achieved through wired connections or wireless

communication protocols. Remote control systems or autonomous algorithms enable operators to control the robot's movements and cleaning processes.

7. Maintenance and Upkeep: Regular maintenance and upkeep are necessary to ensure the pipeline cleaning robot's optimal performance. This includes cleaning and maintenance of the robot itself, such as cleaning the brushes, replacing worn-out parts, or calibrating sensors. The robot's cleaning tools or attachments may need to be replaced or adjusted depending on the pipeline's specific requirements.

IV. Results and Discussions

1. Improved pipeline efficiency: By removing deposits, sediments, and contaminants, pipeline cleaning robots can restore the desired flow capacity, optimizing the overall efficiency of the pipeline system.

2. Extended pipeline lifespan: Regular cleaning and maintenance with pipeline cleaning robots can help prevent corrosion, reduce the risk of leaks, and minimize structural damage, potentially extending the lifespan of the pipeline.

3. Enhanced operational safety: Pipeline cleaning robots eliminate or reduce the need for manual cleaning methods, minimizing risks associated with human entry into confined spaces or hazardous environments.

4. Real-time inspection and monitoring: Many pipeline cleaning robots are equipped with sensors and cameras that enable real-time inspection and monitoring of the pipeline's condition. Early detection of issues such as cracks, leaks, or corrosion allows for timely repairs and maintenance.

5. Cost efficiency: While the initial investment in pipeline cleaning robots can be significant, they can offer cost savings in the long run by reducing manual cleaning operations, minimizing downtime, and preventing costly damages.

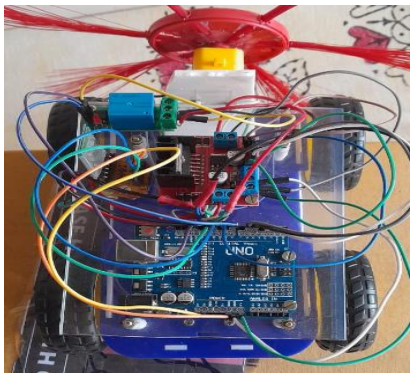

Fig 2. Proposed Model of "Pipeline Cleaning Robot"

V. Conclusion

Robots can be effectively used as tools to carry out work in labor intensive, hazardous and unreachable work environments. Pipeline systems are one such environment. Robots can be successfully implemented in pipe line inspections for better detection of defects. The project aimed to create an in-pipe robot with adaptable structure, autonomy and achieve vertical motion. The following conclusions can be drawn from the project. Our robot is able to inspect in practical situations. It has ability to travel in vertical as well as horizontal directions and turn in elbows. It is employed with dual locomotion system to achieve this goal. It helps to show the actual image inside the pipe. It able to easy to find defect, flaws, material decay, corrosion and crack. Robot have a good work accuracy and very fast in process than human being

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