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Pipe Inspection and Declogging Robot

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***Abstract* - Pipeline transports oil and gases for far distances. Routine maintenance is necessary for these pipes which avoid any abnormality things such as, crack, leakage or deposit. Although it's less common, corrosion also can occur on the inside surface of the pipe and reduces the strength of the pipe. If crack goes undetected and becomes severe, the pipe can leak and, in rare cases, fail catastrophically. Extensive efforts are made to mitigate corrosion. Hence it is important to maintain it safely and economically, therefore the robot becomes most useful product available for this purpose. Automated inspection of the inner surface of a pipe can be achieved by a mobile robot. In the present project, trial has been made to design the robot in such a way that it moves with lower pace, which is highly necessary for the function of inspection. The wheels of the robot are designed in such a way so that it can traverse inside a curved surface of the pipe without slipping .it is also designed such that it is totally automated and controlled by Smartphone using Bluetooth.**

Keywords— Pipeline; Crack; Leakages; Corrosion; Declogging; Smartphone; Bluetooth.

I. INTRODUCTION

Robotics is one of the fastest growing engineering fields of today. It designed to reduce the human factor labor intensive or potential risks and to work in inaccessible environment. Robots are more common now than ever before and it is not necessarily only using in the heavy production industries. Pipeline transports the oil, gases, and other for far distances. The routine maintenance is necessary for these pipes which avoid any abnormality things such as, crack, leakage or deposit. That's why it was important to use safely and economically thing, therefore the robot becoming most attractive product available. The major companies supplying and maintaining the oil pipelines faces many problems and difficulties when people want to inspect or check the oil pipeline and spent huge money on this process. During the maintenance of these pipelines, the employee's exposure to the risk of choking. Moreover the companies also incurred more maintenance cost also staff and labor costs. And more often they did not able to find any faults in pipeline so they lose money, time and human effort. Hence, it is proposed to design a simple pipeline inspection robot to inspect pipeline for any malfunctions and to perform maintenance work. This robot may solve the problems of companies facing for inspection and we can implement it. Many kinds of pipes are being utilized to construct important lifelines such as water and gas supply in our contemporary society. Also pipes are widely used in chemical industries and in gulf countries for carrying petrol, diesel, oil etc. But after some years these pipes get damaged and defects are occurring in pipe. If the defects in the pipe are caused by rust and nature calamity, it is difficult to find out the defects and the place of the defects, and also there is great amount of loss. Thus scheduled inspection must be done. If we decide to do this inspection manually then large amount of time, effort and labor is necessary to grub up the pipes that are buried in the ground. If the robot can inspect inside the pipes, fast and accurate examination will be able to be done at low cost.

II. PROBLEM DEFINITION

Recently, many industries use different diameter pipes for different applications, like to carry chemicals, high pressure steam gases and water. Hence there may be chances of problems like corrosion, cracking, dents, metal losses and leakages. These problems are inevitable. The blockage inside the pipe can reduce the efficiency of the water flow. The conventional method is very difficult, tiring and expensive. These problems are not only seen in industry but also in houses and power plants. To overcome this, the pipe can be inspected with the help of "PIPE INSPECTION ROBOT".

III. OBJECTIVES

The objectives of the project are ,

- To traverse a robot inside a pipe with forward and backward motion and declogg the blockage.
- To design the robot to move in pipes of diameter eight inches and above.
- To build a fully autonomous pipeline cleaning robot, which can be controlled using Smartphone.
- To construct a robot that can minimize the mud and scales inside the pipe.

IV. DESIGN OF THE ROBOT

Design consists of application of scientific principle, technical information, and imagination for development of new mechanism to perform specific function with maximum economy and efficiency. Hence careful design approach has to be adopted. The pipe inspection robot has been designed such that, it can fit inside 8 inch or greater diameter pipes easily. The shape of the body of the robot is kept similar to a

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pipe, so that it can easily traverse inside the pipe, without any unnecessary friction. A declogging system has been designed in front of the robot, which has five circularly placed blades on a turbine like structure. The wheels are placed not orthogonally but at an angle of 60 degree with the bas , so that it provides necessary contact surface for the locomotion of the robot. The pipe inspection robot was designed using Catia V5 software as shown in the figure.

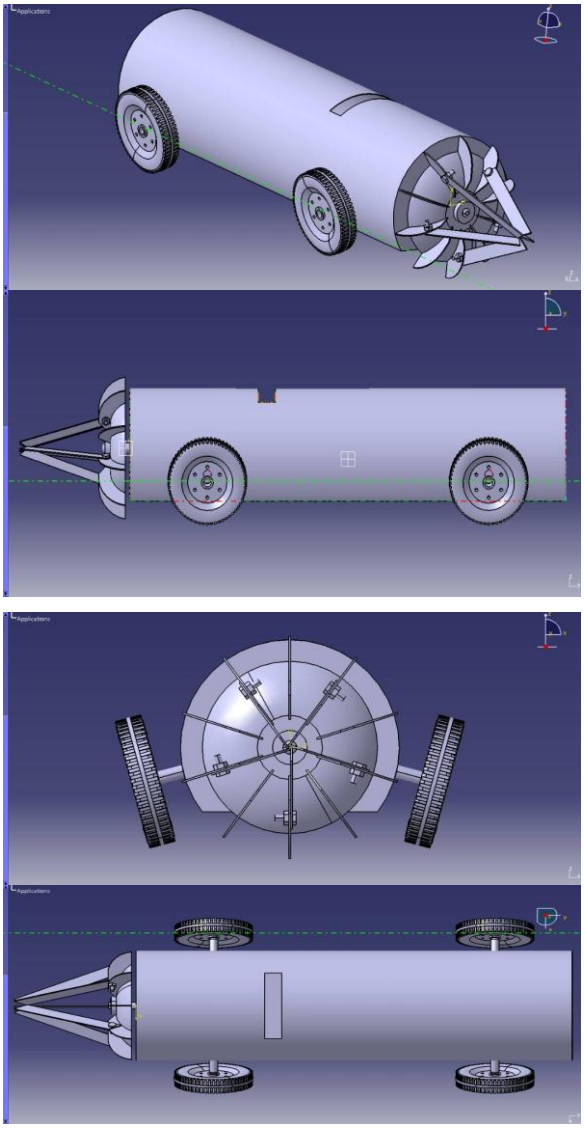

Fig 1. Geometrical model of the robot

V. INSPECTION

The main function of the pipe inspection robot is inspection of the pipe. It checks for various defects such as dents, cracks leakages, and blockages inside the pipe. This function is carried out by installing a Smartphone on the robot. The Smartphone has 5 mega pixels of camera which captures the inside of the pipe and by using wifi sends the live video to another Smartphone which is used to control the robot. The Smartphone which is used to control the robot, receives the video and by seeing that video, the robot can be controlled. The 5 megapixels of camera gives a fine clarity of image and the flashlight on the Smartphone is required to provide light during video streaming.

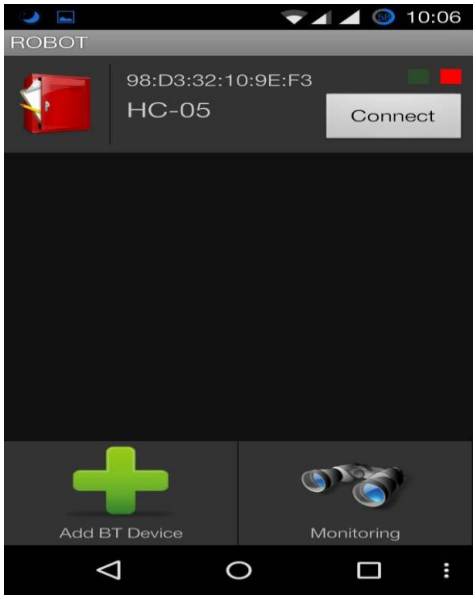

Fig 2. *Application used for control and monitoring*

VI. CONSTRUCTION OF THE ROBOT

a. Body of the robot

The body of the robot is made up of Galvanized Iron sheet (GI sheet), with zinc coating which provides resistance against corrosion and rusting. It is designed in such a way, that it can accommodate inside 8inch and above pipes. The GI sheet provides the best strength to weight ratio, which reduces the overall weight of the robot. Galvanizing is a process of coating iron or steel with zinc in order to provide greater protection against corrosion for the iron or steel base.

b. Declogging system

A declogging system has been installed at the front of the robot. It consists of a turbine and 5 stainless steel blades have been fixed at the front of the turbine. The whole system is driven by a motor, fixed with a help of a clamp to the base of the robot.

The function of the declogging system is to cut through the blockages in the pipe. When a blockage is detected in the pipe by camera, the turbine is switched on using the controlling Smartphone the blades cuts the blockage and clears the way for the fluid water to flow.

Fig 3. Declogging System

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c. Battery

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smart phones, and electric cars. We have installed 12v DC rechargeable battery which powers microcontroller, four drive DC motors of 45rpm.One DC motor of 200rpm and Bluetooth device.

d. Bluetooth device

A Bluetooth transceiver module has been installed in the robot .this device helps in the control of the robot through smart phones .when the battery is switched on, the Bluetooth is on and is connected to the Smartphone.

The following are some of the features of Bluetooth device used:

- Serial port BluetoothDrop-in replacement for wired serial connections, transparent usage
- Frequency – 2.4GHZ
- BER Speed: Asynchronous: 2.1 Mbps(Max) / 160 kbps, Synchronous: 1Mbps/1Mbps .
- Bluetooth serial port Power supply: +3.3VDC 50m.

Fig 4. *Bluetooth device*

e. Microcontroller

A microcontroller is a small computer on a single integrated circuit. In modern terminology, it is a system on a chip or SiC. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips. A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. Components (e.g. capacitors, resistors or active devices) are generally soldered on the PCB. The robot is installed with SST89E51RD2, where SST – Silicon Storage technology E – Version E RD – Research and Development.

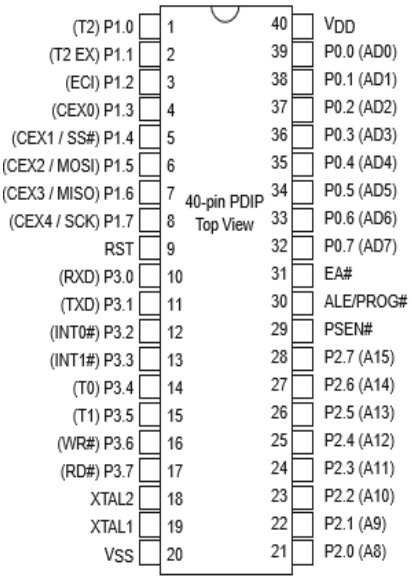

Fig 5. Functional block diagram of embedded circuit

VII. EMBEDDED CIRCUIT

An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today. Ninety-eight percent of all microprocessors are manufactured as components of embedded systems. Modern embedded systems are often based on microcontrollers (i.e. CPU's with integrated memory or peripheral interfaces), but ordinary microprocessors (using external chips for memory and peripheral interface circuits) are also common, especially in more-complex systems.

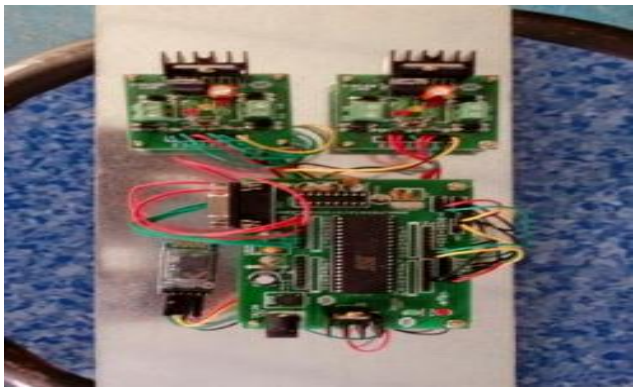

Fig 6. Embedded circuit.

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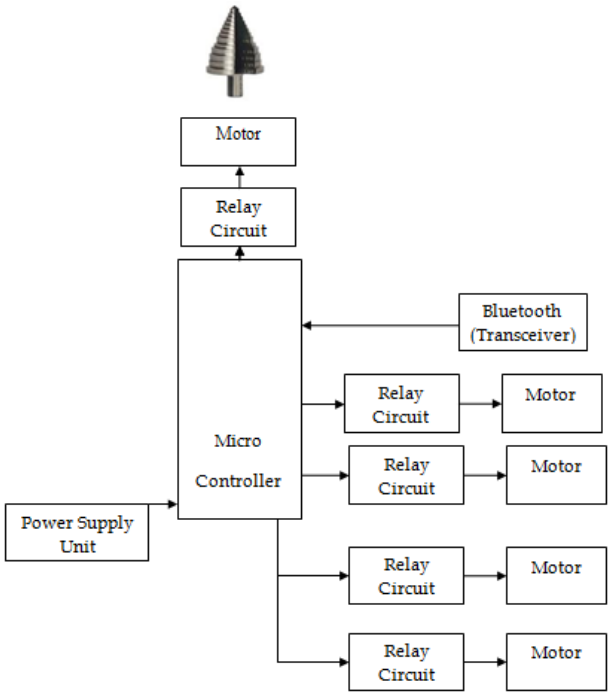

Fig 7. Block diagram of receiver circuit

VIII. WORKING OF THE PIPE INSPECTION ROBOT

As Pipe Inspection Robot is designed mainly for drainage pipes, it has ability to move inside any bore diameter pipes ranging from 8 inch to 12 inch. Suitable mechanisms are provided so that it gains ability to move inside the bends and tapered pipes. The PIR have ability to see inside the dark pipes where no human eyes can see. This made possible by mounting the smart phone with 5MP camera and flash light on the top of the robot. The output is send to outside screen where the digital hi-quality image can be received. The perfect fitness between the pipe and robot is first conformed after inserting the robot in the pipe. Then the supply of DC 12V dc current from is on for working of robot and the camera is also started. The robot is controlled by using another Smartphone which displays the control icons to the forward ,reverse ,right and left by swiping that icon .it also displays a real time video so that, we can see the pictures and videos inside the pipe.

Working of PIR is starts from its insertion in pipe.. PIR is about 42.5 cm in length and to move it freely inside the bend pipes. As switch is on and current is flowing through wires, wheels starts moving and forces PIR to PIR could have more than three arms for better judgment and perfection but it would increase the weight and cost of manufacturing and hence we need to do tradeoff between money involvement and perfection. PIR wheel motion is provided with 45 rpm, 12 V DC motors hence its speed can be maintained between 0.1m/s to 1.5m/s. The power provided to motors is from single 12V dc adapter hence load on each motor will be minimum that expected. The robot is run inside pipe by forward and reverse motion of the wheel which has the speed of 45 rpm. This constant slow speed is to insure better inspection because of the high speed there may be possibility to miss the any defect .The smart phone on the robot captures the picture with clarity of 5 mega pixels. The output image from camera is send to another smart phone which is used to control the robot.

Operator can control the robot and see the picture of the inside pipe on the output screen and thus if there is any defect such as such as internal material loss , big crack, weld defects dents corrosion erosion or blockage in the pipe . The exact location of the defect is judge by the distance meter provided on the robot it gives distance in centimeters from the starting point from which the robot was inserted inside the pipe. the distance the robot can travel i.e. the length which it can capable to inspect is depends upon the length of the extension cable provided to robot. To insure the tractive force required pulling the long extension cable and other accessories, robot train can be used which can be made by joining the two or more robots through the universal joints at the end. The inspection can be done on the basis of video and pictures inside the pipe provided by camera. The result can be obtained directly on the basis of these pictures or with the help image processing.

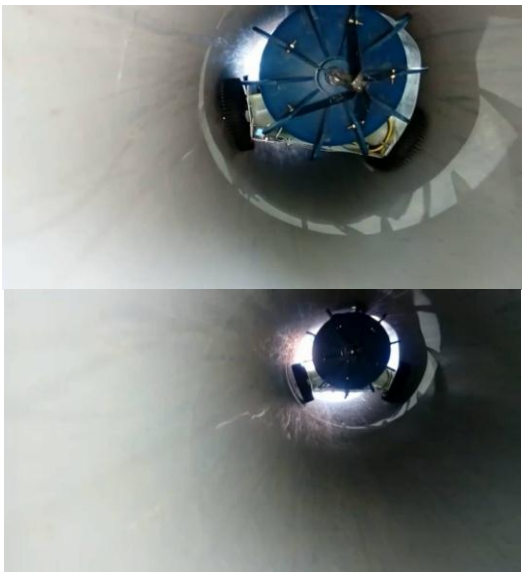

Fig 8 . Working of the Robot

IX. APPLICATIONS

Today's mobile robots are used for inspection, surveillance, monitoring and non-destructive tasks. Some of the current applications are as below:

- Allow inspection of inaccessible and / or hazardous equipment or work areas.
- Provide on-line inspection / maintenance without loss of equipment / plant availability & remove
- Helps human from potentially hazardous work situations.
- Provide information about the health and condition of critical plant components to facilitate decision
- Reduce equipment / plant downtime and improve maintenance and inspection procedure thorough better coverage and documentation.
- The robot has great application in accessing the regions of pipe where human cannot reach. It can be mounted with a camera which sends pictures of inside and help in inspection.

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- It can be fitted with ultrasonic sensors and can pin point the location of a hole.
- It is of course vital to continually reduce the risks brought about by the manufacture, transport and storage of chemicals. This means that the possible dangers need to be examined and the necessary testing and inspections carried out in order to avoid or at least lessen and contain them. The use of our robots has become obligatory in many well known companies.
- Leakages in long distance heat conduits, caused through external corrosion, cause energy and water losses resulting in damage to, among others, subterranean constructions. Minimizing energy loss during the transport of heat from source to end user is one of the most important requirements in order to exclude danger to people and the environment. This robot help in this important duty

X. CONCLUSION

Robots play an important role in inside pipe-network maintenance and their repairing. Some of them are designed to realize specific tasks for pipes with constant diameters, and other may adapt the structure function of the variation of the inspected pipe.

Here, inside pipe modular robotic system is proposed. An important design goal of this robotic system is the adaptability to the inner diameters of the pipes. The given prototype permits the usage of Smartphone camera for visualization of the in-pipe inspection. This prototype is wirelessly controlled by a Smartphone using Bluetooth connectivity.

The major advantage is that it can be used in case of pipe diameter variation with the simple mechanism. A pipe inspection robot was developed that can be applied to 8inch - 15 inch pipeline. A real prototype was developed to test the feasibility of this robot for inspection of in-house pipelines. The types of inspection tasks are very different. A modular design was considered to easily adapt to new environments with small changes. Presence of obstacles within the pipelines is a difficult issue. In the proposed mechanism, the problem is solved by the installation of a declogging system at the front of the robot. The robot is designed to be able to traverse horizontal 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.

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