# Investigation of Design & Fabrication of In-Pipe Inspection Robot

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**Abstract : This paper proposes an in pipe inspection robot with the wall-pressing force adjustment using DC motor. It is developed for long distance inspection in sea-water pipelines such as horizontal pipelines and slope pipelines with large variable diameters from 600mm to 800mm. Its mechanical design consists of two modules as driving module and control module. The driving module has three pantograph type links spaced in 120° with three caterpillar track wheels. This design makes it possible to realize the adaptation to pipe diameter and the adjustment of wall-pressing force. The control module consists of a micro controller, motor driver and sensor interface. To control the in pipe inspection robot, firstly, the in pipe inspection robot is considered as a dynamic model of mass-spring-damper system. Secondly, an observer is designed to estimate the unknown wall-pressing force to sustain the robot in pipeline. Thirdly, an algorithm of wall-pressing force generator is presented to find out an appropriate reference value of wall-pressing force. Finally, the driving tests results of the developed in pipe inspection robot are shown to prove the effectiveness of the proposed controller and the applicability of the developed in pipe inspection robot.**

**Keywords: wall-press robot, in-pipe inspection.**

## I. INTRODUCTION

An important application for robotic systems is the area of pipe inspection in the oil, chemical and nuclear industry, and the public water systems see in fig no (1). In this context and on the basis of its experience in mobile robots the, a new concept of wheeled robot for in-pipe inspection. The inspection of pipes may be relevant for improving security and efficiency in industrial plants. These specific operations as inspection, maintenance, cleaning etc. are expensive, thus the application of the robots appears to be one of the most attractive solutions. 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.

The robot has a number of advantages:

- The vehicle has a very simple kinematics and uses a single motor.
- Low energy consumption, thanks to the simple kinematics.
- It can move in horizontal, vertical as well as curved pipe geometries.
- The robot can adapt to changing diameters and to small obstacles on the inner surface of the tube.
- The robot can easily be protected against humid and dirty environments.
- It can be used for weld inspection, fault detection, cleaning and repairing of internal pipe surfaces, etc.

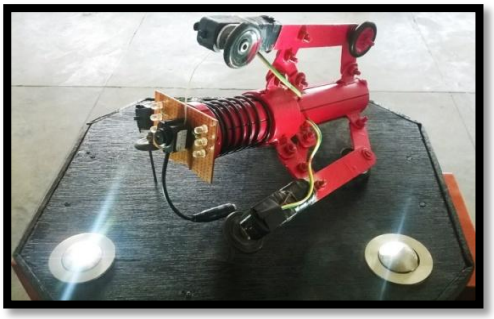

Fig.1 pipe inspection robot

## II. OBJECTIVE

1. This project is made to inspect the underground horizontal gas pipe line. This project is very useful for inspection team to inspect the leakage, blockage, or any other destruction
2. This project reduces labor cost and accidental cases. Inspect the damage portion and easily we recover from it by finding proper area where it is damage.
3. To reduces human efforts, wastage of money material handling cost. Easy to operate and find the cracks and defect.

## III. SELECTION OF MATERIAL

The materials used for this machine are light and rigid. Different materials can be used for different parts of the robot. For optimum use of power the materials used should be light and strong. Wood is light but it is subjected to wear if used for this machine. Metals are the ideal materials for the robot as most if the plastics cannot be as strong as metals. Material should be ductile, less brittleness, malleable, and high magnetic susceptibility.

Among the metals, aluminum is the material chosen for the linkages and the common rod, which is made as hollow for reduction in weight. However, other materials are chosen for the motor. The materials chosen for the motor should have high magnetic susceptibility and should be good conductor of electricity. The materials are copper and so on. But aluminum is chosen as the materials for the linkages and central body because of its much-desired properties. Aluminum has lightweight and strength; it can be used in a variety of applications. Aluminum alloys with a wide range of properties are used in engineering structures. The strength and durability of aluminum alloys vary widely, not only because of the components of the specific alloy, but also because of heat treatments and manufacturing processes.

## IV. COMPONENTS OF PIPE INSPECTION ROBOT

1. **Central Frame:** Central body is the frame of the robot. It supports all other components and holds batteries at the Centre of the body. The joints are brazed on the central frame at 120 degrees. The central body is drilled and its ends are threaded internally for the insertion of pencil batteries and closing with externally threaded caps. Wireless camera is fixed at one end of the frame.


Fig.2 Central Frame

2. **Translational Element:** Translational Element is the movable part in the robot which slides along the central body for repositioning in case of pipe diameter variation. This element is drilled at the Centre for the translating along the central body. This will restrict the links to some extreme angles beyond which it could not be translated. The extreme angles are found to be 15 degrees and 60 degrees. The joints are brazed on the translational element at 120 degrees for the links to be fixed onto it.


Fig.3 Translation Element

3. **Compression Spring:** A spring is an elastic object used to store mechanical Energy. Spring used here is made out of hardened steel. Compression spring is mainly used to exert tension. The purpose of spring is as follows.

- 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 axis assures the repositioning of the structure, in the case of the pipe diameters variation.


Fig.4 compression spring

4. **Links:** Each resistant body in a machine which moves relative to another resistant body is called Kinematic link or element. A resistant body is which do not go under deformation. While transmitting the force. Links are the major part of the robot which translates motion. Links are connected to form a linkage. The mechanism involved here is a 4 bar mechanism which has 3 revolute pairs and 1 single prismatic pairs as depicted. Links holds the receiver, switch, and 9v battery for the camera.

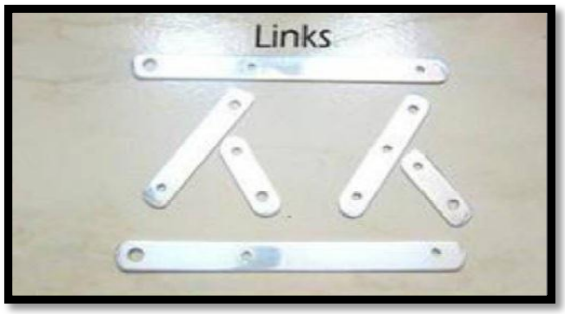


Fig.5 Links

5. **Actuators:** An **Actuator** is a type of motor for moving or controlling a mechanism or system. An actuator is the mechanism by which a control system acts upon an environment. The control system can be simple (a fixed mechanical or electronic system), software-based (e.g. a printer driver, robot control system), or a human or other agent. Actuators are the drive for the robot. Since we have chosen aluminum material for fabrication, the weight is comparatively less. So the motor should have 2 kg torque to travel inside the pipe. We used 3 motors which has 1 kg torque to make the robot in motion. The supply for the motor is

6v which is from the central body. The 3 motors are placed at 120 degrees and are supported on the links by a tag.

6. **Batteries:** Batteries give supply for a motor and wireless camera. Motor and radio frequency gets 6v supply from the central body and wireless camera gets supply from a 9v battery. And 3v batteries for transmitter which has two toggle switch. One is for motor forward and reverse control and the other one is for glowing LED's.


Fig.6 Batteries

**Wireless Camera:** Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". The distances involved may be short or long Wireless cameras have a channel also. The receiver has channels to tune in and then you get the picture. The wireless camera picture is sent by the transmitter the receiver collects this signal and outputs it to your TV or in a desktop by a TV tuner card. Camera transmits signal to the receiver which receives the signal and is connected to the monitor to view the inner side of the pipe.


Fig.7 Wireless Camera

## V. REQUIRED MOTIONS IN A ROBOT

As it is already cleared from its name that the robot is used to inspect pipes so the name that is pipe inspection robot is given to it. For the proper inspection of pipes, the motions and movements of the robot while inspection in pipes plays an important role. For proper inspection, robot is provided with two motions that are –

- LINEAR MOTION
- ROTORY MOTION

For obtaining both motions at a same time, position of wheels attached with the robot plays an important role. Therefore, wheels are attached with links at some angle along the circumference of the body of a robot. The wheels are attached at an angle of 120 degree for obtaining boot linear and rotary motion at the same time.

By this, due to both motions, wireless camera attached with a robot displays a clear and proper image inside the pipe which is to be inspected and image is displayed on a screen.

## VI. ASSEMBLY OF COMPONENTS

There are different components of pipe inspection robot which are already discussed. These components should be assembled in such a way that robot can work properly and have flexibility so that it may be adjusted according to different diameters of pipes which means that the size of robot can be changed according to the the size of pipes to be inspected.

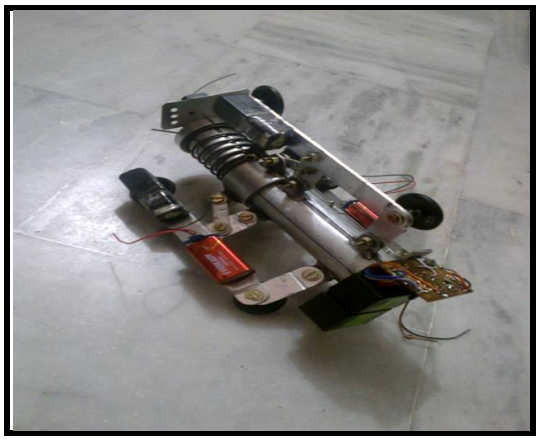

Fig.8 Assembly of Components

In robot assembly, a sleeve is fitted on the outer circumference of a body. A sleeve can slide longitudinally on the body of a robot. At the one end of body, a stopper is provided whose

Function is to stop a spring which is present between stopper and sleeve. While adjusting a size of robot, this spring plays an important role and helps in the adjustment of sleeve with which links are attached by it compression and expansion and then wheels are attached to the links and whole size of robot is changed and by this it can inspect pipes of various sizes. At the front of a robot, a wireless camera is attached to it with the help of which images of inside view of pipes are displayed on a screen and all the defects in pipes are displayed and by this inspection of pipes is done.

## VII. PIPE INSPECTION ROBOT TEST

Following the design and modeling of the proposed mechanism a prototype unit was built. The body of the robot was fabricated mostly from aluminum. The Robot

was driven by three dc motors. Pipe Inspection Robot tested successfully for movement in horizontal and vertical pipes. The robot has a good mobility and ability to pass over small obstacles. The important thing is the amount of force between robot tracked units and pipe wall. Even in horizontal moving, attachment of the up tracked unit in addition to bottom ones, improve the movement of robot. Because in this state 3 motors participate in robot move although friction is more. In addition to this, the robot is more stable and distribution of load on different actuators is more similar. Monitoring the pipe inside was suitable and the control of different actuators was effectively possible.

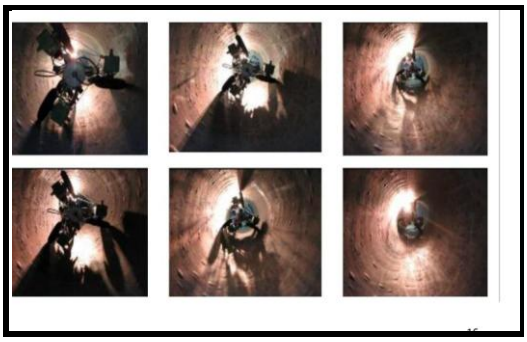

Fig.9 Pipe Inspection Robots Test

## VIII. CONCLUSION

This paper presents development results of an inpipe inspection robot. Its mechanical design is designed by 3D machine design program. The control module consists of a micro controller, motor driver and sensor interface. To control the inpipe inspection robot, firstly, when the inpipe inspection robot was considered as a mass-spring- damper system, the dynamic model of the system was obtained by process model identification method. Secondly, an observer was designed to estimate the unknown wall-pressing force to sustain the inpipe inspection robot in pipeline. Thirdly, an algorithm of wall-pressing force generator was presented to find out an appropriate wall-pressing force, and the appropriate wall-pressing force was given as a reference value of wall-pressing force. Fourthly, PID fuzzy controller was designed to make the estimated wall-pressing force track the reference wall-pressing force irrelatively to variable diameter of pipeline. Finally, the driving tests of the inpipe inspection robot were performed in horizontal pipelines and slope pipelines of 30°. The test results were shown to prove the effectiveness of the developed in pipe inspection robot.

## REFRENCES


[1] Young-Sik Kwon, and Byung-Ju Yi, "Design and Motion Planning of a Two-module collaborative Indore pipeline Inspection Robot", IEEE Transaction on Robotics, VOL 28, NO 3, JUNE 2012.

[2] A. A. Transeth and K. Y. Pettersen, "Snake robot obstacle-aided loco-motion: modeling, simulations, and experiments," IEEE Trans. Robot., vol. 24, no. 1, pp. 88–104, Feb. 2008.

[3] S. Hirose and H. Yamada, "Snake-like robots [Tutorial]," IEEE Robot.Autom., Mag., vol. 16, no. 1, pp. 88–98, Mar. 2009.

[4] J. H. Lee, B.-J. Yi, S. R. Oh, and I. H. Suh, "Optimal design and de- velopment of a five-bar finger with redundant actuation," Mechatronics, vol. 11, no. 1, pp. 27–42, 2001.

[5] T. Oya and T. Okada, "Development of a steerable, wheel-type, in-pipe robot and its path planning," Adv. Robot., vol. 19, no. 6, pp. 635–650,2005.

[6] S. Hirose, H. Ohno, T. Mitsui, and K. Suyama, "Design of in-pipe inspec- tion vehicles for _25, _50, _150 pipes," in Proc. IEEE Int. Conf. Robot. Autom., 1999, pp. 2309–2314.

[7] C. Jun, Z. Deng, and S. Y. Jiang, "Study of locomotion control character- istics for six wheels driven in-pipe robot," in Proc. IEEE Int. Conf. Robot., Biomimetics, 2004, pp. 119–124.

[8] S. G. Roh and H. Choi, "Differential-drive in-pipe robot for moving inside urban gas pipelines," IEEE Trans. Robot., vol. 21, no. 1, pp. 1–17, Feb.2005.

[9] T. Fukuda, H. Hosokai, and M. Uemura, "Rubber gas actuator driven by hydrogen storage alloy for in-pipe inspection mobile robot with flexible structure," in Proc. IEEE Int. Conf. Robot. Autom., 1989, pp. 1847–1852.

[10] A. M. Bertetto and M. Ruggiu, "In-pipe inch-worm pneumatic flexible robot," in Proc. IEEE/ASME Int. Conf. Adv. Intell. Mechatronics, 2001, vol. 2, pp. 1226–1231.

[11] H. Lim, J. Y. Choi, Y. S. Kwon, E. J. Jung, and B.-J. YI, "SLAM in indoor pipelines with 15mm diameter," in Proc. IEEE Int. Conf. Robot. Autom., 2008, pp. 2616–1619.