PIPE INSPECTION ROBOT

Aaqib Husain Sheikh[1], Fazil Amin Mir[2], Saquib Hussain

Department: Electronics and Communication Engineering
College: Model Institute of Engineering and Technology, Kot Bhalwal Jammu

---

Abstract— *project aims to create an inspection. The mechanism used involves a central rod upon which a translational element is fitted which in turn is connected to three frames of links and wheels. DC motors are attached to the wheels to achieve the drive required. The mechanism allows autonomous robot used for in-pipe for small accommodation in pipe diameters. An electronic circuit consisting of three relay switches is used to control the entire circuitry of DC motors, camera and translational element. The camera is mounted on the top of the assembly, which in itself can be rotated thus giving a wide field of view in the pipe. The robot allows for detection of cracks, buckle, corrosions, pitting and many others*.

Key Words: DC motor, defects, In-pipe inspection, links, Robot.

I. INTRODUCTION

Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labor intensive or dangerous work and also to act in inaccessible environment. The use of robots is more common today than ever before and it is no longer exclusively used by the heavy production industries. Inspection robots are used in many fields of industry. One application is monitoring the inside of the pipes and channels, recognising 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. Because pipelines are typically buried underground, they are in contact with the soil and subject to corrosion, where the steel pipe wall, and effectively reducing wall thickness. 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. Pipe inspection is necessary to locate defects due to corrosion and wear while the pipe is transporting fluids. This ability is necessary especially when one should inspect an underground pipe. In this work, Pipe Inspection Robot (PIR) with ability to move inside horizontal and vertical pipes has been designed and fabricated. The robot consists of a motor for driving and camera for monitoring.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.

Fig. 1: Pipe inspection robot

II. DESIGN PARAMETERS

The parameter for design of the robot is the diameter of pipe. We have chosen 8'' and 10'' (approx. 200 mm and 260 mm) pipes as the lower and upper limits respectively for our robot.

Selection of the Wheel:

The wheels of the robot should be chosen such that they should be capable of moving without slipping in the vertical direction by exerting the required traction force. They should also not wear out easily with use. These factors are determined by the co-efficient of friction between the wheel and the pipe. Rubber wheels are a natural choice for this environment as they meet the above demands. The co-efficient of friction between rubber and two commonly used pipe materials (concrete and PVC) are considered. Coefficient of friction between rubber and concrete is in the range of 0.6 – 0.85. Coefficient of friction between rubber and PVC is in the range of 0.5 – 0.7. The power requirements are calculated using a coefficient of friction of 0.8. The range of diameter of pipes considered in the present work is 200 to 260 mm. To accommodate the mechanism with rubber wheels and considering market availability of standard wheels, the diameter was chosen to be 80 mm.

Mechanism Synthesis:

The robot mechanism is to be designed in such a way as to expand and contract between the chosen limits. This necessitates the use of a mechanism where the input link causes the other links to move in a uniform fashion without any crossovers. A parallelogram linkage offers the required type of uniform motion.

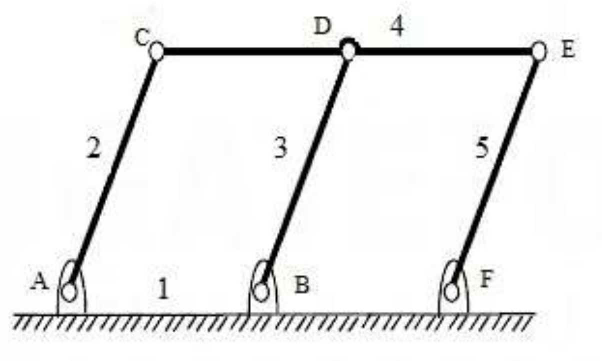

Fig. 2 – Simple Parallelogram Mechanism

But, the required way of motion is not achieved from this design. The joint F is made into a screw pair. The orientation of link 5 is changed so that when e, link 5 moves in the opposite direction pushing the screw pair direction forward the input, link 2 moves in the clockwise and vice versa. This combination of linkages makes the mechanism contract in the clockwise direction and expands in counter clockwise direction.

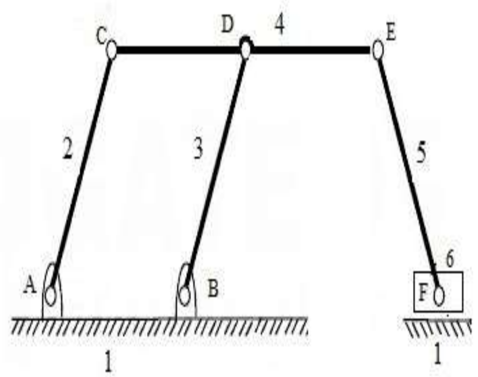

Fig.3-Modified Mechanism

Link dimensions are to be equal for execution of uniform motion. For the pipe diameter range of 200 mm to 260 mm, link length can be varied. Angular position of link at the maximum diameter must not exceed 90 and not go below 45 for proper functioning. The link dimensions can vary from 65 to 85 mm with angles ranging from 67.4to 44.9 respectively at max diameter of 260 mm. The mechanism has been checked to work for all the values and the dimensions are chosen to be 75 mm.

Degrees of freedom of the mechanism is obtained from Gruebler's criterion F = 3(N-1)-2L-H

Where, F – Number of degrees of freedom, N – Number of links, L – Number of lower pairs, H – Number of higher pairs. Substituting the values, we get F = 1, hence it is a single degree of freedom system.

III. FABRICATION AND WORKING

The fabrication phase of the project involves production of the parts designed. It also entails the selection of appropriate electronic circuitry which can be effectively used to achieve and control the robot motion.

Microcontroller PIC 16FXXX Series

A micro-controller has a CPU (a microprocessor) in addition to the fixed amount of RAM, ROM, I/O ports, and timers are all embedded together on the chip: therefore, the designer cannot add any external memory, I/O, or timer to it. Micro-controller Unit is the heart of our project. It controls all the major activities of our project. The Micro-controller unit used in our project is based on PIC family.

PIC Microcontroller:

The PIC micro-controller family of micro-controllers is manufactured by Microchip Technology Inc. Currently they are one of the most popular micro-controllers used in many commercial and industrial applications. The PIC micro-controller architecture is based on a modified Harvard RISC (Reduced Instruction Set Computer) instruction set with dual-bus architecture, providing fast and flexible design with an easy migration path from only 6 pins to 80 pins, and from 384 bytes to 128 Kbytes of program memory.

In our project we will use PIC16F877.

This micro-controller is a 40-pin device and is one of the popular micro-controllers used in complex applications. The device offers 8192 _14 flash program memory, 368 bytes of RAM, 256 bytes of non-volatile EEPROM memory, 33 I/O pins, 8 multiplexed A/D converters with 10-bits resolution, PWM generator, 3 timers, analogue capture and comparator circuit, USART and internal and external interrupt facilities.

Simple Switch Pad:

A switch is used as a human machine interface and is used to give input to the Micro-controller unit. A particular task can be performed by pressing a particular switch so micro-controller when senses that a switch is pressed then it performs the task corresponding to that switch.

Fig 4: Switch

Display Unit (Liquid Crystal Display):

The LCD, which is used as a display in our project, is LMB162A. The main features of this LCD are: 16 X 2 display, intelligent LCD, used for alphanumeric characters & based on ASCII codes. This LCD contains 16 pins, in which 8 pins are used as 8-bit data I/O, which are extended ASCII. Three pins are used as control lines these are Read/Write pin, Enable pin and Register select pin. Two pins are used for Backlight and LCD voltage, another two pins are for Backlight & LCD ground and one pin is used for contrast change.

It can display 32 characters at a time on the display. There are two rows (lines) and 16 characters can be displayed in each line. And it will be used in 8 bit mode i.e. its 8-bit data bus will be used to transfer the data codes from MCU to LCD.

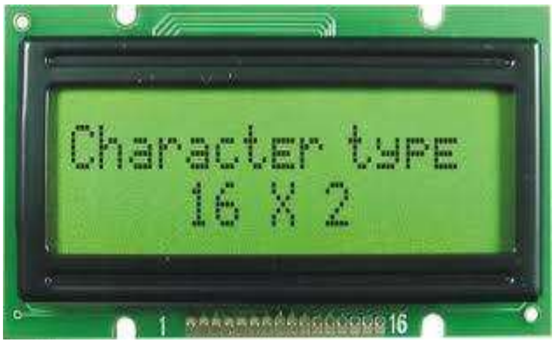

Fig 5: LCD

Temperature Sensor (LM35):

The LM35 series are precision integrated-circuit LM35 temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 sensor thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 sensor does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full -55 to +150°C temperature range.

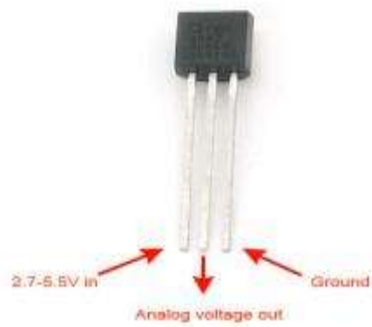

Fig.6:Temperature Sensor

DC motors: DC (direct current) motor works on the principle, when a current carrying conductor is placed in a magnetic field; it experiences a torque and has a tendency to move. If the direction of current in the wire is reversed, the direction of rotation also reverses. When magnetic field and electric field interact they produce a mechanical force, and based on that the working principle of dc motor established. DC motors are used to achieve the drive on wheels and rotation of rods. Two types of DC motors used in the project are shown

Fig.7:MOTOR

Circuit integration and assembly: At the end of fabrication, the electronic circuitry is implemented onto the robot. The DC motors are fitted for the wheels, screw rod and camera plate rod. The 4 channel relay is integrated with all the DC motors. Appropriate wiring is done and a 12 V battery is connected to all electronic components. The fully assembled robot is shown

Fig.8 – Fully assembled pipe inspection robot

Working: The complete assembly of the robot leads to the next phase of the project – Working. Here the robot is checked for its performance of the desired functions.

Drive to the wheels is achieved through DC motors. These motors are connected through relay switches which govern the start/stop functions and rotational direction of the motors. The robot works through the electronic circuit - mechanism interface.

One relay switch, worked manually, is used to control the expansion or contraction of the frames.

The camera placed at the other end of the robot is switched on manually. RF receiver is set up with connections made to a TV monitor.

The DC motors to the wheels are started through the 4 channel relay circuit. This makes the wheels rotate at a set rpm of 60.

Once placed sufficiently inside the pipe, the manual relay switch is actuated to expand the frames so as to accommodate to the pipe diameter. The expansion is continued till sufficient gripping is achieved. The gripping ensures motion in horizontal or vertical direction. The 4 channel relay circuit is actuated through the remote for forward motion.

As the robot moves inside the pipe, the signals are conveyed to the receiver giving a view of the inside surface.

The surfaces are checked for defects visually.

Results: Pipeline systems are prone to degradation and corrosion resulting in a number of defects. Identification of defects is an important problem in chemical plants, sewage pipes and other industries. This project aimed to create an autonomous robot for in-pipe inspection capable of vertical and horizontal motion.

The following results were obtained from the completion of the project.

The robot was capable of adapting to pipe diameters in the range of 200 mm to 260 mm.

The robot was tested for motion in a 250 mm PVC pipe. It was found to move well in both horizontal and vertical direction.

The wired camera transmitted the video feed through the USB Cable onto a Computer screen.

The velocity of the robot is 30 cm/s.

Conclusions and future scope

Conclusions:

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.

Future Scope:

The project is limited in several ways and can be worked upon to broaden its features and applications.

A few of the improvements that can be implemented are mentioned below.

Use of tilted and guide wheels for traversing curves and bends in pipes.

Use of lighter material for the links to reduce the weight.

Infrared/Ultrasonic inspection for better detection of defects.

Implementation of long range sensors. Implementation as a bore well rescue robot. Alternate design without links to facilitate better motion.

References:

[1] AA Hashim, M Eng - eng.cu.edu.eg; Oil and gas pipeline design, maintenance and repair, Cairo University, Department of Mining, petroleum and metallurgical Engineering, Egypt.

[2] AH Heidari, H Najjaran, M Mehrandezh, R Paranjape - 2010 - cdn.intechopen.com, Design, development, dynamic analysis, and control of a pipe crawling robot.

[3] I Doroftei, M Horodinca, E Mignon - 2000 - irisa.fr, A conceptual wheeled robot for in-pipe inspection.

[4] M Horodinca, I Doroftei, E Mignon... - Proc. Int. Colloq. Mobile ..., 2002 - researchgate.net, A simple architecture for in-pipe inspection robots.

[5] SS Rattan, Theory of machines, McGraw Hill, 3 Edition, 2009.

[6] K.Mahadevan, K. Balaveera Reddy, Design data hand book, CBS, 3 Edition, 1987.