Pipe Inspection Robot

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Abstract— Pipeline systems deteriorate progressively over time. Corrosion accelerates progressively and long term deterioration increases the probability of failure (fatigue cracking). Limiting regular inspecting activities to the "scrap" part of the pipelines only, results ultimately into a pipeline system with questionable integrity. The confidence level in integrity will drop below acceptance levels. Inspection of presently uninspected sections of the pipeline system becomes a must. This project provides information on the "robotic inspection technology".

Keywords: Pipeline Systems, Robotic Inspection Technology

I. INTRODUCTION

Pipelines are proven to be the safest way to transport and distribute Gases and Liquids. Regular inspection is required to maintain that reputation. The larger part of the pipelines system is accessible by In-Line Inspection Tools but this access is limited to the section in between the launching and receiving traps only. Unfortunately, corrosion does not have this limitation. The industry looks for means of inspecting these in-accessible pressure holding piping systems, preferably, without interrupting the operations. It is a fact that sufficiently reliable and accurate inspection results can only be obtained by direct pipe wall contact/access. If that is not feasible from the outside, we have to go inside. Since modifying pipeline systems for In-Line Inspection is mainly not practical, GSM CONTROLLED PIPE INSPECTION ROBOT pursues development of ROBOTIC inspection services for presently in-accessible pipeline systems. 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.
Keyword, Pipe inspection, Robotics, industries

A. Objective

To design a robotic vehicle for pipe inspection purpose that can be controlled by mobile using GSM network

B. Design Parameter

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.

C. Mechanical Analysis

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.

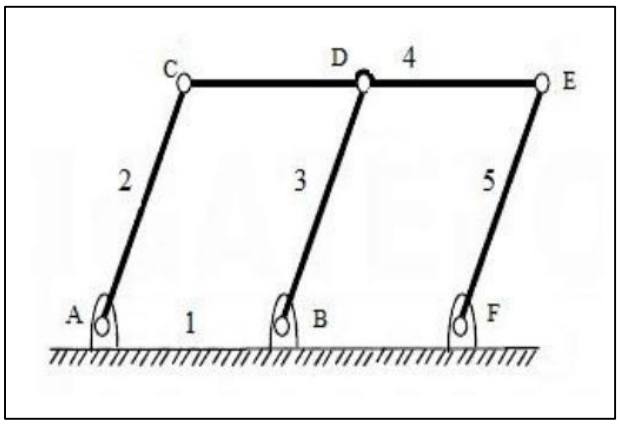

Fig. 1: Simple Parallelogram Mechanism

But, the required way of motion is not achieved from this design. The joint F is made into a screw pair with link - 3This combination of linkages makes the mechanism contract in the clockwise direction and expands in counter clockwise direction.

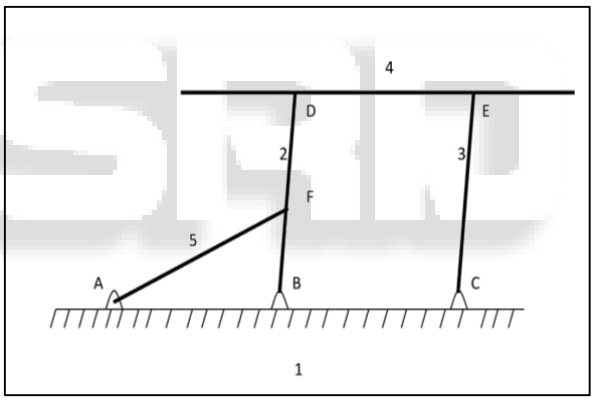

Fig. 2:

D. Modified Mechanism

Link dimensions are to be equal for execution of uniform motion. For the pipe diameter range of 200 mm to 230 mm, link length can be varied. Angular position of link at the maximum diameter must not exceed 90oand not go below 45o for proper functioning. The link dimensions can vary from 65 to 85 mm with angles ranging from 67.4o to 44.9o respectively at max diameter of 230 mm. The mechanism has been checked to work for all the values and the dimensions are chosen to be 75 mm.

E. Calculation

Gross robot weight
1.250 kg X 9.81 m/s^2
= 12.262 N
Weight per wheel
ww = 12.262/6 = 2.043 N
Radius of wheel
= 3.25 cm = 0.0325
Tractive effort

Ft = ww X μ μ = co-efficient of friction = 0.8
= 1.6344 N
Torque required per wheel
Tw = Ft X r
= 1.6344 X 0.0325
= 0.05311 Nm
The safety of factor in some critical design reach 4 but in most cases 1.25

F. Degree of Freedom

Degrees of freedom of the mechanism isobtained from Gruebler's criterion
n = 3(L-1)-2j-h
Where,
n – Number of degrees of freedom,
L– Number of links,
j – Number of lower pairs
h – Number of higher pairs.
N=3(5-1) - 2(5) - 0
= 2

G. Design of Element

Translational element:
Inner diameter -17 mm
Outer diameter -19.05 mm
Length of the element -25 mm
Material – stainless steel

H. Translation Element

1) Links

Link 1 = 56 mm
Link 2 = 56 mm
Link 3 = 110mm
Thickness – 4 mm
Drill hole – 15 and 5 mm
Material – stainless steel
Components of pipe inspection robot

I. 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.

J. 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 joints are brazed on the translational element at 120 degrees for the links to be fixed onto it

K. Wheels

The wheels of the robot should be chosen such that they should be capable of moving without slipping in the vertical and horizontal 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 (galvanized sheet metal pipe) are considered.
Diameter : 65 mm
Radius : 0.0325 cm
Link

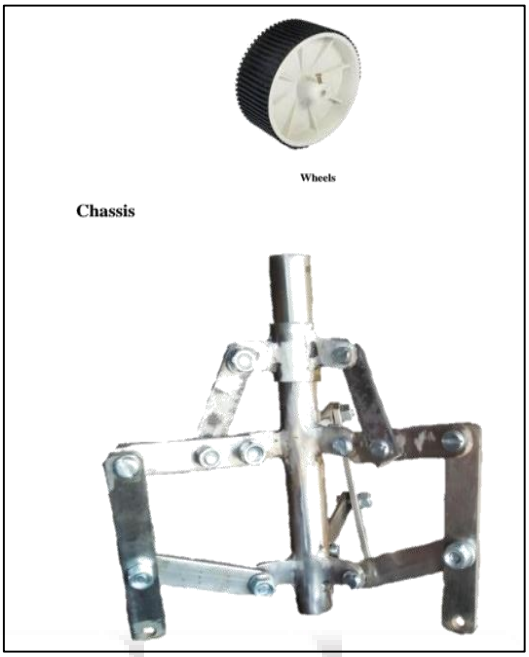

Fig. 3: Selection of the wheel

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 and1 single prismatic pairs as depicted. 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.

II. ELECTRICAL COMPONENTS

A. DC Motors

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.
12V and 300 rpm DC motor

III. MALE-FEMALE WIRES

A. General Description

Handy for making wire harnesses or jumpering between headers on PCB's. These premium jumper wires are 6" (150mm) long and come in a 'strip' of 40 (4 pieces of each of ten rainbow colors). They have 0.1" male header contacts on

one end and 0.1" female header contacts on the other. They fit cleanly next to each other on standard-pitch 0.1" (2.54mm) header. The best part is they come in a 40-pin ribbon cable. You can always pull the ribbon wires off to make individual jumpers, keep them together to make neatly organized wire harnesses .This male to female jumper wires are used robotics and embedded projects for interfacing devicesMale Female wire connector.

IV. ELECTRONIC CIRCUIT AND COMPONENTS

A. *Transmitting Cell Phone*

Intel communications, transmission is the process of sending and propagating an analogue or digital information signal over a physical point-to-point or point-to-multipoint transmission medium, either wired, optical fiber or wireless. One example of transmission is the sending of a signal with limited duration, for example a block or packet of data, a phone call, or an email. Transmission technologies and schemes typically refer to physical layer protocol duties such as modulation, demodulation, line coding, equalization, error control, bit synchronization and multiplexing, but the term may also involve higher-layer protocol duties, for example, digitizing an analog message signal, and data compression. Transmission of a digital message, or of a digitized analog signal, is known as digital communication.

B. *Cell Phone*

Cell phones use radio waves to communicate. Radio waves transport digitized voice or data in the form of oscillating electric and magnetic fields, called the electromagnetic field (EMF). The rate of oscillation is called frequency. Radio waves carry the information and travel in air at the speed of light.Cell phones transmit radio waves in all directions. The waves can be absorbed and reflected by surrounding objects before they reach the nearest cell tower. For example, when the phone is placed next to your head during a call, a significant portion (over half in many cases) of the emitted energy is absorbed into your head and body. In this event, much of the cell phone's EMF energy is wasted and no longer available for communication.

C. *Antenna*

Cell phones contain at least one radio antenna in order to transmit or receive radio signals. An antenna converts an electric signal to the radio wave (transmitter) and vice versa (receiver). Some cell phones use one antenna as the transmitter and receiver while others, such as the iPhone 5, have multiple transmitting or receiving antennas. An antenna is a metallic element (such as copper) engineered to be a specific size and shape for transmitting and receiving specific frequencies of radio waves. While older generation cell phones have external or extractable antennas, modern cell phones contain more compact antennas inside the device thanks to advanced antenna technologies. It's important to understand that any metallic components in the device (such as the circuit board and the metal frame for the iPhone) can interact with the transmission antenna(s) and contribute to the pattern of the transmitted signal.

D. *DTMF Decoder*

DTMF (dual tone multi frequency) is the signal to the phone company that you generate when you press an ordinary telephone's touch keys. In the United States and perhaps elsewhere, it's known as "Touchtone" phone (formerly a registered trademark of AT&T).

E. *Use of DTMF Decoder?*

Decoder is also used for receiving data transmissions over the air in amateur radio frequency bands. The following are the frequencies used for the DTMF (dual-tone, multi-frequency) system, which is also referred to as tone dialling.Dual-tone multifrequency (DTMF) is a method used to dial telephone numbers or to issue commands to switching systems. DTMF is widely used for telecommunication signaling between telephone handsets and switching centers over analog telephone lines in voice-frequency bands.

F. *Motor drive IC*

ICs regulator is mainly used in the circuit to maintain the exact voltage which is followed by the power supply. A regulator is mainly employed with the capacitor connected in parallel to the input terminal and the output terminal of the IC regulator. For the checking of gigantic alterations in the input as well as in the output filter, capacitors are used. While the bypass capacitors are used to check the small period spikes on the input and output level. Bypass capacitors are mainly of small values that are used to bypass the small period pulses straightly into the Earth. A circuit diagram having regulator IC and all the above discussed components arrangement revealed in the figure below

G. *Phone Camera*

Ip Phone Camera will turn your phone into a IP camera. This is a great way to utilize your old Android phones! Use any device that has a browser and is on the same Wi-Fi network to view mobile camera. Choose from 2 connection types such as 'Wi-Fi network' and 'Mobile hotspot' for establishing connection with your PC or mobile device. You can easily switch from Wi-Fi network to mobile hotspot. Use Mobile hotspot connection type to prevent lag issue while broadcasting. This will bypass your network completely because it is a direct connection from your PC to your mobile device. Just like any good IP camera, this application also works with video surveillance software, such as - Security Monitor Pro and IP Camera Viewer. Use IP Phone Camera with Security Monitor Pro to view multiple cameras, capture videos and photos, send email notifications on motion detection and much more

H. *Key Features*

- View your mobile camera in browser or in a video surveillance software, such as - Security Monitor Pro and IP Camera Viewer.
- No USB cable is required for connection.
- Support for ONVIF IP cameras.
- Control how and when your phone's screen should stay on. It helps to prevent mobile from going into sleep mode while streaming is in progress.
- Broadcast your camera in greyscale to save data and make your camera updates faster.

V. INSPECTION METHOD

Robots deployed for the video inspection of pipe systems possess amaneuverable head .The PIR have ability to see inside the dark pipe where no human eyes can see this made possible by moving the surveillance mobile camera and mobile flash light and mobile fitted at the front of the PIR to see inside the dark pipe. The output is send to outside mobile screen where the high quality image and live video can be received. The robot is run inside pipe by forward and reverse motion of the wheel which has the constant speed. This constant slow speed is to insure better inspection because of the high speed there may be possibility to miss the any defect. The output image from the mobile camera is send to computer screen which may be laptop, monitor, or any such device which gives the visual picture. Operator can control the robot and see the pictures of the inside of the3 pipe on the output mobile screen and thus if there is any defect suggest internal material big crack weld effects dents corrosion or blockage in the pipe

A. Applications

Nuclear power plants
Conventional power plants
Refineries
Chemical and petrochemical plant
Food and drinks industries:

VI. 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 and horizontal motion. The following conclusions can be drawn from the project.

A. GSM Control Pipe Inspection Robot

GSM Pipe Inspection Robot

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