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Development of In-Pipe Robot for Cleaning and Inspection

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Abstract: *The aim of the project is to design a pipe cleaning and inspection robot for industrial applications. This is going to use a very simple mechanism for cleaning the internal area of the pipe with changing diameters. The design is focusing on developing a bevel gear mechanism which is able to clean and translate the robot body into the pipe effectively. Here we are going to use only a single DC motor for both cleaning and locomotion in the pipe. The inspection of the pipe is by using the ultrasonic sensor. The ultrasonic sensor is going to give the distance between the obstacle and the robot. According to the distance measured we are going to know about the bends and joints. The ultrasonic sensor is also going to give information regarding the waste materials accumulated in the pipe.*

Keywords: Cleaning Device, Robot, Pipeline, Engineering Design Process, etc.

I. INTRODUCTION

Plumbing networks, like any other structure, are vulnerable to damage from various sources: thermal cycling (A especially when ground freezes around the pipe), mechanical impacts vibration, corrosion, etc. pipes can feel or clog with debris, sediments as with the zebra mussel infestation in the north east United States, living organisms. Smaller fluid systems, such as those serving residences may be repaired with easy, low-cost methods in many causes it may be best simply replace the pipes. Operators of larger, complex systems, however frequently need some better way of dealing with plumbing failures. For instance, it is not cheap to replace large diameter pipes: it is even worse if hundreds of meters of pipelines must be unearthed to determine which section is 0. responsible for a drop in pressure. Preventative inspection can be another difficult requirement of industrial users: critical system or those serving sensitive machinery may have to inspect periodically, to ensure the safety of human users or to prevent damage to expensive systems.

It is possible to detect cracks or corrosion thinning in plumbing with sensors, but this requires access to the outside of the pipes; difficult and costly in many situations, such as long, buried lengths. Furthermore, this does not address the problem of clogging or fouling. In much such application an internal inspection solution may be preferable.

If robot were designed to travel the length of the pipe and conduct such inspection it might have other uses as well. For instance, it could carry a cleaning mechanism or manipulators to remove foreign object. It could pull electrical or communications cables through conduits. Such machine has potential as life –saving tool also when building collapse, due to earthquakes or other disasters the internal pipe network may still be negative for a pipe inspection robot, which could carry video cameras to locate signs of humans trapped below.

II. LITERATURE SURVEY

2.1 Conventional Inspection Methods

Statistical method based on the number of pipe brakes per kilometer and reactive inspection techniques such as leak detection have been mainly used in the past for evaluation water pipe condition. New testing technologies make it possible to develop more efficient and accurate approaches to maintain pipeline integrity through direct inspection. These techniques provide a verity of information about the condition of pipes depending on their materials. Examples are the numbers of wires broken in a single section of the prestressed Concrete Pipe (PCCP), the depth of corrosion pitting in a ductile iron pipe, the extend of graphitization in a cast iron pipe or more generally the presence of liking water (Grigg,2006), (Eiswirth et al.,2001) and (Gummow Eng.2000) [2].

2.2 Pipeline Inspection Vehicles

Remotely operated or autonomous vehicles moving inside pipes that can deploy NDT equipment have been studied extensively for the past 2 decades. An exhaustive review of the literature is impossible due to the limited space available. However, various locomotion systems develop and fitted in literature for in-pipe operation can be categorized into three main groups as follows.

2.2.1 Pipe Inspection Gauges (PIG)

They are passive devices widely used for inspection of oil pipes and are designed so that sea link elements provide a positive interference with the pipe oil. Once inserted into a line, PIGs are driven through the line by applying pressure in the direction of required movements. Pressure differential is created across the PIG, resulting in movement in the direction of the pressure drop. Upon removal, the information log using the PIG on board data storage unit is played back an analyzed PIGs are normally employed for the inspection of pipelines with large diameters.

Their inspection operations are limited to relatively straight and uninterrupted pipe lines operating in the high-pressure range. Short inspection run is costly decides, the pipeline must be relatively clean for precise inspection. (Shiho et al., 2004), (Nguyen Et al.,2001) [5].

2.2.2 Floating Systems / Robots

Autonomous under water vehicles (AUV) and under water Remotely Operated Vehicle (ROV) are oceanographic locomotion interfaces used for data acquisition in subsea and deep-water mission. The applicability of existing floating robots in the confined environments such as pipes will be very limited . Further modifications will be needed to make them suitable for inspection of pressurized pipelines. (Griffiths, 2003), (Mickols etal1997) [4].

2.2.3 Mobile Robots

Significant effort has been put into devising an effective mechanism to drive a robotic system carrying on dash board sensors / testing devices through different pipe configurations. The sensors on this robot must be small in physical size, light weight and low in power consumption as compared to the other system mentioned above. Academic researches and Industrial Corporation have investigated many variations of drive mechanisms such as wheels, crawlers, wall press, walking, inch warm, screw and push rod. Some systems have complex mechanisms and linkages, which in turn require complicated actuation and control.

Wheeled systems claimed edge over the majority.

Due to their relative simplicity and is of navigation and control. Comparatively, they are able to travel relatively first and far. However, most of the mobile robots developed for this purpose have been residential in research lab because of their lack of ability to move inside pressurized pipes, e.g. (Kogi,1999), (Roh Choi,2005) and (Miwa et al.,2002). Some popular variants of mobile robots for pipe inspection are briefly describe below.

2.3 Wheeled / Tractor Carriers

These are the simplest drive mechanisms that are targeted for inspecting empty pipes. These remotely control vehicles are designed to serve as platform to carry cameras and navigate through pipes and conduits.

2.4 Pipe Crawlers

These are locomotion platforms that crawl slowly inside a pipeline. They can move down the pipeline independent of the product flow and maneuver passed the physical barriers that limit inspection. They can ever stop for detail assessment. This robot is reconfiguration and can fit pipes with variety size (Bradbeeretal, 2000)

2.5 Walking Robots

Wall-climbing robots with pneumatic suction cups and / or electro magnet have been used for inspection of vertical pipes, conduits, and steel structure (Glass et al., 1999). Walking robots are particularly useful for inspection of irregular and rough surface. Pipe inspection robot can be configured as tethered or wireless. They can be control remotely, or being totally autonomous. To the best our knowledge, all existing pipe rovers are for inspection purpose only. In general, current mobile robotic system not yet adequate for on-the-fly repairs in a complex pipe environment. [3] Development of the locomotion unit of a robot capable of in-service pressurized pipes remains a very challenging and novel research topic. More over precise control of such pipe inspection robot when subjected to flow disturbances necessitates development of nonlinear control strategies. This study addresses the mechanical design of a pipe crawling robot capable of moving inside pressurized pipes and a fuzzy logic-based control strategy to maintain a constant speed for the robot when moving inside lice pipes 0(3)

III. IMPLEMENTATION

The final robot employs three articulated segments: one unit providing propulsion, two carrying the actuator and the brush assembly, two 'stator' or guiding wheeled sections used to carry the actuator and prevent it colliding with the walls of the pipe. The figure below illustrates the arrangement of these segments (so that the mechanical and structural components can be seen clearly, this picture depicts the robot lacking most of the wiring and electronics that would be added later).

We have used the final projects in different types of pipes with different diameter. Also, we have used different types of brushes like nylon and copper. It is working good with different applications; with the increasing angle of pipe the accuracy of robot is decreasing.

IV. CONCLUSION AND DISCUSSION

The work performed in this project is to develop a wall-pressed in-pipe robot for cleaning and inspection. In developing the wall-pressed in-pipe robot we require various mechanisms for cleaning, moving, actuation and inspection. For cleaning there are four cleaning wipers mounted on the cleaning portion. The wipers are self-adjustable according to the size of the pipe. The cleaning portion contains springs for automatic adjustment. There are two wheels in the system for moving the robot in and out of the pipe. The wheels are mounted on the wheel support. The wheel support is placed on the body. The suspension spindle in the drive shaft makes the wheels to self-adjust according to the pipe diameter.

The actuation part of the robot has two actuators. One is an electronic actuator that is a DC motor. The second one is a mechanical actuator that is a bevel gear. The motor is connected to the bevel gear. The bevel gear is actuating both the wheels and the cleaning device of the robot.

For the inspection there is an ultrasonic sensor included in the robot. The main reason behind using the ultrasonic sensor is its accuracy in detecting the flaws in the pipe. The device is also very small so we can easily use the ultrasonic sensor for small size pipes.

Robots have been used in many areas to replace human efforts. Specially, pipeline maintenance is challenging for which robots can be employed. In-pipe inspection is one of them.

This project pays attention to browsing them. A fully autonomous mobile pipeline inspection robot should have three principal features; firstly, good mobility in the pipeline networks a must, secondly good sensing ability for pipeline inspection, thirdly sophisticated control and lastly powerful batteries to increase its potential mission range.

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