Design of Pipe-Inspection Robot for All Pipeline Configurations

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***Abstract*: A Wheel based pipe inspection robot is designed for inspecting 200mm to 300mm diameter pipes which is mostly used in oil and gas field industries. The main aim of this design is to perform vertical crawling, independent multi elbow turning, and maintenance free and commercially economic model. Designed robot contains of two major modules upper and lower module. Upper and lower arrangement have three configuration wheel with simple scissor mechanism for wheel expansion. These two modules are connected by spring which is compressive type to achieve wheel expansion and flexible elbow turning. Full design done in solidworks software. As a result the robot design works fine in vertical movement and complex elbow turning.**

Keywords: Pipe inspection robot, Design aspects.

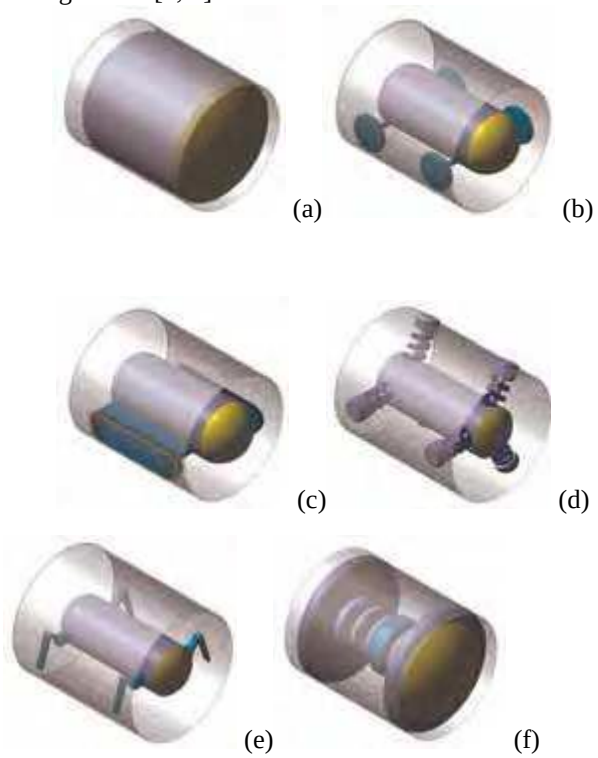
I. INTRODUCTION

Form olden days to till now pipeline is the only major source to transfer oil and gas form one destination to another destination. And it is more economic when compare to other transportation sources. Metal pipes are most commonly used. These metal pipes are required proper periodic maintenance due to corrosion, leakage of fluid, low quality etc., Moreover most of the pipelines are being taken placed in underground and seashore. The direct inspection of these pipes by human is too difficult. So that the inspection robot is invented by human.

Pipeline inspection robot is the greatest invention for maintenance purpose. In [1], there are seven types of inspection robot used worldwide. They are Pig type, Wheel type, Caterpillar type, Wall press type, Walker type, Inch worm type, Lead screw type.

The Pig type robot [2] illustrated in fig 1(a). These pig type robot is most commonly used in pipe inspection. This type of robot is passively driven by the pressure of fluid present inside the pipeline. So it requires liquid medium to work. [3,4]As shown in the fig 1(b) represents the wheel type robot, same as the mobile robot used in ground surface [6]. Active caterpillar type robot is introduced [7,8] Fig 1(c) shows that [9,10]Caterpillar type robot, Instead of wheel, belt track is used to drive the robot. [9] It is mainly developed for indoor pipe inspection purpose. As shown in fig 1(d), Wall press type robot here compressive spring is used to gripping the wall. The main advantage of these robot is climbing vertically. Walker type robot is given in fig 1(e), same as four wheel based mobile robot, but instead of four wheels highly motion sophisticated legs are used. As depicted in fig 1(f), Inchworm type robot these type of robot is suitable only for smaller diameter pipes. Fig 1(f), represents the lead screw type robot displacement is achieved by rotation motion of the screw. It is most suitable for both smaller and lager diameter pipe.

Most of the pipe inspection robot hires the possessing feature of above mentioned mechanisms or their combinations only. Actually the design target of the inspection robot has close relationship with workspace of particular applications. Because the standard requirement of inspection robot is that the mechanical device should be able to move wherever it has to travel within its limited workspace. Normally the exiting inspection robot models are effectively travel along horizontal pipeline but only few of them can survive with complex pipeline structures, such as vertical pipe, multi elbows etc. And also hardly few of them be able to negotiate subdivisions such as T-joint pipelines. For effective steering, on the other hand, inspection robots are strongly recommended to have the ability of flexible steering on elbows, subdivisions and their arrangements [5, 6].



(g)

Fig. 1. Types of pipe-inspection robot. (a) Pig type, (b) Wheel type, (c) Caterpillar type, (d) Wall press type, (e) Walker type, (f) Inchworm type, (g) Lead screw type.

A wheel based pipe inspection robot intended design to work in 200 to 300 mm diameter vertical pipeline with multi elbows is discussed clearly in this paper. The robot consists of two major modules upper and lower module. Upper and lower arrangement have three configuration wheel with simple scissor mechanism for wheel expansion. As a result the robot design works fine in vertical movement and complex elbow turning.

II. FEATURES OF ROBOT

A CHASSIS/ FRAME

The designed inspection robot consists of two segments, namely upper active and lower active segments. The active word mentions to the use of high compression spring to expand and retract the wheels, The both upper and lower active segments is used for generate pressure on the wall due to center spring arrangement so that robot can able to grip inner wall of the pipe exclusively moving in elbows, vertical pipe configurations. Additionally, the lower unit is used to support the upper unit in case that the upper unit can't able move in some situations such as moving over multi complex elbow, and passing over choked pipeline configurations.

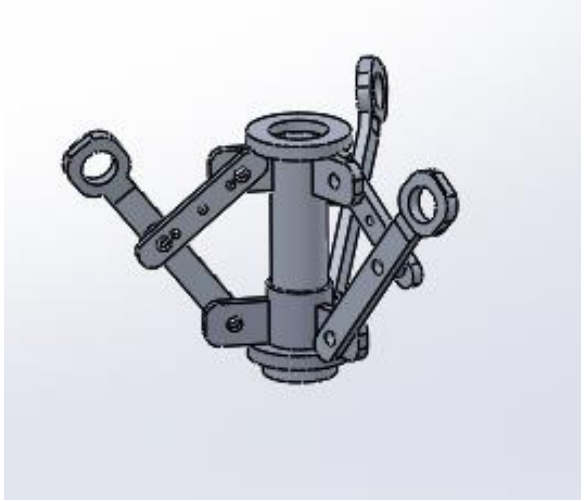


Fig. 2 Upper module

Fig. 2 shows the construction design of the upper active unit in SolidWorks. This unit consists of three wheel patterns, a main frame tube, three 4-bar linkage, a highly compressed spring to expand and retract the wheels. Each wheel configuration consists of a 12V DC gear motor and a rubber wheel. 4-bar link mechanism are used to pledge the robot to have durable grip on the pipe wall as shown in Fig. 3. Rubber layer in the wheel makes the wheel to give better pressing forces against the wall. Expansion and retraction of the 4-bar link mechanism is done by highly compressed spring and thus making the sliding tube to move front and back. Sliding tube, as shown in Fig. 3, is used to transmit the energy from compressive spring to the 4-bar link mechanism.

Fig. 4 shows that the structural design of the lower module. Lower module has similar structural construction with the upper module. Center helical compression spring is used for expansion and retraction of 4-bar link mechanism in the lower module. This is because the inspection robot wants two active device module to work well in any types of pipeline configuration.

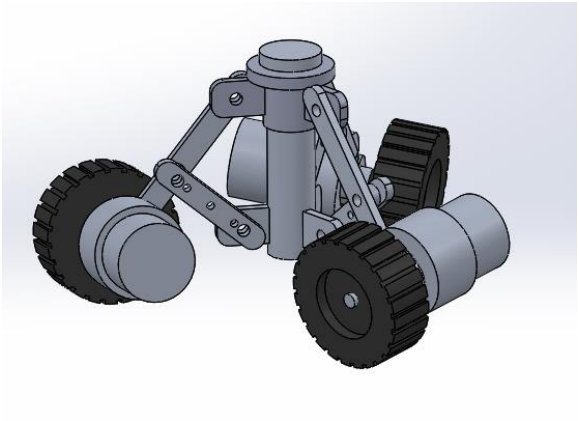


Fig. 4a Lower Module

B COMPARISON OF VARIES TYPES OF INSPECTION ROBOT WITH WHEEL BASED PIPE INSPECTION ROBOT

Comparison of wheel based inspection robot with varies types of pipe inspection robot is shown in Table 1.

Table 1. Comparison of varies types of inspection

TYPES	**PIG**	**CATERPI-LLAR**	**WHEEL BASED**
STRUCTURE	Wall press	Belt drive mobility	Wall press
PRINCIPLE OF MOTION	Moving by pumping force of the fluid	Moving with the help belt drive	Moving by pressing on the wall
EXTERNAL DIAMETER	Above 300mm	150-450mm	200-500mm
ADVATAGES	Economic, can able to move in fluid medium	Can able to adapt in varies types of diameter	Fast inspection
DISADVATAGES	Vertical inspection is not possible	Wall surface may be damage due to high friction	Complex mechanism

C ROBOT SPECIFICATION

Specification of inspection robot is depicted in Table II. The actual length of the inspection robot, including both upper and lower modules and a compressive spring, is 250 mm. The maximum weight of the robot is 4.5 kg. The inspection robot designed to work in 200 to 300 mm diameter vertical pipeline with multi elbows.

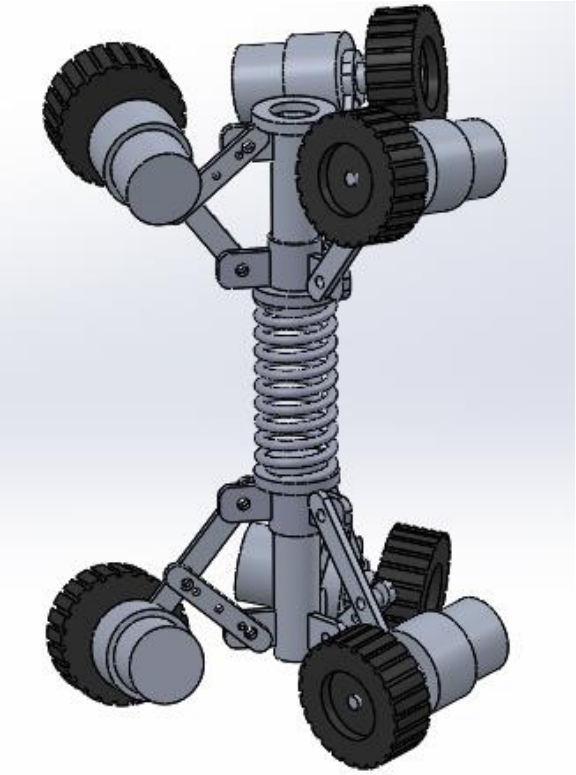


Fig. 4b Design of Pipe Inspection Robot

Table 2 represents the full dimension detail about the robot.

Specification	**Value**
Total weight	4.5kg
Length of the upper module	75mm
Weight of the upper module	2kg
Length of the lower module	75mm
Weight of the lower module	2.5kg
Total length of the robot	250mm
Exterior diameter	200-300mm
Normal speed	6.5RPM
Maximum speed	10RPM

CONCLUTION

In this paper the detailed design of pipe inspection robot was done by considering the design parameters. On comparing the available pipe inspection robots namely PIG type, caterpillar type, Inch Worm, Lead screw, walker type it was found that vertical climbing of the robot and multi elbow turning configuration of the robot was difficult. In the developed model a suitable spring type flexible arrangement is provided for effective vertical climbing and complex elbow turning configuration. The specification of the designed pipe inspection robot is stated in Table 2.

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