DESIGN OF PIPE-INSPECTION ROBOT FOR PIPELINE SYSTEMS

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Abstract: A Wheel based pipe inspection robot is designed for examining 300 mm to 400 mm diameter pipes which is mostly used in chemical and food industries. The fundamental point of this plan is to perform vertical slithering, autonomous multi elbow turning and support free and viable financial model. Planned robot contains of two significant modules upper and lower module. Upper and lower course of action have three design wheel with straightforward scissor system for wheel extension. These two modules are associated by spring (compressive) to accomplish wheel extension and adaptable elbow turning. Full plan is done in solidworks programming. Accordingly the robot configuration turns out great in vertical development and complex elbow turning.

Keywords: Pipe inspection robot, Design aspects.

I. INTRODUCTION

From olden days to till now pipeline is the only major source to transfer oil and gas from one destination to another metal lines are generally utilized. These metal lines require standard support because of erosion, spillage of liquid and the immediate assessment of these lines by human is excessively troublesome. So investigation robots are utilized.

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

The Pig type robot [2] outlined in fig 1(a). These pig type robot is for the most part utilized in pipe investigation. This sort of robot is driven by the pressing factor of liquid present inside the pipeline. So it requires fluid medium to work. [3,4]As displayed in the fig 1(b) addresses the wheel type robot, same as the portable robot utilized in ground surface [6]. Dynamic caterpillar type robot is presented [7,8] Fig 1(c) shows that [9]Caterpillar type robot, Instead of wheel, belt track is used to drive the robot. [9] It is created for indoor line examination reason. As displayed in fig 1(d), Wall press type robot has compressive spring to grasp the divider. The fundamental benefit of these robot is to climb upward. Walker type robot is given in fig 1(e),

As portrayed in fig 1(f), Inchworm type robot is suitable only for smaller diameterpipes.Fig1(f),represents the lead screw type robot for which displacement is achieved by rotation motion. It is most suitable for varying diameter pipe.

Most of the pipe inspection robot have the featureofabovementionedmechanisms.Actuall ythedesigntargetoftheinspection robot has a relationship with work area of specific applications. Since the standard prerequisite of the robot is that the mechanical gadget ought to have the option to move to any place it needs to go inside its restricted work area. The examination robot models travel along level pipeline yet not many of them can make through complex pipeline structures like, vertical line, multi elbows and so forth and further more barely not many of them have the option to pass through T-joint pipelines. For powerful guiding, then again robots are unequivocally prescribed to have the capacity of adaptable controlling on elbows, developments and their arrangements[5,6].

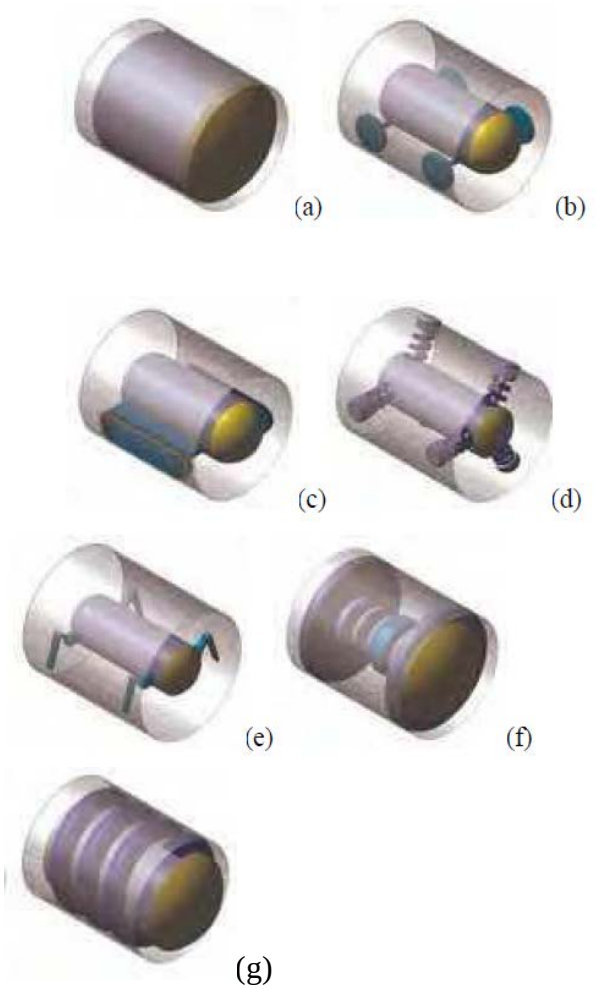

Fig. 1. Types of pipe-inspection robot. (a) Pig type,(b)Wheeltype,(c)Caterpillartype,(d)Wallpresstype,(e)Walkingtype,(f)Inchwormtype,(g)Leadscrewtype.

I a. OBJECTIVES:

A wheel based line examination robot expected plan to work in 300 to 400 mm distance across vertical pipeline with multi elbows is proposed.

To develop two significant modules upper and lower module.

To develop upper and lower course of action having three arrangement wheel with basic scissor component for wheel extension.

To get a robot configuration in vertical development and complex elbow turning.

LITERATURE REVIEW

From the examination paper of AtulGargade, robots are used to eliminate individual from relentless and hazardous work. This venture depicts an in-pipe examination robot. This robot comprise of a front leg framework, a back leg framework and a body.

The front and back leg frameworks are developed by utilizing three worm gear framework that are masterminded at a point of 120 degree as for one another to work inside a line of various breadths. The springs are appended to every leg andthe robot body to work in lines of 140mm to 200mm distance across range. Here, all significant parts of robot are planned.

Demonstrating and gathering of robot parts is done in Solidworks 11. Stress examination of all major parts is done in Solidworks 11 and Static pressure examination of proposed in-pipe review robot gathering is completed in Ansys 13. This robot is utilized for disconnected visual assessment of gas pipelines, water pipelines and channel pipes and so forth This robot likewise has wide applications in substance enterprises just as in inlet nations for assessment of oil and gas pipelines.

II. FEATURES OF ROBOT

ACHASSIS/FRAME

The planned investigation robot comprises of two sections, to be specific upper dynamic and lower dynamic fragments. The dynamic word notices to the utilization of high pressure spring to expand and withdraw the wheels, The both upper and lower dynamic sections is utilized to produce tension on the wall so robot can grasp inner wall of pipe by moving in elbows for vertical line arrangements. The lower unit is utilized to help the upper unit in the event that that the upper unit can't capable move in certain circumstances, for example, moving over multi complex elbow and ignoring gagged pipeline designs.

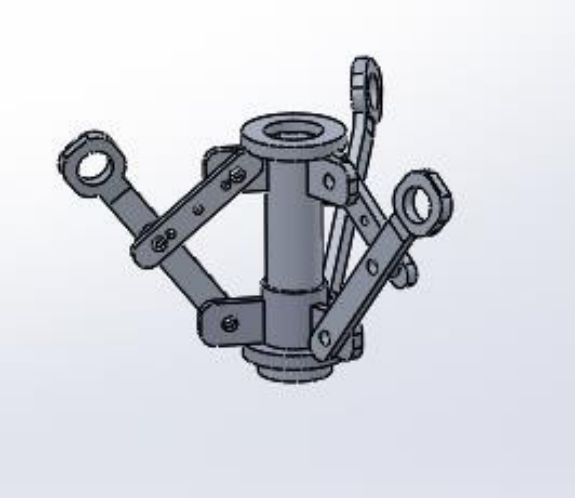

Fig.2Upper module

Fig.2shows the construction design ofupper unit in SolidWorks.This unit consists of three wheel patterns, a main frame tube, three 4-bar linkage, a compressed spring to expand and retract the wheels. Each wheel configuration consists of a 12V DC gear motor and rubber wheel.

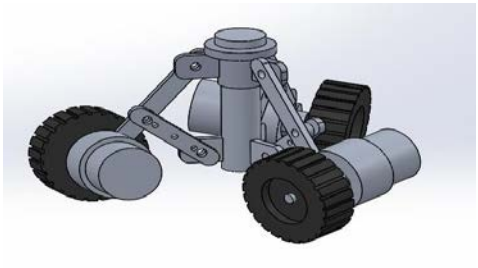

Fig. 3 shows that the structural design of the lower module.

Lower module has same structural construction as the upper module. Center helical compression spring is used for expansion and retraction of four -bar link mechanism in lower module. This is because the inspection robot wants two active device module for proper working in any types of pipeline configuration

B COMPARISON OF VARIES TYPES OF INSPECTIONROBOTWITHWHEELBASEDPIPEINSPECTIONROBOT

Comparison of wheel based inspection robot with types of pipe inspection robot is shown inTable1.

Table1. Comparison of types of inspection robot

TYPES	**PIG**	**CATERPI-LLAR**	**WHEELBASED**
STRUCTURE	Wall press	Belt drive mobility	Wall press
PRINCIPLE OFMOTION	Moving by pumping force of the fluid	Moving with the help of belt drive	Moving by pressing on the wall
EXTERNALDIAMETER	Above300 mm	150-450mm	200-500mm
ADVATAGES	Economic, can able to move in fluid medium	Can able to adapt in various types of diameter	Fast inspection
DISADVATAGES	Vertical inspection is not possible	Wall surface may be Damaged due to high friction	Complex mechanism

CROBOTSPECIFICATION

Specification of inspection robot is shown in TableII. The length of the inspection robot, comprising both upper and lower modules and a compressive spring, is250 mm. The maximum load carrying capacity is 4.5 kg. The inspection robot designed to operatein 300to400mmdiameter vertical pipeline with multi elbows.

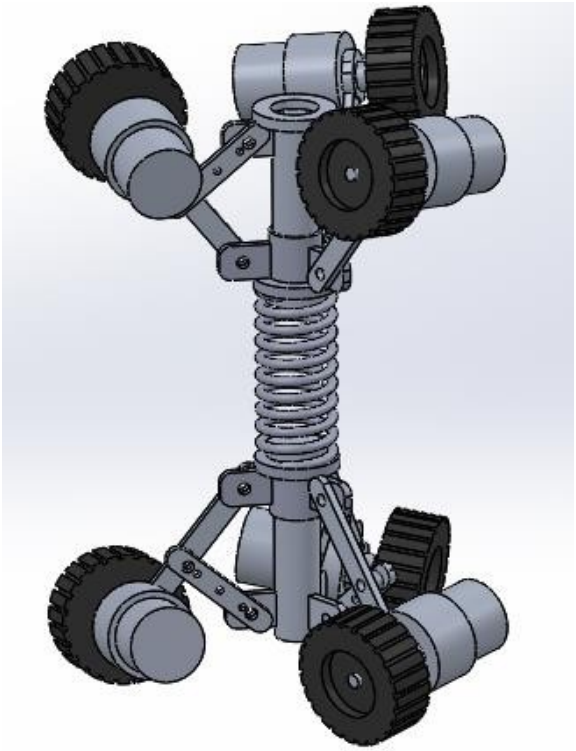

Fig.3bDesignofPipeInspectionRobot

Table2 represents the full dimension detail about the robot.

Specification	**Value**
Totalweight	5kg
Lengthoftheuppermodule	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	300-400mm
Normal speed	6.5RPM
Maximum speed	10RPM

IV. DESIGN AND ANALYSIS OF PIPE INSPECTION ROBOT

A. Selection of motor

∴ Total load acting on robot = 47.5N

Power required for robot to carry weight of 47.5 N with 0.1388 m/s speed is, P = W × v

∴ = 47.5 × 0.1388

P = 6.593 watts.

In worst case if only one motor is working then it has to give total

∴ power.

∴ Power required to two DC motors to drive the robot is,

$P_{required}$ = 2 × 6.593 ∴ $P_{required}$ = 13.188 watts

If a motor of 12v & 1 amp current is selected then power provided by two motors is,

$P_{provided}$ = 19.2 watts

here, $P_{provided} > P_{required}$ …….. hence ok.

So, select two DC motors of 12v, 1 amp current & 400rpm each.

B. Design of Motor Shaft

StepI:

Materialselection&Calculationofmotorshaft Material: C_{45}

We know that diameter of shaft can be calculated by using following formula,

$$d^3 = \frac{16}{\pi \tau_{max}} \sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

where,

$[M_t]$=twisting moment

$[M_t]$=0.1574N-m

$[M_b]$=bending moment

$[M_b]$=1.8533N-m

K_t=torsionalfactor=1.5&K_b =bending stress factor=2

Nowfor C_{45} shaft material,

σ_{ut}=yield stress=353N/mm^2 $\tau = 0.5\ \sigma_{ut}$

τ = 176.5 N/mm^2 Let"s take fos = 1.5

$[\tau_{max}] = \tau/1.5$

$[\tau_{max}] = 176.5/1.5$

$[\tau_{max}]_{design}$ = 117.6667 N/mm^2 = 117.6667 × 10^6 N/m^2 Diameter of motor shaft is,

$$d^3 = \frac{16}{\pi \times 117.6667 \times 10^6} \sqrt{(2 \times 1.8533)^2 + (1.5 \times 0.1574)^2}$$

d = 0.005438 m = 5.438 mm ≈ 6 mm

Select a motor of shaft of 30 mm length and 6 mm diameter.

$\tau = 0.5\sigma_{ut}$

τ = 176.5 N/mm^2 Let"st akefos=1.5

$[\tau_{max}]=\tau/1.5$

$[\tau_{max}]$=176. 5/1.5

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d=0.005438 m=5.438 mm≈6 mm

Selectamotorofshaftof30mmlengthand6mmdiameter.

S.no.	Components
1	75 mm - Steel pipe – 2 no.s
2	12V DC gear motor
3	Wire 10 feet
4	Controller switches DPDT
5	Camera - 1
6	4-bar link mechanism
7	Rubber wheels- 6
8	Compressed spring - 75 mm
9	Nut
10	Bolt

I. RESULT AND DISCUSSION

In order to confirm the effectiveness of the mechanism of the pipe inspection robot, movement of robot for two different diameters is conducted in horizontal and vertical pipe in Solidworks

A. Horizontal movement

Using the pipe inspection robot, motion of robot in forwards and backwards direction inside the pipe that was laid horizontally is done in solidworks. So, the horizontal movement of the robot is achieved.

B. Vertical movement

The vertically upward and downward motions of robot are conducted in

Solidworks. In this way a vertical movement of robot is achieved.

CONCLUSION

In this paper the design of pipe inspection robot was done by considering the design parameters. On comparing the available pipe inspection robots namely PIG type, caterpillar type, Lead screw, walking 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 given inTable 2.

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