

DESIGN OF INTERNAL PIPE PAINTING ROBOT¹Popat Sawase, ²Aishwarya Mane, ³Nihal Waghmode, ⁴Nilesh Pundge⁵Prof. S.R. JoshiDepartment of Mechanical Engineering, ICOER, Pune^{1,2,3,4}, Professor, Department of Mechanical Engineering, ICOER, Pune, Maharashtra, India⁵**ABSTRACT**

The purpose of this project is to describe the reviews of past research work on various in-pipe robotic systems and their operations. This investigation has been focused on implemented methodologies for performing in-pipe cleaning and inspection. Design/methodology/approach This work has been concentrated on review of various sensors used in robot to perform in pipes inspection in cracks/flaws corrosion-affected areas, blocks and coated paint thickness. Various actuators like DC motors, servo motors, pneumatic operated and hydraulic operated are discussed in this review analysis to control the motion of various mechanical components of the robot. Findings In the current analysis, categorisation of various pipe cleaning robots according to their mechanical structure has been addressed. A lot of information has been gathered regarding the control of in-pipe robots for performing inspection and cleaning tasks. Originality/value In this paper, various in-pipe cleaning and inspection techniques have been studied.

Key Words: Painting Robot, Corrosion Resistance, Time Sensing, , Uniform Coating.

INTRODUCTION

Pipeline systems deteriorate progressively over time. Corrosion accelerates progressively and long term deterioration increases the probability of failure (fatigue cracking). Limiting regular painting 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. Painting of presently uninspected sections of the pipeline system becomes a must. This project provides information on the "Robotic Painting Technology". Pipelines are proven to be the safest way to transport and distribute gases and liquids. Regular painting is required to maintain that reputation.

Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labour 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. The painting of pipes may be relevant for improving security and efficiency in industrial plants. Pipelines which are tools for transporting oils, gases and other fluids such as chemicals, have been employed as major utilities in a number of countries for long time. Recently, many troubles occur in pipelines, and most of them are caused by aging, corrosion, cracks, and mechanical damages from the third parties. So, continuous activities for inspection, painting, maintenance and repair are strongly demanded.

1.1 Problem Statement

The main problem is the corrosion. Due to corrosion life of pipe is reduce, and small area and hazardous chemicals flow through the pipe it can't possible to paint manually. By considering those factors we decided to develop this project.

1.2 Objectives

1. To obtain a simple, compact design and to reduce human efforts.
2. To traverse a robot inside a pipe with forward and backward motion and should also climb in inclined pipes.
3. It should be able to move in various diameters of pipe.

4. To control the whole system with switch pad and to paint the pipe uniformly.

1.3 Corrosion

Corrosion of the pipe wall can occur either internally or externally. Internal corrosion occurs when corrosive liquids or condensates are transported through the pipelines. Depending on the nature of the corrosive liquid and the transport velocity, different forms of corrosion may occur, including uniform corrosion, pitting/crevice corrosion, and erosion-corrosion.

1.4 Internal corrosion

Internal pipeline corrosion is mitigated through various measures, including dewatering, inhibition, cleaning (pigging), and internal pipeline coatings. Dewatering consists of removal of the corrosive fluids prior to their introduction into the pipeline.

2. Design

System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man and machine interactions, no. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

2.1 System Selection Based on Physical Constraints

While selecting any machine it must be checked whether it is going to be used in a large-scale industry or a small-scale industry. In our case it is to be used by a small-scale industry. So space is a major constraint. The system is to be very compact so that it can be adjusted to corner of a room. The mechanical design has direct norms with the system design. Hence the foremost job is to control the physical parameters, so that the distinctions obtained after mechanical design can be well fitted into that.

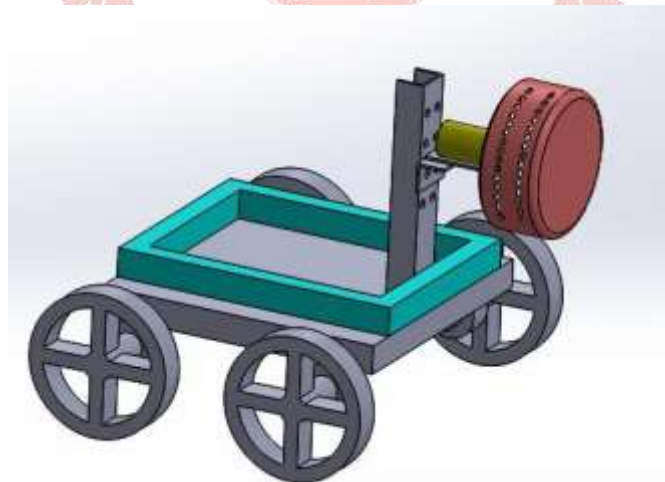


Fig - 1: CAD model of assembly

2.2 Chances of Failure

The losses incurred by owner in case of any failure are important criteria of design. Factor safety while doing mechanical design is kept high so that there are less chances of failure. Moreover periodic maintenance is required to keep unit healthy.

2.3 Arrangement of Various Components

Keeping into view the space restrictions the components should be laid such that their easy removal or servicing is possible. More over every component should be easily seen none should be hidden. Every possible space is utilized in component arrangements.

2.4 Man Machine Interaction

The friendliness of a machine with the operator that is operating is an important criteria of design. It is the application of anatomical & psychological principles to solve problems arising from man-machine relationship.

3. Mechanical Design

3.1 Selection of Front drive motor

We select DC motor as a drive motor for robot because of following advantages:-

1. Speed control over a wide range both above and below the rated speed.
2. High starting torque, having high efficiency.
3. Quick starting, stopping, reversing and acceleration.
4. These are small in size & many factors which make DC motors more advantageous compared to AC induction motors.

Table 3.1 Summary of calculations for drive motor

Sr. No.	Input Parameter		Output Parameter
1	$m = 10 \text{ kg}$	$g = 9.81 \text{ m/s}^2$	Normal Reaction (R_N) = 58.86 N
2	$\mu = 0.7$	$N = 58.86 \text{ N}$	Frictional Force (F) = 41.2 N
3	$F = 41.2 \text{ N}$	$R = 0.05 \text{ m}$	Torque (T) = 3.4335 N-m
4	$S = 1.5$	$T = 2.06 \text{ N-m}$	Starting Torque (T_s) = 3.09 N-m
5	$T_s = 3.09 \text{ N-m}$	$N = 10 \text{ rpm}$	Power (P) = 3.23 Watt

Table 3.2 Summary of calculations for DC motor

Sr. No.	Input Parameter			Output Parameter
1	$V = 2 \text{ m/min}$	$r = 0.25 \text{ m}$	$D = 0.14 \text{ m}$	Speed (N) = 1092 rpm
2	$m = 0.4 \text{ kg}$	$r = 0.07 \text{ m}$	$N = 1092 \text{ rpm}$	Centrifugal Force (F_c) = 1.8 N
3	$F_c = 1.8 \text{ N}$	$R = 0.07 \text{ m}$	—	Torque (T) = 0.126 N-m
4	$T = 0.126 \text{ N-m}$	$N = 1092 \text{ rpm}$	—	Power (P) = 14.4 Watt

3.2 ASME code for design of shaft:

Since the loads on most shafts in connected machinery are not constant, it is necessary to make proper allowance for the harmful effects of load fluctuations. According to ASME code permissible values of shear stress may be calculated from various relations.

$$\tau_{sk} = 0.18 S_{ut}$$

$$\tau_{sk} = 0.18 \times 505$$

$$\tau_{sk} = 90.9 \text{ N/mm}^2$$

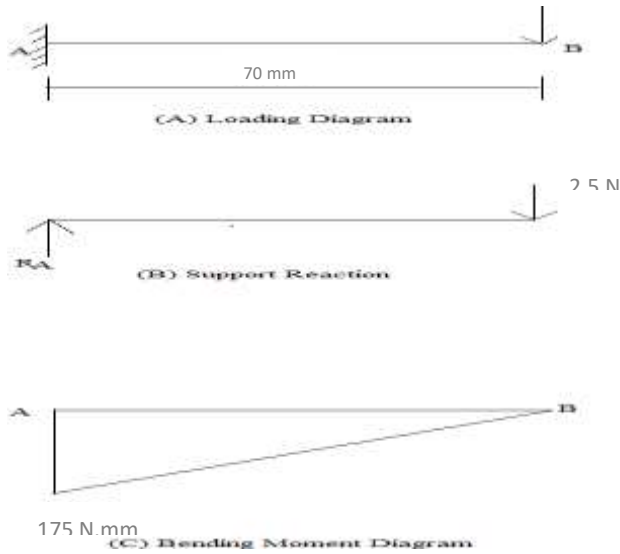
Or

$$\tau_{sk} = 0.3 S_{yt}$$

$$\tau_{sk} = 0.3 \times 215$$

$$\tau_{sk} = 64.5 \text{ N/mm}^2$$

Shaft is supported on one side by a motor with bracket and at other end rotor is mounted having its own weight; hence shaft will act as a cantilever beam. So the shaft will fail under the action of combined bending & shear stress.



Torque on shaft is given by,

$$P = \frac{2\pi \times N \times T}{60}$$

$$5 = \frac{2\pi \times 3000 \times T}{60}$$

$$T = 0.0159 \text{ N-m} = 15.91 \text{ N-mm}$$

For rotating shafts with gradual load, combined shock (K_b) & and fatigue factor (K_f) are,

Table 3.3 Summary of calculations for rotor shaft

Sr. No.	Input Parameter			Output Parameter
1	$S_{ut} = 505 \text{ N/mm}^2$	$S_{yt} = 215 \text{ N/mm}^2$	-	Max. shear stress (τ_{max}) = 16.125 N/mm^2
2	$W = 2.5 \text{ N}$	$L = 70 \text{ mm}$	-	Bending moment (M) = 175 N-mm
3	$P = 5 \text{ W}$	$N = 3000 \text{ rpm}$	-	Torque (T) = 15.91 N-mm
4	$K_b = 1.5$ & $K_f = 1$	$M = 175 \text{ N-mm}$, $T = 15.91 \text{ N-mm}$	-	Equivalent torque (T_e) = 175.72 N.mm
5	$T_e = 175.72 \text{ N.mm}$	$\tau_{max} = 16.125 \text{ N/mm}^2$	-	Diameter of shaft (d) = 3.81 mm
6	$T_e = 175.72 \text{ N.mm}$	$d_o = 8 \text{ mm}$	$d_i = 3.17 \text{ mm}$	Actual shear stress (τ_{act}) = 1.792 N/mm^2

4. Future Validation

4.1 Advantages

The painting robot saves on time required for painting.

The painting robot saves on the labor cost.

As robot is automatic it reduces human effort.

It is easy to maintain.

Manufacturing and maintenance cost of robot is very less.

4.2 Applications

For painting of boiler fed pipes.

It can be used for painting water supply pipes.

For painting process industry pipes.

It can use for painting oil refinery pipes.

For painting of screen type water filters.

4.3 Further Modification

DC motor speed control can be made remote operated.

Flow control valve can be made solenoid control for automatic operation.

PLC control will make the machine programmable for ease of operation.

As web camera is used on the robot, same machine can be used for pipeinspection.

It could be fitted with ultrasonic sensors and can pin point us the location of ahole.

CONCLUSIONS

1. It is also an object of the machine to provide apparatus wherein a spray coating head may be pulled through the pipe at a uniform speed either manually or with automated equipment.
2. The robot is automated and reduces the losses of paint occurred during the painting. Also painting robot reduces the human efforts largely.
3. Pipe ID painting robot can be also implemented for the inspection of the pipe by using webcam in the future it will also help for detection of defects in the internal diameter of pipe by using PLC we can also implement our project fully automated.

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