International Journal of Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: 10.31695/IJASRE.2023.9.5.3

Volume 9, Issue 5
May - 2023

Design and Development of Robot for Industrial Pipe Cleaning and Inspection

Chethan B P[1], Anilkumar P R[2], Chethan kumar S[3], Pramod Kumar H[3], Ankush G[3], Yeshwanth Kumar B[3]

Assistant professor[1 2], Students [3]

Department of Mechanical Engineering

Sapthagiri College of Engineering

Bengaluru, Karnataka

India

ABSTRACT

Nowadays many industries used different diameter pipes for different applications like carrying chemicals, high-pressure steam, and gasses hence there may be chances of problems like corrosion, and leakages. The proposed system suggests the robot will be built to clean the residues that are built up inside the pipe. This is done through a brushing mechanism. Not only this robot will also be able to relay live video feedback from the ground to the controller that the user has. By this, the users can verify the cleaning that is done by the robot.

Key Words: Bluetooth control, Cleaning, Inspection, Robot, WIFI Camera.

1. INTRODUCTION

Robotic inspection is employed in many industrial sectors. One application involves keeping an eye on the inside of pipes and channels in order to spot issues and find solutions. A mobile robot can automate the inspection of a pipe's inner surface. Because they are typically buried underground, pipelines are in contact with the soil and are therefore vulnerable to corrosion, which causes the steel pipe wall to oxidise and thereby reduce the wall thickness. The release of new technology, the world changes every day. The main goal of technology is to make human life easier and simpler dependent. Occasionally, due to illness or accident, people who have lost their hand, legs, or both temporarily or permanently in this situation they require a wheelchair that works on voice commands.

Inspection of the pipe is required to find flaws brought on by corrosion and wear while the pipe is carrying fluids. This skill is especially important when it comes to inspecting subsurface pipes. In this study, a Pipe Inspection Robot (PIR) that can travel within both horizontal and vertical pipes was conceived and made. The robot has a driving motor and a camera for a monitoring station, respectively. One of the engineering disciplines with the fastest current growth is robotics. Robots are made to perform labor-intensive or dangerous tasks without the involvement of humans and to operate in environments that are difficult to access. However, if you take a look at the prices of those robots you will find that they are way too expensive. This proposed system aims to create another kind of pipeline inspection robot. Because we think that it is beneficial to have a robot with an adaptable structure to the pipe diameter, and cheaper at the same time [1].

2. LITERATURE SURVEY

The different existing systems for robotic inspection were looked into to analyse the gaps and find objectives for the current system.

Ana Sakura Zainal Abidin et al., Pipelines are essential tools for transporting water, oils, gases and sewer from one place to another [1]. Pipelines are used to interconnect networks from one station to another that involved various diameter sizes and fittings to compensate intended directions. There are many issues that influenced performance of the pipelines namely aging, corrosion, cracks and use to clog up with debris, or sediments after long use. There are number of methods available to clean the

inside of the closed pipeline namely traditional method like boiling, picking, alcohol and salt and cleaning kits, or tools kits such as wire and plunger or large-gauge snake. However, all the methods can over-stress older pipeline and cause leaks that make even more extensive repair procedures needed to fix the problem. Chemical fluid for pipe cleaning is also not suitable to all types of pipeline because the chemical can erode the pipe wall. Currently, service robot is the best solution that purposely developed to facilitate humans being activities including cleaning, inspection for cracks or repairing damage in pipeline. This paper intends to report about the development of cleaning device for in-pipe robot application. The development covers both software and hardware of the device [2].

Zhixiang Li ec.al., Industry pipework has already seen a wide use, but cleaning piping is a problem needed to be solved urgently at present. Based on the types of cleaning piping, this paper presents a biomimetic robot in the shape of crocodile, and makes related research with the crocodile's physiological features, movement patterns, digestive mechanism and so on. The research correlates biological characteristics with the achieving function in actual system, at last forming a new industrial pipeline cleaning way by the method of combining physics and chemistry [3].

Chang Doo Jung et.al., Recently, interests on cleaning robots workable in pipes (termed as in-pipe cleaning robot) are increasing because Garbage Automatic Collection Facilities (i.e., GACF) are widely being installed in Seoul metropolitan area of Korea. So far research on in- pipe robot has been focused on inspection rather than cleaning. In GACF, when garbage is moving, we have to remove the impurities which are stuck to the inner face of the pipe (diameter: 300mm or 400mm). Thus, in this paper, by using TRIZ (Inventive Theory of Problem Solving in Russian abbreviation), we will propose an in-pipe cleaning robot of GACF with the 6-link sliding mechanism which can be adjusted to fit into the inner face of pipe using pneumatic pressure (not spring), well as rotation of brush in cleaning [4].

Luis A. Mateos et al., Pipelines carrying fresh water are vulnerable to damage because of ageing, heavy traffic, and geological changes. Due to these damages, the pipe-joints might not be entirely hermetically sealed, which could lead to water loss along the pipeline. Leakage is an issue not only because it wastes a valuable resource but also because it undermines the foundations of roads and buildings, causing financial loss. Pipeline construction or replacement is expensive and requires the use of large equipment like cranes. In addition, adverse effects could manifest in the form of construction sites along streets that block pedestrian and vehicular traffic [5].

Nur Shahida Roslin et al., Researchers have improved the current in-pipe inspection robots during the last five years by creating hybrid locomotion, which combines two or more propulsion mechanisms to create a sturdy but flexible robot platform. According to the implemented locomotion mechanism, a number of hybrid robots have been studied and categorised in this work. Caterpillar wall pressing, wheeled wall pressing, and wheeled wall pressing screw are the three types of hybrid locomotion systems. Each hybrid locomotion system is created in accordance with specific design criteria for a given environment, and they might not be appropriate for all applications. This review's objective is to draw attention to the in-pipe robot for inspection's recent advances in technology [6].

A pipe inspection robot is a device that is placed into pipes to look for obstruction or damage. These robots tend to be manufactured overseas, are very expensive. As a result, related environmental services had been cut back. A New Zealand company using this equipment must endure extended periods of downtime while their robots are being repaired. They recently informed the public that a number of robots were no longer supported. The idea behind this project was to use the already-existing mechanical platform to modify one of these PIR's electrical control systems [7].

3.OBJECTIVES

During the execution of the projects we have had specific and transparent objectives. These
include the following:

- Increased pipeline carrying capacity: As the deposits are removed the volume inside the pipe increases.
- Improved product quality: Corrosion can cause catastrophic failure with a check in corrosion such a risk is avoided.
- Power savings by reducing pump pressure: As carrying capacity increases the pump requires less pressure to pump the fluid into the pipe
- Confirmation of pipe and flow integrity
- Live video streaming: To monitor the condition of the pipe and to make sure that the cleaning is done
- Remote robot control

4.MATERIALS and METHODOLOGY

DOI: 10.31695/IJASRE.2023.9.5.3

A. 100 RPM DC MOTOR

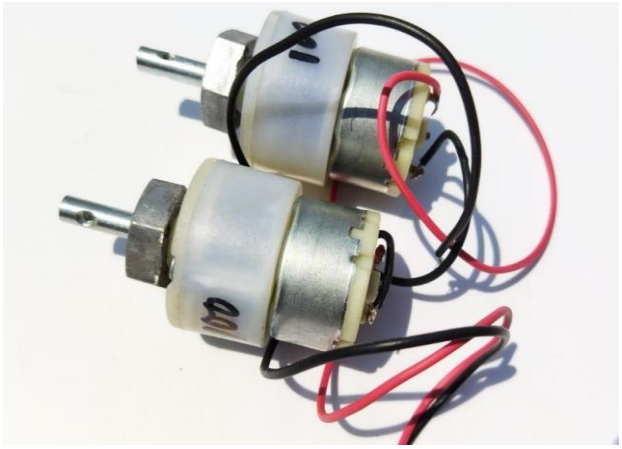

Fig. 1: 100 RPM Gear Motor

100 RPM 12V DC geared motors widely used for robotics applications. Very easy to use and available in standard size. Also, you don't have to spend a lot of money to control motors with an Arduino or compatible board. The most popular L298N H-bridge module with onboard voltage regulator motor driver can be used with this motor that has a voltage of between 5 and 35V DC or you can choose the most precise motor diver module from the wide range available in our Motor divers' category as per your specific requirements as in Fig. 1. Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel. DC Geared motors with robust metal gearbox for heavy-duty applications, available in the wide RPM range and ideally suited for robotics and industrial applications.

Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel.

- RPM: 100
- Operating Voltage: 12V DC
- Gearbox: Attached Plastic (spur)Gearbox
- Shaft diameter: 6mm with internal hole
- Torque: 2 kg-cm
- No-load current = 60 mA (Max)
- Load current = 300 mA (Max).

B. MOTOR DRIVE

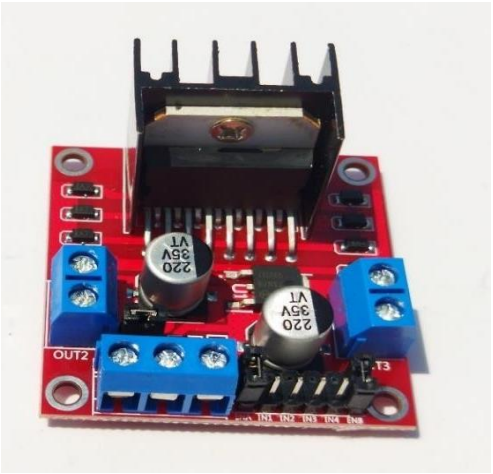

Fig 2: Motor Driver

As in Fig. 2, this L298N Based Motor Driver Module is a high-power motor driver perfect for driving DC Motors and Stepper Motors. It uses the popular L298 motor driver IC and has the onboard 5V regulator which it can supply to an external circuit. It

DOI: 10.31695/IJASRE.2023.9.5.3

can control up to 4 DC motors, or 2 DC motors with directional and speed control. This motor driver is perfect for robotics and mechatronics projects and perfect for controlling motors from microcontrollers, switches, relays, etc. Perfect for driving DC and Stepper motors for micro mouse, line following robots, robot arms, etc [8].

C. BLUETOOTH MODULE

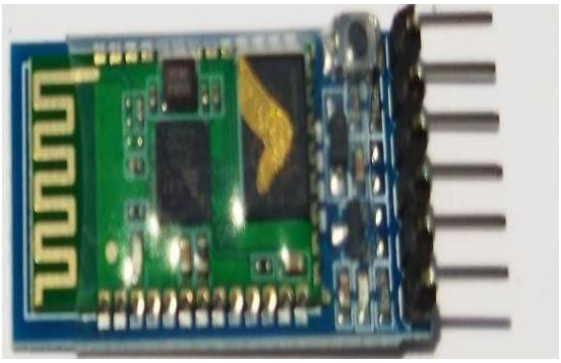

Fig 3: Bluetooth Module

A HC-06 is the popular Bluetooth module as in Fig. 3. This HC06 module is slave mode only. It's very easy to add wireless serial connectivity for your device with this module. Examples for Arduino and other boards are available. Once you pair with other Bluetooth devices you work like with normal UART to exchange data.

This module has built-in 3.3V voltage regulator and helps to break out the important pins (Vcc, Gnd, Txd, Rxd). Based on CSR BC4 chip, Bluetooth V2.0 + EDR. You can set the baud rate, name and pair password by AT commands when there is no Bluetooth connection. This module is a slave- it can be paired with Computer- Bluetooth master- mobile phone- PDA- PSP and so on [9].

D. RELAY

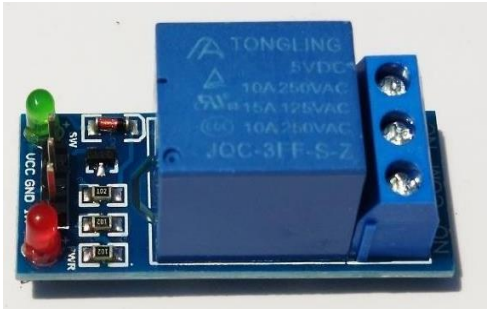

Fig 4: Relay

Fig. 4 shows 1-channel 5V control Single-Pole Double-Throw (SPDT) High-level trigger AC power relay board can be controlled directly via a microcontroller and switch up to 10A at 250 VAC. The inputs of 1 Channel 5V Relay Module are isolated to protect any delicate control circuitry. The default state of the relay when the power is off for COM (Power) to be connected to NC (Normally Closed). This is the equivalent of setting the relay board IN pin to HIGH (has +5V sent to it)[10].

METHODOLOGY

DOI: 10.31695/IJASRE.2023.9.5.3

This block diagram consists of Arduino Nano, Bluetooth module, relay, motor driver and power supply. The Arduino Nano as in Fig. 5 is Arduino's classic breadboard friendly designed board with the smallest dimensions. The Arduino Nano comes with pin headers that allow for an easyattachment onto a breadboard and features a Mini-B USB connector[11].

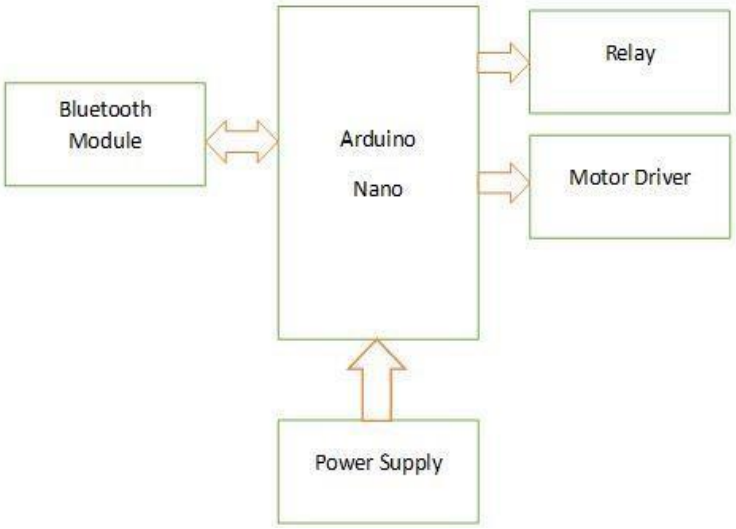

Fig 5: Block diagram

The classic Nano is the oldest member of the Arduino Nano family boards. Arduino is an open hardware development board that can be used by tinkerers, hobbyists, and makers to design and build devices that
interact with the real world. The movement of the DC motor can be controlled by the bluetooth module, its work based on the Arduino nano fixed in the circuit.
The circuit fixed to the bread board and movement control can be operates with the bluetooth RC controller. It requires Basic Python code to connect the bluetooth module, the python program dumped to the circuit. The Arduino Nano is a small, complete, and breadboard-friendly board based on the
ATmega328 (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove , but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.

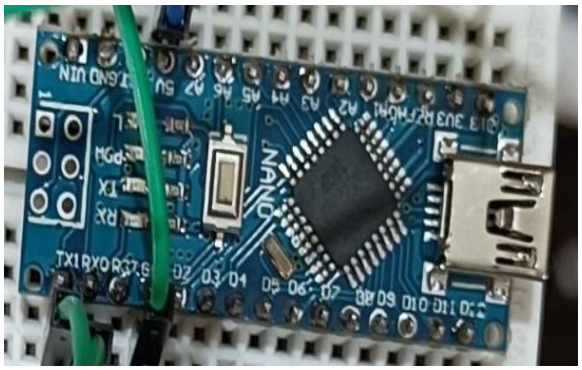

Fig 6: Arduino Nano

This circuit diagram helps/guide to the the circuit as per the block diagram. Arduino nano is the heart of the pipe cleaning and inspection robot as in Fig. 7. This circuit contains the all movement control of the pipe cleaning and inspection robot. Firstly, circuit is designed as per our requirement, the circuit placed on the bread board to make connections. Two channel relay, rechargeable lithium poly battery, bluetooth module, three 100 rpm gear motor, and one 60 rpm gear motor connected to the circuit. Which
is connected to the as shown in the block diagram and circuit diagram. Here we prepare the program for to connect the robot to Bluetooth RC Controller, it is help to control the movement of the pipe cleaning and inspection robot. We plan the design the robot of the pipe cleaning and inspection robot
clean the pipe with the help of the brush, which is mounted bottom of the robot. Here we clean the 100m.

DOI: 10.31695/IJASRE.2023.9.5.3

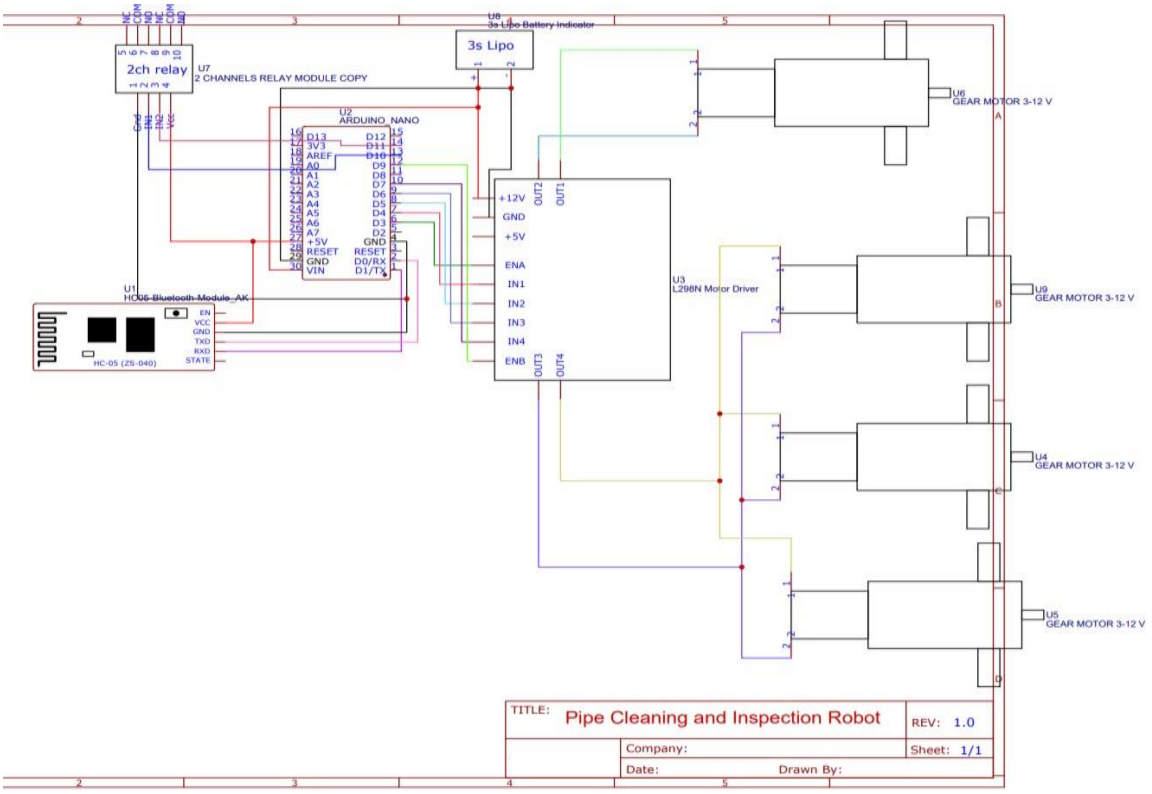

Fig 7: Circuit and Circuit Diagram

pipe because the Bluetooth frequency is 100 m and duration of the cleaning robot is based on battery charge, and we inspect the dust forign particle within the range of 150 meter because the Wi-Fi frequency is 150m[12].

5. RESULTS

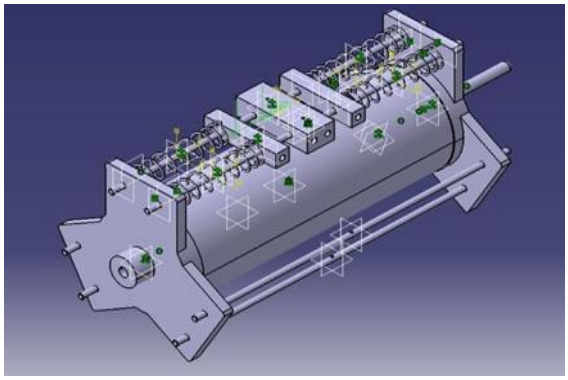

Fig 8 : Model Design of Pipe Cleaning and Inspection Robot

In this project we first make the 2D drawing of the project and create the 3D model of the project using the Catia V5 software. We prepare each parts of the 3D model with the dimension. Then make assembly of the pipe cleaning robot and see the 3D model as in Fig. 8 of the project, then we made the small correction of the project, like design, dimension, material used etc[13].

Here we use a transparent acrylic sheet material, PVC pipe. We give the cutting work of each component to workshop. The acrylic sheet used in this project to cut each component with 5mm thickness. The components are circular body, connecting rod, roller frame, covering cap, shaft, slider, arm. Then we purchase the electronic components, electrical components are three 100 rpm motor, one 60rpm motor, rechargeable lithium poly battery, lithium poly battery tester, jumper cables, bread board, relay, Bluetooth module, motor driver, WIFI camera, 12 V LED strip, and also purchase the roller belt, spring, nut and bolts, and wheels. We made the circuit with the help of Arduino Nano. The Arduino Nano require a programming to control the movement by the robot. Here we prepare pipe cleaning and inspection robot, the movement control/operate a robot wireless (Bluetooth control), and we provide the Wi-Fi camera for inspection purpose. With the help of CS department professor prepare a coding, with the help of C program and we prepare a circuit diagram with the help of EC department professor. After the prepare the

DOI: 10.31695/IJASRE.2023.9.5.3

block diagram of the pipe cleaning robot. Then we finalise the circuit, circuit diagram, block diagram, and collect the components from work shop. Then we test the battery, circuit, electronic components and WiFi camera, led strip[14].

We starting a assembly of the pipe cleaning robot with the help of the circuit diagram and rig up, then we made a all connections as per the circuit diagram. We develop the body part using the pvc pipe and the components as per the 3D mode of the pipe cleaning robot. Then we fix the WiFi camera for inspection purpose and fix the brush for cleaning purpose. And connect the robot to Bluetooth control using the Bluetooth RC Control Application in mobile and connect the Wi-Fi camera to HD WIFI Cam pro Application for inspection purpose. Then we operate the pipe cleaning robot[15].

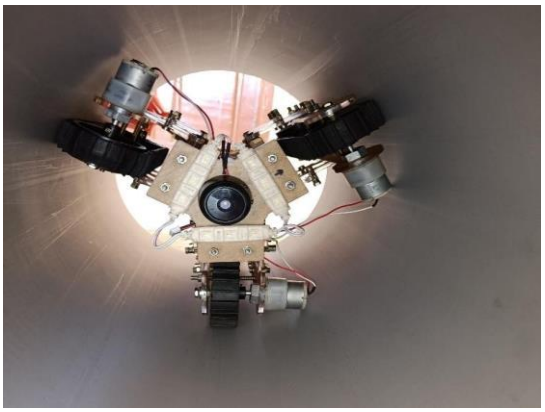

Fig 9: Pipe cleaning and inspection robot in inside the pipe and Robot

Fig 10: Pipe cleaning and inspection robot

In this pipe cleaning and inspection robot first, we check the pipe cleaning and inspection robot, and then check the battery charge with the help of lithium battery tester. Then rig up the circuit and then turn on the battery connection, the battery supplies the 5V power supply to the circuit and wifi camera. Then we connect Bluetooth module to Bluetooth RC Controller Application using the Bluetooth and connect the WIFI camera to HDwifiCam Pro Application using mobile wifi. Afer the all connection we place the pipe cleaning and inspection robot in side the pipe, and check the robot once again after place the pipe cleaning and inspection robot.

Then we operate the pipe cleaning and inspection robot using the Bluetooth RC Controller Application and watch the inspection video in HDwifiCam Pro Application. The pipe cleaning and inspection robot clean the pipe with the help of the brush, which is mounted bottom of the robot. Here we clean the 100m pipe because the Bluetooth frequency is 100 m and duration of the cleaning robot is based on battery charge, and we inspect the dust forign particle within the range of 91 meter because the Wi-Fi frequency is 91m. In control panel of the indicate the red- light blink and green light blink, red light indicates the not connected the robot to Bluetooth RC Control. Green light indicates the robot connected to Bluetooth RC Control. This pipe cleaning and inspection robot clean the minimum 30cm of pipe. Here we provide a buzzer to check the battery empty status, when battery power is going to empty status that time the buzzer is produce sound, and it indicates the battery need to charging and using the charger charge the battery. The robot movement is up and down achieved we check the cleaning progress in HD Wi-Fi pro cam Application and one more time to clean the pipe where pipe required cleaning[16].

DOI: 10.31695/IJASRE.2023.9.5.3

6.CONCLUSIONS

People with disabilities depend on others in theirdaily lives. After testing the system we were able to achieve following results.

- The robot did not move with the lower power motors (Higher torque motors were added)
- The robot did not clean the **bottom of the pipe** (The cleaning brush pipe was readjusted)
- There was significant difference in colour and appearance on the interior of the pipe after cleaning.
- Due to cleaning the rust was dropped and dissipated in the form of a dusty cloud.

Here we achieve the movement control of the pipe cleaning and inspection robot with the help of the **Bluetooth RC Controller Application** and also **achieve the video streaming** when the pipe cleaning and inspection robot working condition in inside the pipe. Here use a minimum **30cm diameter pipe.** In control panel of the indicate the **red-light blink and green light blink**, red light indicates the not connected the robot to Bluetooth RC Control.

Green light indicates the robot connected to Bluetooth RC Control. And in **HD WiFi Cam pro** showing the result of the WiFi camera, in the **HD WiFi Cam pro blink icon** used to checking the camera ON/OFF condition Here the pipe cleaning and inspection robot control only the 100m, because the **Bluetooth frequency is with in 100meter** and **inspect the dust in the range of 91meter** because the wifi range is 91m.

7. SUGGESTION FOR FUTURE WORK

This is the first implementation of the project and hence there is huge scope of improvement in the future. Some of the areas where improvement should be sought include the following:

- Versatility: currently the PIAC only works with pipes of fixed diameter. This has to be corrected in the future enabling the robot to work with different sizes of pipes and even at horizontal and vertical angles.

- Battery life: currently a 1.2 AH 12V lead acid battery is used to power the system. Due to the low capacity of the battery the system runs out of charge relatively quickly. This should be corrected in the future with the use of larger size batteries and also by improving the over efficiency

- Engineering standards: since this build is the first prototype just to prove the concept no engineering standards are approved.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to the Management and Principal, Sapthagiri College of Engineering Bangalore for the facilities provided and their support. Also, we would like to thank the Head of department Mechanical Engineering and faculties for their encouragement and support.

REFERENCES

[1] Ana Sakura Zainal Abidin, Muhammad Hamizan Zaini, Muhammad Farhan Aiman Mohd Pauzi, Mohammad Muaz Sadini, Sim Chia Chie, Shahrol Mohammadan, Annisa Jamali, RasliMuslimen, Muhd Fadzli Ashan, Mohd Syahmi Jamaluddin, Chong Yee Ming, “Development of cleaning device for in pipe-robot application”, in Procedia Computer Science, Vol.79, pp.506-511, 2015.

[2] Zhixiang Li, Jing Zheng, and Xin Lin, “Research on biomimetic robot-crocodile used for cleaning industrial pipes”, Institute of Mechanical and Electronic Engineering, Wuhan University of Technology, {lzx1370, zhengjing19870718}@yahoo.com.cn, lx6120@163.com.

[3] Ahireakash, Kumkarsachin, Waghchaure Atul, V.S. Gavli, “Study of pipe inspection and cleaning robot”, Vol.04, No.03, March 2016.

[4] Nguyen Truong, Nguyen Ngoc, Tuong Phuoc, “A study of pipe-cleaning and inspection robot”, Vol. 4, pp.7-11, 2011.

[5] Mahmoud Tavakoli, Lino Marques and Anı´bal T. de Almeida, “Development of an industrial pipeline inspection robot”, Vol.37, No.3, pp.309-322, 2013.

[6] Mohd Zamzuri Ab Rashid, Mohd Fitri Mohd Yakub a, Sheikh Ahmad Zaki bin Shaikh Salim, Normaisharah Mamat, Sharifah Munawwarah Syed Mohd Putra, Shairatul Akma Roslan, “Modeling of the in-pipe inspection robot: A comprehensive review”, Vol.20, 2010,: www.elsevier.com/locate/oceaneng.

DOI: 10.31695/IJASRE.2023.9.5.3

[7] Luis A. Mateos, Markus Vincze, "In-pipe Robot with Capability of Self Stabilization and Accurate Pipe Surface Cleaning", Vol. 5, December 2017.

[8] L. Mateos, M. Sousa, and M. Vincze, "Dewalop remote control for in-pipe robot," in, 2011 15th International Conference on Advanced Robotics (ICAR), pp. 518 –523 june 2011.

[9] Horodinca M, Dorftei I, Mignon E and Preumont, "A Simple Architecture for in Pipe Inspection Robots", in Proc. Int. Colloq. Mobile, Autonomous Systems, pp. 61-64, 2011.

[10] Mohammed Moustafa, Sabreen A. Abdelwahab, "Mechanical Design and Simulation of Water Pipes Cleaning Robot", in Port said engineering research journal, Vol.25, No.1, pp.128-141, March 2021.

[11] Chang Doo Jung, Won Jee Chung, Jin Su Ahn, Myung Sik Kim, Gi Soo Shin, Soon Jea Kwon, "Optimal mechanism design of in-pipe cleaning robot", in IEEE International Conference on Mechatronics and Automation, Vol.12, 2011.

[12] Yoon-Gu Kim, Dong-Hwan Shin, "Design and implementation of an optimal in-pipe navigation mechanism for a steel pipe cleaning robot", in 8th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI) Vol .8, pp. 85-89, August 2012.

[13] Ajit Salunke, Swapnil Ramani, Sujay Shirodkar, Osburn Vas, Kedar Acharya, "Pipe cleaning robot", in 2019 International Conference on Nascent Technologies in Engineering (ICNTE), Vol.3, January 2020.

[14] Veerajagadheswar Prabakaran, MohanRajesh Elara, Thejus Pathmakumar, Shunsuke Nansai, "Floor cleaning robot with reconfigurable mechanism", in Automation in Construction, Vol.91, pp.155-165, July2018.

[15] Nur Shahida Roslin, Adzly Anuar, Muhammad Fairuz Abdul Jalal, Khairul Salleh Mohamed Sahari, "A Review: Hybrid Locomotion of In-pipe Inspection Robot", in Procedia Engineering, Vol.41, pp.1456-1462, 2012.

[16] Kumkarsachin, Changhwan Choi, Byungsuk Park, Seungho Jung, "The Design and Analysis of a Feeder Pipe Inspection Robot with an Automatic Pipe Tracking System", in IEEE/ASME Transactions on Mechatronics, Vol.15, No.5, October 2010.

DOI: 10.31695/IJASRE.2023.9.5.3