

Design And Fabrication of a Manual Sliding Pipe Choke Cleaning Robot

Dr. Dipali Bhoyar

Ass. Professor,

Department of Mechanical Engineering
Tulsiramji Gaikwad-Patil College of
Engineering & Technology, Nagpur,
Maharashtra, India

Abhijeet Humendra Dongre

Student,

Department of Mechanical Engineering
Tulsiramji Gaikwad-Patil College of
Engineering & Technology, Nagpur,
Maharashtra, India

Khushal Rajesh Sonewane

Student,

Department of Mechanical Engineering
Tulsiramji Gaikwad-Patil College of
Engineering & Technology, Nagpur,
Maharashtra, India

Mayur Tukaram Tembhaker

Student,

Department of Mechanical Engineering
Tulsiramji Gaikwad-Patil College of
Engineering & Technology, Nagpur,
Maharashtra, India

Prashant Puranlal Thakre

Student,

Department of Mechanical Engineering
Tulsiramji Gaikwad-Patil College of
Engineering & Technology, Nagpur,
Maharashtra, India

Deepak Ramdham

Student,

Department of Mechanical Engineering
Tulsiramji Gaikwad-Patil College of
Engineering & Technology, Nagpur,
Maharashtra, India

Abstract— Pipeline systems are widely used for transporting water, oil, chemicals, and other fluids in industrial and municipal applications. During continuous operation, internal surfaces of pipes can accumulate rust, sludge, grease, scale, and other unwanted deposits, resulting in partial or complete choking and reduced fluid flow. Conventional cleaning methods may require significant manpower, pipeline dismantling, and specialized equipment. To address these limitations, this project proposes the design and fabrication of a Manual Sliding Pipe Choke Cleaning Robot. The proposed system is a compact and economical mechanical cleaning device designed to move inside a pipe through a manual sliding mechanism. Guide wheels provide proper alignment and stability, while a cleaning assembly consisting of brushes and/or scrapers removes accumulated deposits from the internal pipe surface. A manually operated push-pull arrangement enables the operator to control the movement and cleaning action without requiring electrical power. The system is intended to provide simple operation, easy maintenance, portability, and repeated usability. The developed prototype can help reduce cleaning time, minimize pipeline maintenance effort, and improve flow conditions. The project focuses on laboratory-scale design, fabrication, and functional testing of the manual sliding mechanism and cleaning arrangement.

Keywords—Manual Sliding Robot, Pipe Choke Cleaning, Pipeline Maintenance, Mechanical Scraper, Cleaning Robot.

I. INTRODUCTION

Pipelines are an important part of modern infrastructure and are extensively used for transporting water, oil, gas, chemicals, wastewater, and other fluids. Industrial and municipal pipelines often operate continuously under demanding environmental and operating conditions. Over time, the internal surface of a pipeline can be affected by corrosion, scaling, sludge accumulation, grease, sediment, and other impurities. These deposits gradually reduce the effective internal diameter of the pipe and restrict fluid movement. If the accumulated material is not removed at regular intervals, it can develop into a severe choke or blockage, resulting in reduced flow rate, increased pressure losses, higher energy consumption, and interruption of the pipeline service. Regular inspection and maintenance are therefore important for maintaining pipeline reliability and operational efficiency. The reference project similarly identifies corrosion, leakage, scaling, and structural defects as important pipeline maintenance problems [1][2].

Conventional pipe cleaning techniques include manual cleaning, flushing, chemical treatment, mechanical rods, and specialized pipeline cleaning equipment. Although these methods can be effective, their suitability depends on the pipe diameter, type of deposit, pipeline accessibility, and operating conditions. Cleaning narrow or confined pipelines manually can be difficult because workers may not be able to directly access the internal surface. Such activities can also require considerable physical effort and time. The reference material notes that manual inspection inside pipelines is unsafe and often impractical because of limited space and hazardous environments. Therefore, a simple mechanical device that can enter a pipe and remove deposited material can provide a useful alternative for small- and medium-scale maintenance applications [3][4].

Robotic systems have increasingly been considered for pipeline inspection and maintenance because they can operate within confined internal spaces and reduce direct human intervention. Existing in-pipe robotic concepts commonly use wheels, caterpillar mechanisms, cameras, sensors, or cleaning tools. The uploaded reference presentation describes a pipe robot using wheels, a camera, and a cleaning mechanism for internal pipeline applications. However, advanced robotic systems can involve electronic controllers, batteries, sensors, wireless communication, and complex mechanisms. Such additional components may increase manufacturing cost, maintenance requirements, and system complexity [5].

The proposed Manual Sliding Pipe Choke Cleaning Robot focuses on developing a simpler and economical mechanical solution. Instead of depending on an electrically powered drive system, the robot is designed to move through the pipeline using a manual sliding or push-pull mechanism. The operator can insert the robot into the pipe and move it forward and backward using a handle or sliding rod. Guide wheels or supporting elements help maintain proper contact and alignment with the internal pipe surface. A cleaning tool, such as a brush, scraper, or combination of cleaning elements, is mounted on the robot body to physically remove deposits as the robot moves through the pipe [5][6][7].



Figure 1. Internal pipe leakage and choke

The major advantage of the proposed concept is its simple construction and ease of operation. Since the system is manually operated, it does not require a complex motor-control system or continuous electrical power for basic movement. This can make the prototype suitable for educational laboratories, workshops, maintenance activities, and small-scale pipeline applications. The cleaning mechanism can also be designed with replaceable tools so that different types of deposits can be addressed. The uploaded reference work emphasizes that compact and economical robotic systems can reduce inspection effort and operating costs compared with conventional approaches [8][9][10].

The project therefore concentrates on the design, fabrication, and functional evaluation of a manually sliding pipe-cleaning mechanism. The prototype aims to demonstrate controlled movement inside a pipe, proper alignment, effective contact between the cleaning tool and pipe wall, and removal of representative choke materials. The overall objective is to develop a low-cost, portable, reusable, and mechanically simple solution for pipeline choke cleaning. Such a system can reduce manual cleaning effort, improve maintenance efficiency, and provide a practical foundation for future development toward motorized, camera-assisted, or semi-automated pipe-cleaning robots.

II. PROBLEM IDENTIFICATION

- **Internal Choke Formation:** Pipelines gradually accumulate rust, sludge, grease, scale, sediment, and other deposits, which reduce the effective flow area and may cause partial or complete blockage.
- **Reduced Flow Efficiency:** Accumulated deposits increase resistance to fluid movement, resulting in reduced flow rate, increased pressure loss, and inefficient pipeline operation.
- **Difficult Internal Access:** Many pipelines have narrow internal diameters or are installed in confined locations, making direct access for cleaning difficult and impractical.

- **High Manual Effort:** Conventional manual cleaning requires considerable physical effort and repeated operations, particularly when deposits are hard or strongly attached to the pipe surface.
- **Time-Consuming Maintenance:** Traditional cleaning procedures can require significant time and may interrupt normal pipeline operation, increasing maintenance downtime.
- **Safety Concerns:** Workers may face hazardous and confined working conditions while attempting to access or clean pipeline interiors.
- **Complex Existing Systems:** Advanced robotic inspection and cleaning systems can involve cameras, sensors, controllers, motors, and communication systems, increasing system complexity and cost.
- **Need for Economical Solution:** There is a need for a compact, portable, low-cost, manually operated mechanism that can enter a pipeline and mechanically remove choke materials efficiently.

A. Existing System

Existing pipe-cleaning systems mainly use manual rods, flushing, chemical cleaning, pigging, or powered robotic mechanisms to remove internal deposits and blockages. Conventional manual methods require workers to insert cleaning tools into the pipeline and apply physical force, making the process difficult for long or narrow pipes. Advanced robotic systems use wheels, motors, cameras, sensors, and control units for inspection and cleaning, but these systems can be costly and mechanically complex. The reference presentation also identifies existing systems involving robotic inspection, leakage detection, and cleaning mechanisms. These limitations create a need for a simpler manual sliding cleaning solution.

B. Drawbacks

Existing pipeline cleaning methods have several limitations. Manual cleaning requires considerable human effort and may be difficult in narrow or confined pipelines. Conventional methods can be time-consuming and may require pipeline dismantling, resulting in maintenance delays. Advanced robotic systems provide better inspection and cleaning capabilities but require motors, batteries, sensors, controllers, cameras, and communication systems, increasing manufacturing and maintenance costs. Wireless communication can also be affected inside metallic pipelines. Furthermore, complex systems may require skilled operators and specialized maintenance. Therefore, a compact, economical, manually operated pipe choke cleaning robot can overcome several of these practical limitations.

III. LITERATURE REVIEWS

A) Literature Survey:

Yanbin Ning et al. (2025), developed an integrated micro-robot for detecting, unclogging, and cleaning domestic drainage pipes. The study targeted DN25–DN75 pipes and focused on improving the limitations of manual dredging, which is inefficient and can create environmental and safety problems. A crawler-based mechanism was designed to provide movement and cleaning capability inside narrow

pipes. Structural design and simulation were used to evaluate the main components. The work demonstrates the feasibility of combining detection and cleaning functions in a compact robotic platform. It provides useful design concepts for the proposed manual sliding pipe choke cleaning robot.

Zhenxiang Li, Chang Wang & Jianlong Li (2025), proposed a crawler-type pipeline cleaning robot for medium- and large-diameter pipelines. The robot was designed to operate in pipes ranging from 800 to 1200 mm in diameter. A variable-diameter crawler mechanism was incorporated to improve adaptability to different pipeline sizes. The authors analyzed geometric and motion constraints and used ADAMS simulation to investigate the robot's passability. Results indicated that the robot could travel through straight pipes and L-shaped bends within the specified diameter range. This research highlights the importance of mechanical adaptability and stable contact between the robot and pipe wall, which are important considerations for developing an effective cleaning mechanism.

Qianwen Liu et al. (2025), developed a specialized robot for cleaning narrow heat-exchanger tubes. The proposed system used a dual-wheel cross-drive configuration to improve stability and incorporated a gear-rack alignment mechanism with a cam-based propulsion system. A flexible cleaning arm enabled the robot to perform cleaning operations inside narrow tubes. The modular construction allowed easier assembly and maintenance. A vision-guided control system was also introduced for positioning and task scheduling. Experimental evaluation demonstrated automatic navigation and sub-pipe cleaning, with pipe-switching times below 30 seconds. The study demonstrates how compact mechanical cleaning mechanisms can improve accessibility and cleaning efficiency in confined pipelines.

Yuanji Zhu (2025), investigated bionic crawling robots for cleaning and maintaining pipelines. The study addressed common pipeline problems such as dirt accumulation, foreign-object blockage, and corrosion, which reduce transportation efficiency and may create safety hazards. The research examined robotic approaches as alternatives to conventional manual cleaning and high-pressure water-jet methods. Bionic crawling principles were considered for improving movement and adaptability inside confined pipeline environments. The work emphasizes the importance of developing cleaning robots that can negotiate complex internal conditions while maintaining stable contact with pipe surfaces. Its findings are relevant to the proposed project because they support the use of simple mechanical locomotion and adaptable cleaning mechanisms for removing internal pipe blockages.

Dias Akimbay et al. (2025), developed a hybrid in-pipe robot for maintenance and inspection applications. The system used three caterpillar tracks positioned approximately 120° apart to provide stability and maneuverability inside pipes. One important experimental application involved detecting, grasping, lifting, and removing debris from inside pipelines. The reported experiments demonstrated the robot's ability to perform internal cleaning operations, with debris of up to approximately 120 g handled during testing. The research demonstrates the usefulness of combining stable locomotion with an active cleaning or debris-removal mechanism. It provides a technological reference for improving the cleaning capability of the proposed pipe choke cleaning robot.

Chengyuan Zhu et al. (2024), investigated localization and tracking of in-pipe inspection robots. The study addressed the difficulty of determining the position of robots operating inside long and complex pipelines. Distributed optical-fiber sensing was investigated as a method for real-time localization and tracking. The research is particularly relevant to pipeline maintenance because unexpected robot stoppage or blockage can create operational risks. Although the primary focus was localization rather than mechanical cleaning, the study demonstrates the growing importance of monitoring robot position during pipeline maintenance operations. For a manual sliding cleaning robot, the concept can inspire future development of position indicators or tracking systems.

Fang Peng et al. (2024), proposed an intelligent multifunctional pipeline robot capable of damage monitoring, cleaning, and repair. The design incorporated visual recognition, pressure sensing, robotic arms, telescopic mechanisms, and other integrated systems. The robot was intended to operate under different internal pipeline conditions and perform multiple maintenance tasks. Cleaning functions included mechanical tools such as a front cleaning assembly and drilling mechanism. The study demonstrates the advantages of integrating cleaning and inspection capabilities within one platform. However, the relatively sophisticated architecture also increases system complexity. This research supports the need for simpler, low-cost cleaning mechanisms when only pipe choke removal is required.

Jeongyeol Park, Tuan Luong & Hyungpil Moon (2024), developed a wheel-type in-pipe robot incorporating continuously variable transmission mechanisms. The research focused on maintaining suitable movement and traction while operating inside pipelines. Wheel-based locomotion provides a relatively simple mechanical arrangement, but the robot must maintain sufficient contact force with the pipe wall to prevent slipping. The study demonstrates how transmission mechanisms can improve robot mobility and adaptability. Although developed primarily for inspection, the mechanical principles are applicable to cleaning robots because effective cleaning requires controlled movement and stable contact between the cleaning tool and pipe surface. The research provides useful design guidance for wheel arrangement, propulsion, and mechanical stability.

Jalal Taheri Kahnamouei & Mehrdad Moallem (2023), presented a comprehensive review of in-pipe robotic systems used for inspection, maintenance, and repair. The study examined different propulsion mechanisms, adaptive mechanisms, steering systems, and localization approaches. It emphasized that in-pipe robots must maintain adequate traction and stability while negotiating variations in pipeline geometry. The review also highlighted challenges associated with different pipe sizes, bends, and complex internal environments. These findings are directly relevant to pipe-cleaning robot design because successful cleaning depends on reliable movement and continuous contact with the pipe wall. The review provides a broad technical foundation for selecting an appropriate mechanical configuration for the proposed manual sliding cleaning robot.

Jianguo Zhao et al. (2022), reviewed the mechanical structures and operating principles of pipeline pigs and robots used for long-distance pipeline applications. The study

examined different mechanical configurations and discussed the requirements for stable movement inside pipelines. Particular importance was given to mechanical modeling, structural design, and the ability of cleaning or inspection devices to travel through pipelines. The review provides valuable information about the relationship between robot structure, pipeline geometry, traction, and operational reliability. For the proposed project, these concepts are useful for designing the sliding frame, guide wheels, cleaning tool, and contact mechanism so that the robot can move smoothly while removing internal choke deposits.

Yanbin Ning et al. (2025), proposed a compact crawler-driven robot for detecting, unclogging, and cleaning domestic pipes. The robot was designed for DN25–DN75 pipes and combined visual recognition, high-pressure water jetting, flexible adsorption, and mechanical cleaning. The authors used modular construction and simulation to verify structural strength and operational feasibility. The system could select different cleaning approaches according to blockage conditions, including cutting, brushing, adsorption, and flushing. The study demonstrates that integrating locomotion with a dedicated cleaning mechanism can significantly improve pipe-maintenance capability. It is particularly relevant to the proposed project because it identifies blockage removal as a major application for compact pipe robots.

Zhenxiang Li, Chang Wang & Jianlong Li (2025), investigated the design and passability of a crawler-type pipeline cleaning robot. The study focused on the ability of the robot to travel through pipelines having different diameters and geometric configurations. A variable-diameter crawler arrangement was developed to maintain contact with the internal pipe surface while providing stable movement. Simulation and mechanical analysis were used to evaluate the robot's travelling capability. The research highlights that proper wheel or crawler contact is essential for maintaining traction during cleaning. The findings are useful for the present manual sliding robot because guide-wheel arrangement, mechanical stability, and adaptability to pipe dimensions are important factors when designing a compact cleaning mechanism.

Qianwen Liu et al. (2025), developed a cleaning robot specifically for narrow heat-exchanger tubes. The robot used a dual-wheel cross-drive structure, gear-rack alignment mechanism, cam-based propulsion, and a flexible cleaning arm. The design was intended to maintain stability while operating inside restricted tube spaces. A vision-guided system was incorporated to assist positioning and cleaning operations. Experimental results demonstrated automatic movement and cleaning, with rapid switching between sub-pipes. The study shows the importance of compact dimensions, stable contact, and flexible cleaning tools when working in narrow passages. These principles can be adapted to a simpler manually operated sliding mechanism for pipe-choke removal.

Fang Peng et al. (2024), developed an intelligent pipeline robot capable of inspection, cleaning, and maintenance operations. The proposed system incorporated visual recognition, pressure sensing, mechanical cleaning, telescopic components, and robotic manipulation. Different cleaning mechanisms were considered to address different types of pipeline contamination and blockage. The study demonstrates

the advantage of combining multiple maintenance functions in one robotic platform. However, the integration of sensors, actuators, and intelligent control also increases system complexity. For the proposed manual sliding pipe choke cleaning robot, the study provides useful guidance for selecting only the necessary mechanical cleaning functions while avoiding unnecessary electronic components.

Jalal Taheri Kahnamouei & Mehrdad Moallem (2023), reviewed the major mechanical and control aspects of in-pipe robots. Their study covered robot geometry, propulsion mechanisms, adaptive diameter systems, steering arrangements, localization, and navigation. The authors emphasized that pipe robots must generate sufficient traction while adapting to different pipe geometries. They also discussed applications involving inspection, maintenance, repair, and cleaning. The review indicates that wall-pressed, wheeled, tracked, and other locomotion mechanisms each have specific advantages and limitations. These findings provide a strong theoretical basis for selecting a suitable mechanical configuration. For the present project, the study supports the use of stable guide elements and controlled contact between the cleaning tool and internal pipe wall.

Calin Rusu & Mihai Olimpiu Tatar (2022), reviewed adapting mechanisms used in wall-pressed in-pipe robots. Their work examined passive and active mechanisms that generate the force required to maintain contact between the robot and pipe wall. Different linkage arrangements were compared according to their ability to adapt to changes in pipe diameter and operate through inclined or complex pipeline sections. The study shows that maintaining adequate contact pressure is essential for stable robot movement. This concept is directly applicable to pipe cleaning because cleaning brushes or scrapers require controlled contact with the pipe surface. A simplified spring-loaded or adjustable guide mechanism derived from these concepts could improve the performance of the proposed manual sliding cleaning robot.

Heesik Jang et al. (2022), reviewed technological developments in pipeline robot systems. The authors highlighted the importance of robotic maintenance because humans cannot safely enter many small, hazardous, or toxic pipelines. The review discusses the development of different locomotion mechanisms and additional functions intended to improve pipeline maintenance. It also identifies the need for greater efficiency and practical deployment of pipeline robots. The study supports the motivation for developing compact cleaning devices that reduce human exposure to hazardous environments. For the proposed project, it provides a broader justification for replacing difficult manual internal pipe-cleaning operations with a controlled mechanical robot.

Chengyuan Zhu et al. (2024), investigated a distributed optical-fiber sensing method for localizing and tracking robots inside pipelines. In-pipe robots can operate over long distances where conventional positioning systems are difficult to use. Accurate location information is important because a robot may need to identify the position of defects or return to a particular section for maintenance. Although the study primarily addresses localization rather than cleaning, its findings demonstrate the increasing integration of monitoring technology into pipeline robots. For the proposed manual sliding cleaning robot, the research suggests a possible future improvement in which the operator can determine the distance

travelled by the cleaning mechanism and identify the location of a blockage during maintenance.

Jeongyeol Park, Tuan Luong & Hyungpil Moon (2024), developed a wheel-type in-pipe robot using continuously variable transmission mechanisms. The study focused on improving robot mobility and maintaining appropriate traction while travelling inside pipelines. Wheel-based systems offer relatively simple construction, but sufficient contact force must be maintained to avoid slipping. The research provides useful information regarding wheel arrangement, propulsion, and mechanical stability. Although the robot was primarily developed for inspection, its mechanical principles can be applied to cleaning operations where stable movement is required to maintain continuous contact between the cleaning tool and pipe surface. The study therefore provides useful design guidance for the guide-wheel and sliding mechanism of the proposed cleaning robot.

20. Sugin Elankavi (2024), study on a pipeline jet cleaning robot investigated the dynamic characteristics and cleaning parameters of a spiral-driven pipeline inspection and cleaning robot. The research was motivated by the accumulation of impurities on the inner walls of pipelines, which can hinder pipeline operation and create safety risks. The authors analyzed the robot's motion during jet cleaning and investigated suitable operating conditions for effective removal of deposits. The study demonstrates that cleaning performance depends not only on the cleaning tool but also on robot movement and operating parameters. This is highly relevant to the proposed project because the manual sliding speed and cleaning-tool contact will directly influence choke-removal efficiency.

B) Literature Summary

- Recent research shows that in-pipe robots are increasingly used for inspection, maintenance, cleaning, and unclogging, reducing human exposure to confined and hazardous pipeline environments.
- Studies have investigated wheeled, tracked, screw-driven, bionic, and hybrid mechanisms, with each mechanism offering different advantages in traction, stability, adaptability, and maneuverability.
- Recent cleaning robots combine mechanical brushes, scrapers, cutting tools, water jets, adsorption systems, and flexible cleaning mechanisms to handle different types of blockages.
- Adaptive mechanisms are widely studied to maintain sufficient contact between the robot and internal pipe walls, particularly when pipe diameter or geometry changes.
- Modern systems increasingly integrate cameras, sensors, AI, intelligent control, and localization technologies for autonomous operation and real-time monitoring.
- Overall, literature indicates a trend toward multifunctional, intelligent, compact, and adaptable pipeline-cleaning robots, while practical challenges remain in cost, energy, complexity, and reliable operation.

C) Research Gap

- Limited Low-Cost Solutions:** Most recent research focuses on sophisticated robotic systems incorporating motors, cameras, sensors, AI, and autonomous control, increasing manufacturing cost and complexity.

- Lack of Manual Mechanisms:** Comparatively limited attention is given to simple manually operated sliding mechanisms that can perform pipe-choke cleaning without complex electronic systems.
- Cleaning-Specific Focus:** Many studies combine inspection, sensing, localization, and cleaning, whereas a dedicated mechanical system specifically optimized for choke/deposit removal remains less emphasized.
- Complexity of Existing Robots:** Advanced robots require batteries, actuators, controllers, and communication systems, creating additional maintenance and operational requirements.
- Adaptability Challenge:** Sudden changes in pipe diameter, bends, deposits, and internal obstructions remain challenging for existing cleaning mechanisms.
- Need for Simple Fabrication:** There is scope for a compact, portable, economical, reusable, manually sliding robot using guide wheels and interchangeable brushes/scrapers.
- Proposed Contribution:** The present project addresses this gap by developing a mechanically simple robot focused primarily on manual movement and effective pipe-choke removal, making it suitable for laboratory and small-scale maintenance applications.

IV. RESEARCH METHODOLOGY

A) Proposed System

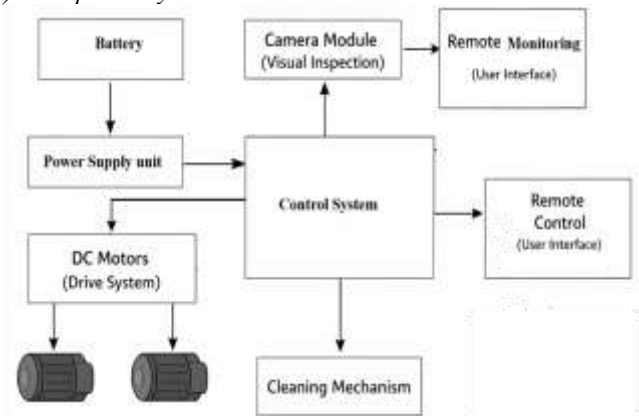


Figure 2. Block Diagram

- Power Supply:** The 12 V, 5 Ah battery supplies electrical power to the regulated power supply unit, motors, wireless camera, and LED lighting system.
- Robot Insertion:** The robot is inserted into the pipeline through the available opening and positioned inside the pipe for cleaning and inspection.
- Manual Control:** The operator uses the wired remote-control box to control the robot's forward and reverse movement according to the pipe condition.
- Wheel Movement:** Six 12 V, 10 RPM DC BO motors drive the robot wheels and provide controlled movement inside the pipeline.
- Camera Monitoring:** A wireless camera mounted at the front continuously captures the internal condition of the pipeline and transmits live images to the operator.
- LED Illumination:** High-intensity LED lighting illuminates the dark internal pipe surface, allowing the operator to clearly observe choke deposits and the cleaning process.
- Cleaning Operation:** A 12 V, 10 RPM DC gear motor drives the front cleaning mechanism. The rotating brush/scrapper removes rust, sludge, grease, and other choke-forming deposits from the pipe wall.

- Continuous Inspection: The operator observes the live camera feed while controlling the robot, ensuring proper navigation and effective cleaning.
- Forward–Reverse Cleaning: Forward and reverse movement allows repeated contact between the cleaning mechanism and deposits for improved blockage removal.
- Completion: After cleaning is completed, the robot is reversed and removed from the pipeline. The system therefore combines controlled movement, illumination, visual monitoring, and mechanical cleaning in one compact platform.

B) Hardware Used

- Lead-Acid Battery: A 12 V, 5 Ah lead-acid battery provides the main electrical power required for the robot's motors, camera, LED, and control system.
- DC BO Motors: Six 12 V, 10 RPM DC BO motors are used to drive the robot wheels and provide forward and reverse movement inside the pipeline.
- DC Gear Motor: One 12 V, 10 RPM DC gear motor drives the front cleaning mechanism for removing accumulated pipe deposits.
- Wireless Camera: A 5 V wireless camera is mounted on the robot to provide real-time visual monitoring of the internal pipeline condition.
- LED Light: A 12 V LED provides illumination inside dark pipelines, allowing the operator to observe the choke and cleaning operation.
- Frame/Chassis: The metal/fiber frame supports the motors, battery, camera, cleaning mechanism, and other components.
- Cleaning Mechanism: The fiber-based brush/scrapper assembly removes rust, sludge, grease, and other choke-forming deposits from the internal pipe surface.
- Adjustable Motor Clamps: Six motor clamps hold and properly align the BO motors with the drive mechanism.
- Power Supply Unit: The PSU provides regulated 12 V and 5 V outputs for the different electrical components.
- Remote Control Box: The wired control box enables the operator to control robot movement during pipeline cleaning.
- Wires, Connectors and Switches: These provide electrical connections and switching between the battery, motors, lighting, camera, and control system.

V. CALCULATION

1. Battery Energy

Battery voltage, $V=12\text{ V}$

Battery capacity, $C=5\text{ Ah}$

$E=V \times C$

$E=12 \times 5=60\text{ Wh}$

Therefore, the battery stores approximately 60 Wh of energy.

2. Battery Operating Time

For a simple estimate, if the complete system draws approximately 5 A:

$$t = \frac{C}{I}$$

$$t = \frac{5}{5} = 1\text{ hr}$$

Thus, the theoretical operating time is approximately 1 hour at a 5 A continuous load.

3. Motor Speed

The six drive motors are rated at:

$N=10\text{ RPM}$

Rotational speed in revolutions per second:

$$N_s = \frac{10}{60}$$

$N_s=0.167\text{ rev/s}$

Thus, each motor rotates at approximately 0.167 revolutions per second.

4. Angular Speed of Motor

$$\omega = \frac{2\pi N}{60}$$

$$\omega = \frac{2\pi(10)}{60}$$

$$\omega = 1.047\text{ rad/s}$$

5. Robot Linear Speed

If the drive-wheel diameter is assumed to be 50 mm for prototype calculation:

$D=0.05\text{ m}$

Wheel circumference:

$C=\pi D$

$C=3.1416(0.05)=0.157\text{ m}$

At 10 RPM:

$$v = \frac{\pi D N}{60}$$

$$v = \frac{3.1416(0.05)(10)}{60}$$

$$v = 0.0262\text{ m/s}$$

6. Total Number of Motors

Drive motors:

$N_d = 6$

Cleaning motor: $N_c = 1$

Therefore:

$$N_{total} = 6 + 1 = 7\text{ motors}$$

7. Total Motor Rated Voltage

Each motor operates at:

$V_m=12\text{ V}$

The motors are connected in a parallel supply arrangement rather than adding their voltages.

Therefore:

$V_{motor} = 12\text{ V}$

8. Cleaning Motor Speed

The cleaning gear motor is rated:

$N_c=10\text{ RPM}$

$$\omega_c = \frac{2\pi(10)}{60}$$

Angular velocity:

$$\omega_c = 1.047 \text{ rad/s}$$

The cleaning brush rotates at approximately 1.047 rad/s, assuming direct coupling.

9. Approximate Power Requirement

If the complete prototype is assumed to draw 5 A at 12 V:

$$P=VI$$

$$P=12 \times 5$$

$$P=60\text{W}$$

Thus, the estimated electrical power requirement at a 5 A load is 60 W.

VI. ADVANTAGES AND APPLICATIONS

A) Advantages

- Low Cost: Uses simple mechanical and electrical components, making the system economical to fabricate.
- Easy Operation: Wired remote control provides simple forward and reverse movement.
- Real-Time Monitoring: Wireless camera provides live internal pipeline visualization.
- Effective Cleaning: Rotating brush/scrapper removes rust, sludge, grease, and choke deposits.
- Portable Design: Compact construction allows convenient transportation and operation.
- Reduced Maintenance Time: Faster cleaning reduces pipeline maintenance duration.
- Improved Safety: Reduces direct human exposure to confined pipeline environments.
- Minimal Downtime: Cleaning can be performed without complete pipeline dismantling.

B) Applications

- Water Supply Pipelines: Removes accumulated deposits and blockages from water transportation pipelines.
- Industrial Pipelines: Supports routine cleaning and maintenance of process pipelines.
- Oil and Gas Pipelines: Helps remove internal deposits affecting pipeline flow.
- Chemical Industries: Can assist in cleaning suitable process pipelines.
- Municipal Drainage: Useful for removing accumulated sludge and debris.
- Sewage Pipelines: Supports maintenance of wastewater and sewage systems.
- Food Processing: Can be applied to suitable fluid transportation pipelines.
- Irrigation Systems: Helps maintain agricultural water pipelines by removing internal choke deposits.

VII. CONCLUSION

The Manual Sliding Pipe Choke Cleaning Robot provides a practical, economical, and efficient solution for removing internal blockages and deposits from pipelines. The proposed system combines a compact robotic structure, drive motors, rotating cleaning mechanism, wireless camera, LED illumination, battery supply, and wired remote control to perform pipeline inspection and cleaning operations. The brush/scrapper mechanism is designed to remove rust, sludge,

grease, and other choke-forming materials from the internal pipe surface, while the camera and LED provide real-time visibility to the operator. The system reduces the need for direct human entry into confined pipeline environments and can minimize maintenance effort, manpower, and downtime. Its portable construction and relatively simple operating mechanism make it suitable for water supply, industrial, oil and gas, chemical, municipal drainage, sewage, food-processing, and irrigation pipelines. The project also addresses limitations of conventional cleaning methods, particularly pipeline dismantling and high maintenance requirements. Overall, the developed concept demonstrates the potential of a low-cost robotic cleaning system for routine pipeline maintenance. Further development can improve its cleaning performance, adaptability to different pipe diameters, monitoring capability, and automation while retaining its economical and user-friendly design.

VIII. FUTURE SCOPE

- Automation: The robot can be upgraded with autonomous navigation, automatic forward/reverse movement, and intelligent control for improved cleaning efficiency.
- Advanced Monitoring: High-resolution cameras, sensors, and IoT connectivity can be integrated for real-time blockage detection, pipeline condition monitoring, and data recording.
- Improved Design: Adjustable cleaning tools and adaptive mechanisms can be developed for different pipe diameters, bends, and blockage types.

REFERENCES

- [1] Y. Ning, H. You, J. Guo, Y. Zhang, P. Xie, and Z. Zheng, "Design and study of an integrated domestic pipe detection-unclogging-cleaning robot based on crawler drive," *Advances in Transdisciplinary Engineering*, vol. 79, 2025.
- [2] Z. Li, C. Wang, and J. Li, "Design and passability analysis of pipeline cleaning robot," 2025.
- [3] Q. Liu, C. Li, G. Wang, L. Li, and J. Wang, "Development of a pipeline-cleaning robot for heat-exchanger tubes," *Electronics*, vol. 14, no. 12, 2025.
- [4] Y. Zhu, "Research on the design and application of bionic in-pipe crawling cleaning robots," 2025.
- [5] D. Akimbay *et al.*, "A novel hybrid robot for in-pipe maintenance and inspection," 2025.
- [6] C. Zhu, Y. Pu, Y. Yang, Z. Lyu, C. Li, and Q. Yang, "Localizing and tracking of in-pipe inspection robots based on distributed optical fiber sensing," 2024.
- [7] F. Peng, Z. Su, M. Lei, Q. Sun, and Y. Chen, "Design of intelligent pipeline detection and cleaning robot," 2024.
- [8] J. Park, T. Luong, and H. Moon, "Development of a wheel-type in-pipe robot using continuously variable transmission mechanisms for pipeline inspection," 2024.
- [9] J. T. Kahnamouei and M. Moallem, "A comprehensive review of in-pipe robots," *Ocean Engineering*, vol. 277, Art. no. 114260, 2023, doi: 10.1016/j.oceaneng.2023.114260.
- [10] J. Zhao, J. Wang, Q. Liu, X. Luo, and X. Dong, "A review of mechanical model, structure, and prospect for long-distance pipeline pig and robot," 2022.
- [11] Y. Ning, H. You, J. Guo, Y. Zhang, P. Xie, and Z. Zheng, "Design and study of an integrated domestic pipe detection-unclogging-cleaning robot based on crawler drive," *Advances in Transdisciplinary Engineering*, 2025.
- [12] Z. Li, C. Wang, and J. Li, "Design and passability analysis of pipeline cleaning robot," 2025.

- [13] Q. Liu, C. Li, G. Wang, L. Li, and J. Wang, "Development of a pipeline-cleaning robot for heat-exchanger tubes," *Electronics*, vol. 14, no. 12, 2025.
- [14] F. Peng, Z. Su, M. Lei, Q. Sun, and Y. Chen, "Design of intelligent pipeline detection and cleaning robot," 2024.
- [15] J. T. Kahnamouei and M. Moallem, "A comprehensive review of in-pipe robots," *Ocean Engineering*, vol. 277, Art. no. 114260, 2023, doi: 10.1016/j.oceaneng.2023.114260.
- [16] C. Rusu and M. O. Tatar, "Adapting mechanisms for in-pipe inspection robots: A review," *Applied Sciences*, vol. 12, no. 12, Art. no. 6191, 2022.
- [17] H. Jang, T. Y. Kim, Y. C. Lee, Y. S. Kim, J. Kim, H. Y. Lee, and H. R. Choi, "A review: Technological trends and development direction of pipeline robot systems," *Journal of Intelligent & Robotic Systems*, 2022, doi: 10.1007/s10846-022-01669-2.
- [18] C. Zhu, Y. Pu, Y. Yang, Z. Lyu, C. Li, and Q. Yang, "Localizing and tracking of in-pipe inspection robots based on distributed optical fiber sensing," 2024.
- [19] J. Park, T. Luong, and H. Moon, "Development of a wheel-type in-pipe robot using continuously variable transmission mechanisms for pipeline inspection," 2024.
- [20] R. S. Elankavi, D. Dinakaran, R. M. Kuppan Chetty, M. M. Ramya, and D. G. Harris Samuel, "A review on wheeled type in-pipe inspection robot," *International Journal of Mechanical Engineering and Robotics Research*, vol. 11, no. 10, pp. 745–754, Oct. 2022, doi: 10.18178/ijmerr.11.10.745-754.