201P – Design Practicum

Wall Climbing Robot

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Certificate

This is to certify that the work contained in the project report entitled "**Wall Climbing Robot**", submitted by **Group 11** to the Indian Institute of Technology Mandi, for the course IC 201P – Design Practicum, is a record of bonafide research works carried out by him under our direct supervision and guidance.

Dr. Amit Shukla   Signature and Date   17/05/2023

Dr. Jagadeesh Kadiyam   Signature and Date

Acknowledgements

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We would also like to express our gratitude to the Mechanical workshop staff for helping us with the fabrication of our prototype and to Mr. Ayush Gupta for assisting us by providing sufficient resources, guidance and other equipment for testing our prototype. We would also like to thank the Electronics Lab and Robotronics club for always being there whenever we needed any general electronics.

Abstract

In this era of automation every task is being automated, but still working or maintaining chambers, tanks for storing different fuels or resources is a dangerous task. Inspection of these tanks takes a lot of manpower and time as it's a difficult task to enter and inspect cracks or damages in the inner surface of tanks.

Our project revolves around the idea of a wall-climbing robot for inspection of such tanks which can be used to automate and simplify the task, reducing the overall cost of such jobs.

There are many wall-climbing robots that use the concept of navigating on the wall via suction using a vacuum and compressor but they are extremely slow. Our basic idea is to build a robot that can easily move on the metallic wall and do the task of inspection of the surface regarding cracks or other faults by the use of magnets. It would be equipped with a camera for capturing the pictures of the surface. Other modifications may include not only detection but fixing the cracks in place etc. In this project we focus on building a wall climbing bot that can navigate autonomously and inspect the metallic tanks, which can be further scaled up for jobs like maintenance and rescue operations.

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Abbreviations

mAH	MilliAmpere Hour
LiPo	Lithium Polymer
DC	Direct Current
V	Voltage
A	Ampere
USB	Universal Serial Bus
IEEE	Institute Of Electrical and Electronics Engineers
EDF	Electric Duct Fan

Chapter 1

Introduction

In today's age of automation, with robots and artificial intelligence becoming an integral part of our lifestyle, there remain certain tasks that are still dependent upon human labor, despite being fully automatable. Even routine tasks such as cleaning, cooking, and washing have been automated, with the advent of products such as robotic vacuums, dishwashers, and cooking machines. Given that such tasks can be automated, it begs the question why certain tasks like inspection of some high facilities such as gas and oil tanks, wind turbines and marine vessels are still not completely automated.

The maintenance, inspection, and cleaning of metallic vertical surfaces, tanks, and pipes are complex and dangerous tasks, requiring skilled personnel and specialized equipment. The current methods of accomplishing these tasks involve human intervention, which is time-consuming, expensive, and poses a significant risk to workers' safety.

1. Problem statement

To address the challenges discussed, we aim to design and develop a Wall Climbing Robot that can navigate and perform various maintenance, inspection, and cleaning tasks on metallic surfaces autonomously, reducing human intervention, increasing efficiency, and improving safety. This robot should be able to operate in various environments, including harsh conditions, and be easy to use and maintain. The Wall Climbing Robot should be cost-effective and provide a high level of performance, making it a valuable tool for companies and organizations that require regular maintenance of their metallic vertical surfaces.

2. Design philosophy used in this report

2.1. Definition

Our prototype is a bot that can easily move on vertical metallic surfaces and can be used for inspection and monitoring of faults that may be present.

2.2. Users

It is intended for companies carrying out tasks related to inspection, monitoring and repair of large tanks and other metallic surfaces.

2.3. Purpose

The main reason to create such a bot is to tackle the above-mentioned pain points like working in unfavorable environments, cost issues for consuming such services each time, health issues, human labor, etc.

2.4. Differentiation

The current prototype is cheap compared to other products in the market, so any company can buy it and by the time it reaches the production line we intend to reduce the cost even more. It shall reduce the amount of human labor required for these tasks, it will reduce the time required to complete these tasks and cost as well. As this product will be released in the market it will be a one-time investment for the companies. The best part is that it is autonomous.

2.5. Value

It makes our users' lives better by reducing the labor required, cutting down the time, eliminating health issues, and also being easily usable by anyone. The final product which would be released in the market shall be very easy to use and even a person without any technical background shall be able to use it.

2.6. Goal

Our end goal is to make all the tasks relating to vertical metallic surfaces like inspection and repair integrated to our bot and our success shall be measured if we are able to achieve at least 50% of our target within the 5 years of our startup or the release of the product.

3. Beneficiaries (Intended market)

A metallic surface wall climbing robot can have various beneficiaries depending on its application and intended use.
Companies and stakeholders associated with the following categories can be potential beneficiaries:

3.1. Industrial Inspection

In industries such as oil and gas, chemical, and power plants, metallic surface climbing robots can be used for inspecting hard-to-reach areas of equipment and structures, including pipes, tanks, and walls. This can help identify potential safety hazards and prevent accidents.

3.2. Maintenance

Climbing robots can be used to carry out maintenance tasks on metallic surfaces, such as painting, cleaning, and coating. This can help reduce the time and effort required for such tasks, as well as the risk of injury to human workers.

3.3. Search and Rescue

In the event of natural disasters or other emergencies, metallic surface climbing robots can be used to search for survivors and navigate difficult terrain, such as damaged tanks.

3.4. Military and Defense

Climbing robots can be used by the military for surveillance, reconnaissance, and other tactical purposes, including inspecting structures and detecting potential threats.

3.5. Entertainment

Climbing robots can be used for entertainment purposes, such as in amusement parks or for filming movies and TV shows. They can simulate climbing on walls and other structures and create exciting and visually impressive experiences.

4. Future Scope of the Project

Currently, we are working towards the smooth climbing of the metallic vertical surfaces focussing on issues such as adhesion, mobility and control. We are also working towards sensing as Wall climbing robots may require sensing capabilities such as cameras, lasers, or other sensors to aid in navigation and inspection tasks.

We will consider the following points for future research and development:

4.1. In future we plan to work towards the tasks such as fixing faults in the surfaces such as cracks.

4.2. Not just this, we aim to develop a user-friendly application which can be used to adjust the mode and operation of the bot at any point of time.

4.3. The bot can be improved aesthetically and cost can be further reduced while the mass production.

4.4. Currently, the bot captures the video of the surface and inspection is done by analyzing that video. Human interference can be reduced as we aim to build an ML based model that can detect the faults.

More details about the wall climbing robot are discussed in subsequent sections of this report.

5. The Final Prototype

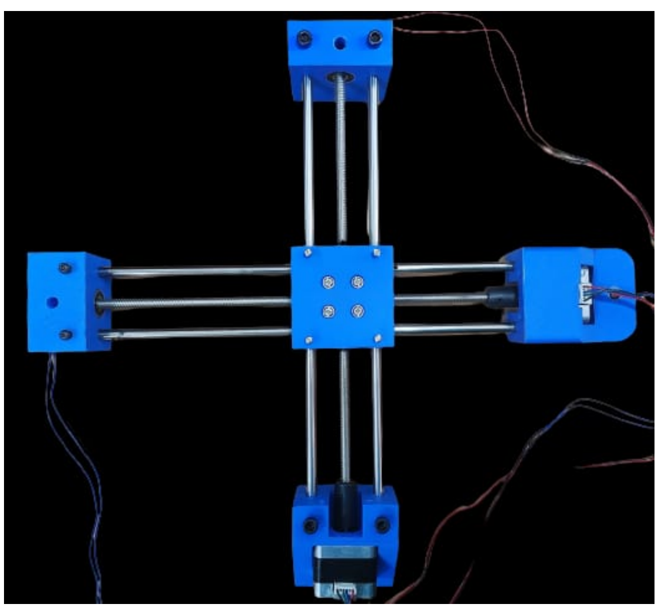

Fig 1.1. *The final wall-climbing robot*

Chapter 2

Market Research

Products launched in the market can be categorized into either the Red Ocean or the Blue Ocean. A "Red Ocean" denotes a highly competitive market with several existing products while a "Blue Ocean" is a relatively unexplored market with fewer competitors. Developing a product in a Blue Ocean involves taking a high-risk approach with the possibility of high returns.

Our product lies in the Blue Ocean as it is unique and quite new for the market. In this chapter, we will analyze existing products, their features, their shortcomings and how our product is different from the available alternatives.

The Existing Products in the market: The Good and the Bad

1. **Remote-controlled wall climbing car**

    1.1. These cars are essentially toys that offer a fun and lightweight playing experience. They are quite affordable, making them accessible to a wide range of individuals.

    1.2. Limitations
    - They are not designed for industrial use
    - They lack the necessary strength to carry payloads or perform tasks like inspection.
    - Additionally, their delicate build makes them prone to breaking easily.

2. **Crawlerbot**

    2.1. This bot is a remote-controlled bot made by Astec engineers with 3D-printed components.

    2.2. It is a bot specifically designed for silos as it uses brushless AC motors for propulsion and magnetized wheels to adhere to the walls of the silo. It can be used to measure the density of asphalt silo walls, which would eliminate the need for inspection scaffolding and send workers up into the silo to take measurements manually.

2.3. Limitation: It has very limited application as it can be used for a single purpose only.

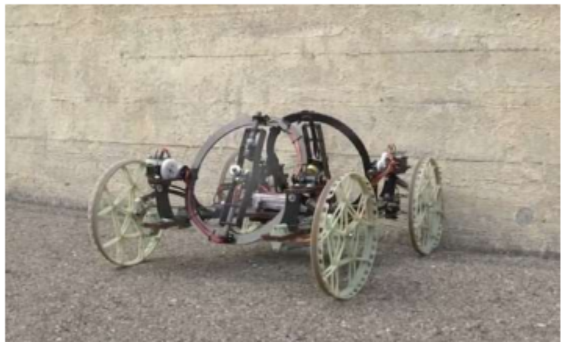

Fig. 2.1. *Crawlerbot*

3. Gecko Wall Climbing Bot

3.1. These robots use the same technique as geckos to climb vertical metal surfaces. They have adhesive pads on their feet that can stick to the surface due to van der Waals forces.

3.2. It is a research project on a wall climbing bot by Ghent University made using impeller technology. It looks like an automatic vacuum cleaner.

3.3. It is a DIY bot that anyone can make easily and is cost effective. It is a good hobby project and a good college club project, and students can easily work on it and make it.

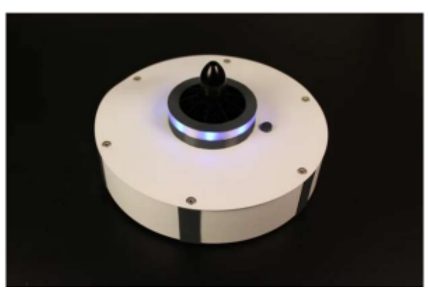

Fig. 2.2. *Gecko Wall Climbing Bot*

Our Wall Climbing Bot

The wall climbing robot we are attempting to make uses the principles of magnetism.

1. For aligning and sticking the bot to the wall, we are using the Magnetic Adhesion Method. It is based on the principle of adhering of ferromagnetic materials into magnets.
2. As the surface on which the robot will move will be made up of ferromagnetic materials, we will use magnetism for movement.
3. An electromagnet is used for adhesion which will help in the alignment of the bot.
4. It has a degree of freedom of two (it is free to move about two axes)
5. It cannot rotate but as it can move horizontally and vertically on the wall, it covers the surface of the wall entirely.

The key features of our product are:

1. The bot is quite versatile. It can easily move on vertical ferromagnetic surfaces and autonomously navigate.
2. It can send a live camera feed to the user for the inspection of the surfaces.
3. It costs less compared to other bots available in the market for industrial purposes, so companies can easily buy it and use it for any purpose. It would serve as a one time investment for them. It is also light and has a reasonable size.
4. There are many wall-climbing robots that use the concept of navigating on the wall via suction using a vacuum and compressor but they are extremely slow. Our bot works on magnetism.

Chapter 3

Conceptual Design

We discussed many ideas, agreed upon some, rejected some, and also had conflicting views on some. We also had many brainstorming sessions to shortlist the ideas and decide the best one to work upon.

Ideation: The quest for finding a suitable problem

1. Our ideation process started with identifying 100 problems that are around us or the ones we usually face or the ones that are faced by a majority of the people.
2. Each one of us contributed around 20 problems and they were all listed down in the diary.
3. Then we started by elimination, we first eliminated the problems that were difficult to solve at our level or would require more funding, then we also eliminated those problems which don't require an immediate solution or solving them won't make much of a difference or a social impact.
4. After multiple meetings, brainstorming and eliminating many problems we finally landed on our final problem of inspection in tanks.
5. We analyzed those problems in depth, we looked for the existing solutions, stakeholders, beneficiaries, ease to solve the problem, pros and cons, motivation to solve the problem, other issues connected with them and also looked for a chance to innovate.
6. We made a detailed presentation and had a discussion with our mentors.
7. We discussed the number of other issues that could be solved with the product, how scalable & adaptable it is, ease of use, cost and time effectiveness, ease of manufacturing, availability of components, varied applications, R&D opportunity, future scope, and user base.
8. After considering all this, we finally decided on our solution to the proposed problem statement of "**Wall climbing robot for metallic surfaces**".

Brainstorming and idea generation

In the beginning, there were many designs regarding wall climbing robots. Some of the ideas are as follows:

1. **Using vacuum**
   1.1. Vacuum can be used to stick the robot to the wall with the help of vacuum fans.
   1.2. Major challenge was not to carry enough load for further implementations.
   1.3. Even it was best for flat surfaces only and implementation on curved surfaces like tanks were not applicable.

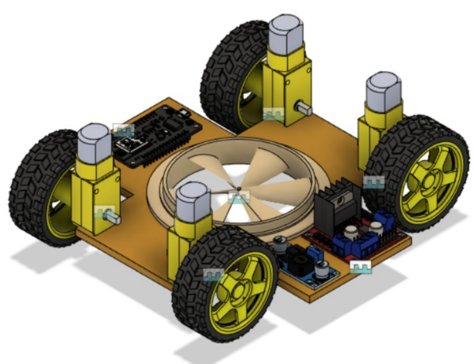

Fig. 3.1. *CAD Design 1*

2. **Using Propellers**
   2.1. Propellers use thrust to move forward and stick to the wall.
   2.2. Major challenge is to maintain the weight to thrust ratio.
   2.3. Even adding a camera or battery to the body can lead to failure of mechanism.
   2.4. Multi Directional movement is also tough.

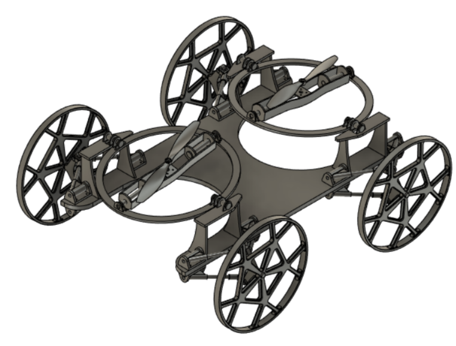

Fig. 3.2. CAD Design 2

3. **Using Thrust**
   3.1. We also tried to use thrust with the help of EDF.
   3.2. Its greatest advantage was its multidirectional movements as it only uses caster wheels.
   3.3. Even by adjustment of thrust and its angle major problems were resolved.
   3.4. Major challenge was to change the angle very fast which can further lead to toppling.

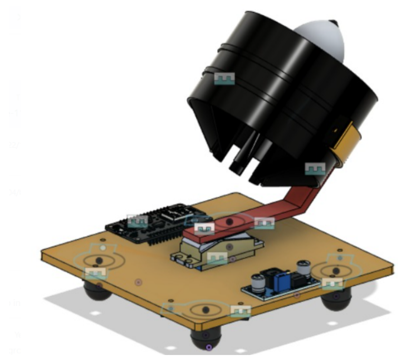

Fig. 3.3. *CAD Design 3*

4. **Using Magnets**
   4.1. As our main aim is inspection of metallic tanks we proposed to use magnets instead to thrust.
   4.2. This design has the capability of carrying high loads by choosing appropriate magnets.
   4.3. It can be used on both flat and curved surfaces.
   4.4. Weight is not a big constraint in this design.
   4.5. Major challenges are to control the RPM of the motor as there should be some delay for the magnet to stick to the surface.
   4.6. Even there are many chances of rolling when the robot is vertical and facing perpendicular to the ground.

Fig. 3.4. CAD Design 4

5. Using Electromagnets with axis mechanism

5.1. We came to the conclusion that we are going to use a mechanism with magnets, to be precise, electromagnets.

5.2. To overcome the problems related to rolling we are going to use the axis mechanism.

5.3. The robot can move from any start location to the end location by just moving in x and y direction.

5.4. Some assumptions that are made with respect to this mechanism are,

5.4.1. Surface should be flat or the radius of the tank is very large.

5.4.2. For inspection, assume the surface to be a matrix where the robot will first traverse the first column then second column and so on.

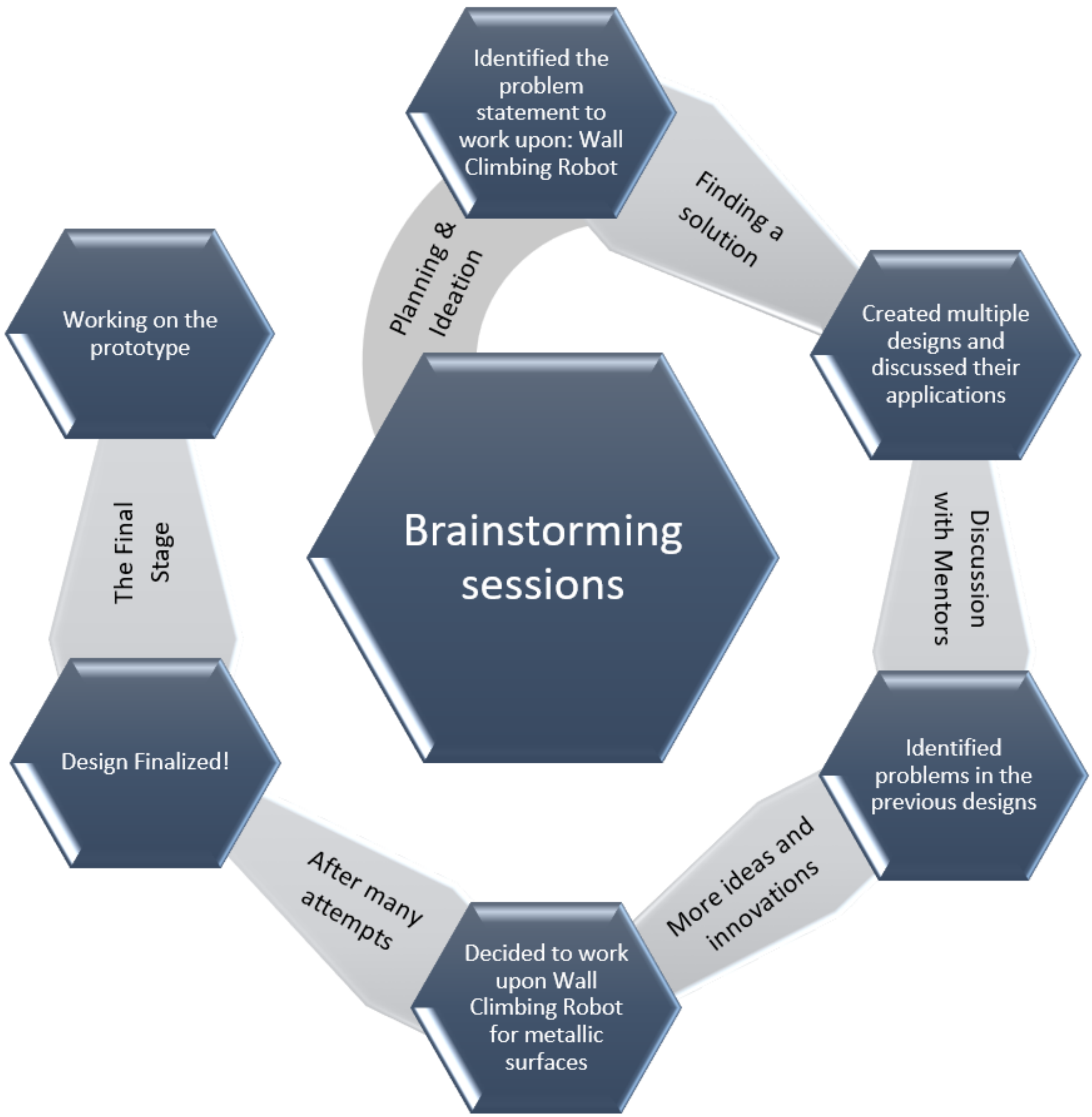

Fig. 3.5. Mind Map*: The Brainstorming sessions*

Decision Matrix

DECISION MATRIX				
	Wall climbing robot by			
Parameters	Vacuum	Propeller	Thrust	Magnetism
Cost	4	1	3	5
Feasibility	3	3	4	4
Stability	3	4	2	4
Weight Constraint	2	2	3	5
Total	12	10	12	18

Scale	
Rating	Description
1	Worse
2	Bad
3	Moderate
4	Good
5	Excelent

The Final Proposed Solution

After multiple meetings, discussions, and brainstorming sessions, we arrived at a final solution for the problem statement.

Our solution was as follows:

> *"To design an Axis mechanism that can freely move on walls using magnetism, which could easily perform tasks under human surveillance where human intervention is not possible. It would inspect industrial tanks and further could be used for maintenance also."*

The rejected ideas and designs:

1. We decided not to go with the vacuum idea because enough load could not be carried.
2. We decided not to go with the propeller idea because weight to thrust ratio can create a major problem.
3. We decided not to go with the thrust idea because stabilization of the robot is a big problem.

We decided to go with the principle of magnetism as it has capability of carrying high loads and its own weight is not a big constraint as it can be adjusted by using the appropriate magnetic strength. An axis mechanism would help in achieving all this in an appropriate way.

Chapter 4

Embodiment and Detailed Design

1. Product architecture

The wall climbing robot is a highly capable machine designed to traverse various surfaces using magnetism as the primary mechanism. The robot's architecture consists of the following key points:

1.1. The wall-climbing robot is designed to utilize magnetic properties to adhere to metal surfaces and move around.

1.2. Chassis

The robot has a robust chassis that provides structural integrity and support for the entire system.

1.3. Electromagnets

Powerful electromagnets are strategically placed along the edges of the robot to generate a strong magnetic field, allowing it to adhere securely to vertical and horizontal surfaces.

1.4. Rod Network

The robot features an interconnected network of rods arranged in a cross-shaped configuration. These rods extend from the chassis and provide reach and mobility during climbing. One rod remains fixed using an electromagnet, while the others enable movement in multiple directions.

1.5. Power Distribution

The robot utilizes a reliable power distribution system, typically powered by high-capacity batteries, to supply electrical energy to the electromagnets, control circuits, and other essential components.

1.6. Control System

The control system consists of microcontrollers, sensors, and actuators. It interprets user commands or automated instructions and coordinates the activation and deactivation of the electromagnets, ensuring precise and controlled movement on different surfaces.

1.7. Safety Features

The robot incorporates safety mechanisms such as redundant adhesion monitoring, emergency shutdown protocols, and sensors to monitor adhesion strength and surface conditions. These features ensure safe and secure climbing operations.

1.8. The use of a wireless control system further enhances the flexibility of the robot, allowing it to be controlled remotely by a PC or mobile device.

2. System-level design

2.1. Relay

2.1.1. Relays are electrically operated switches that open and close the circuits by receiving electrical signals from outside sources.

2.1.2. They receive an electrical signal and send the signal to other equipment by turning the switch on and off.

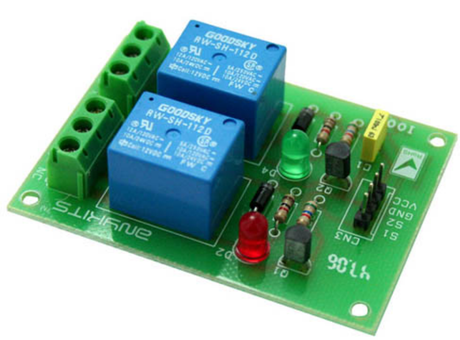

Fig. 4.1 *Channel Relay*

2.2. Arduino CNC Shield

2.2.1. It is basically an Arduino used for Computer Numeric Control.

2.2.2. For connecting the stepper drivers to the Arduino, the easiest way is to use an Arduino CNC Shield. It utilizes all Arduino pins and provides an easy way to connect the stepper motors.

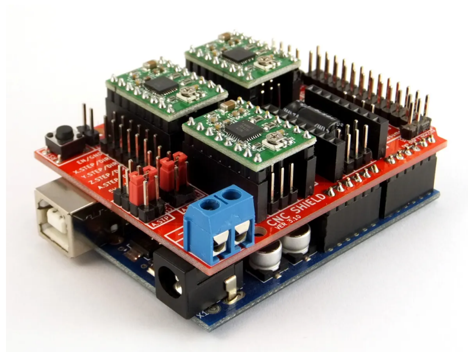

Fig. 4.2. *Arduino CNC Shield*

2.3. AC Adapter

2.3.1. Ratings = 5 A, 12 V

2.3.2. The AC adapter is a small, rectangular device that connects to the wall outlet and converts the direct current (DC) from an electrical source, such as a battery, into alternating current (AC). The adapter is also known as a power supply, battery charger, or inverter.

Fig. 4.3. *AC Adapter*

2.4. Bluetooth Module

2.4.1. Bluetooth module is a technology that acts as an interface that aids the wireless Bluetooth connection of any two devices and establishes a protocol for the communication of data between the devices.

2.4.2. Bluetooth module's mediated data communication range is usually an average of tens of meters and data is communicated in specified frequency bands.

Fig. 4.4. *Bluetooth Module*

2.5. LiPo Battery

Here we are using a 2200mAh 2S 30C/60C (7.4V) Lithium Polymer battery Pack to supply power to our robot.

Fig. 4.5. *Battery*

3. Design configuration - Physical Properties and Calculations:

3.1. Size: 310 x 290 x 100 mm

3.2. Weight: 3 kg

3.3. Actuation: 2 X 12 V DC gear motors with encoders

3.4. Power supply: 11.1 V – 1200 mAh Lithium-Polymer-Battery (operating time about 30 min.)

3.5. Electromagnets Specifications:

3.5.1. Ratings = 12V

3.5.2. Material: Neodymium

3.5.3. Shape: Circular

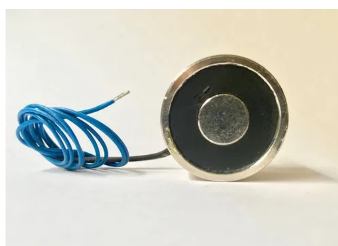

Fig. 4.6. *Electromagnet*

4. Detailed Design

4.1. Electrical/Electronics aspect

4.1.1. Power System

The wall climbing robot uses a high-capacity battery to power its electrical components. The battery is connected to a voltage regulator that provides a stable voltage to the Arduino board and other electronic components.

4.1.2. Arduino Board

The Arduino board serves as the control center for the robot. It receives input from sensors and user commands, processes the information, and generates appropriate output signals to control the motors and electromagnets. The Arduino board is programmed using the Arduino IDE software.

4.1.3. Motor Control

The motor control subsystem consists of motor drivers and associated circuitry. The Arduino board sends control signals to the motor drivers, which regulate the speed and direction of the motors.

4.1.4. Electromagnetic Adhesion System

The electromagnetic adhesion system employs electromagnets to enable the robot's attachment to vertical and horizontal surfaces. The Arduino board controls the activation and deactivation of the electromagnets based on user commands or automated algorithms.

4.1.5. Sensors

The wall climbing robot incorporates various sensors to gather information about its environment and operating conditions. These sensors may include proximity sensors, adhesion strength sensors, and environmental sensors. The sensors communicate with the Arduino board, allowing the control system to make informed decisions and adjust the robot's behavior accordingly.

4.2. Software part

4.2.1. Control Algorithms

The control algorithms are responsible for coordinating the movement of the robot and the activation of the electromagnets. The algorithms use feedback from sensors to adjust the robot's behavior and maintain adhesion to the surface.

4.2.2. User Interface

The user interface provides a means for users to interact with the robot and issue commands. It may include buttons, switches, or a graphical user interface (GUI) on a display screen. The user interface communicates with the Arduino board, allowing users to control the robot's movements, adjust parameters, and monitor system status.

4.2.3. Programming Language

The Arduino board is programmed using the Arduino Integrated Development Environment (IDE) software. The programming language used is based on C/C++, with additional libraries provided by the Arduino platform.

4.3. Mechanical Aspects

4.3.1. Chassis

The chassis provides the structural support for the robot and houses the electrical and electronic components. It is made of lightweight and durable materials, such as aluminum or carbon fiber.

4.3.2. Movement Mechanism

The movement mechanism is responsible for the robot's vertical and horizontal movement on surfaces. It consists of two axes on which rods are arranged in a cross configuration, with electromagnets at the edges. The electromagnets grip the surface to provide adhesion, and the rods can be extended or retracted to move the robot.

4.3.3. Gears

The movement mechanism uses a nut and bolt configuration as the gear system for movement in the vertical and horizontal directions. The gears provide smooth and efficient movement, with minimal wear and tear.

4.3.4. Motors

The motors provide the necessary torque and speed to move the robot. They are connected to the movement mechanism via a gear train, allowing precise control of the robot's movements.

4.3.5. Electromagnets

The electromagnets generate a strong magnetic field, allowing the robot to securely adhere to surfaces. They are connected to the Arduino board via a control circuit, allowing the activation and deactivation of the electromagnets based on user commands or automated algorithms.

o Orthographic Projection:

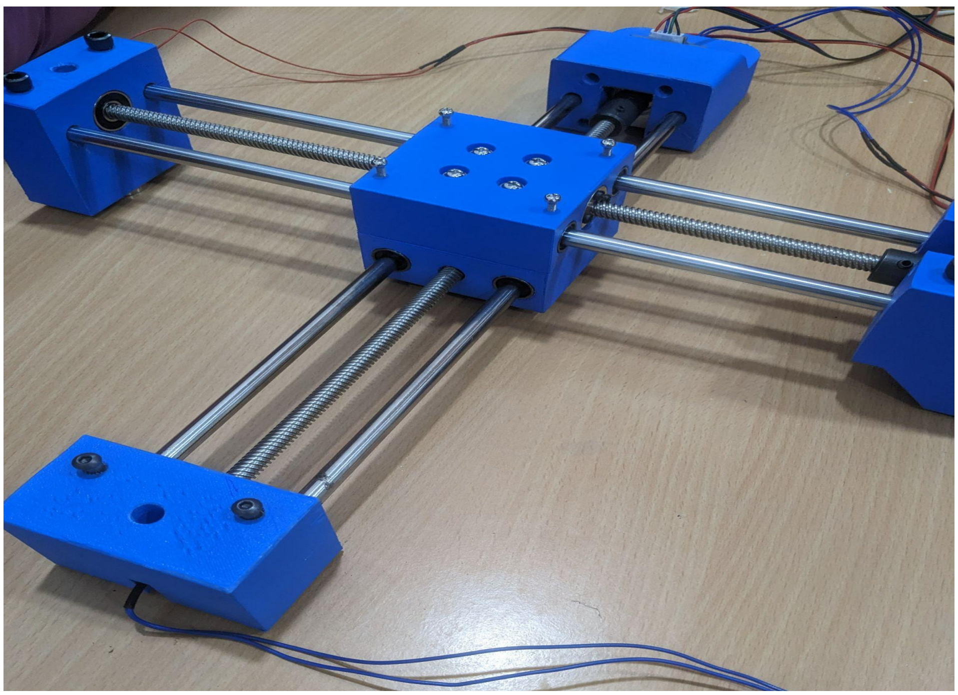

Fig. 4.7. Orthographic Projection

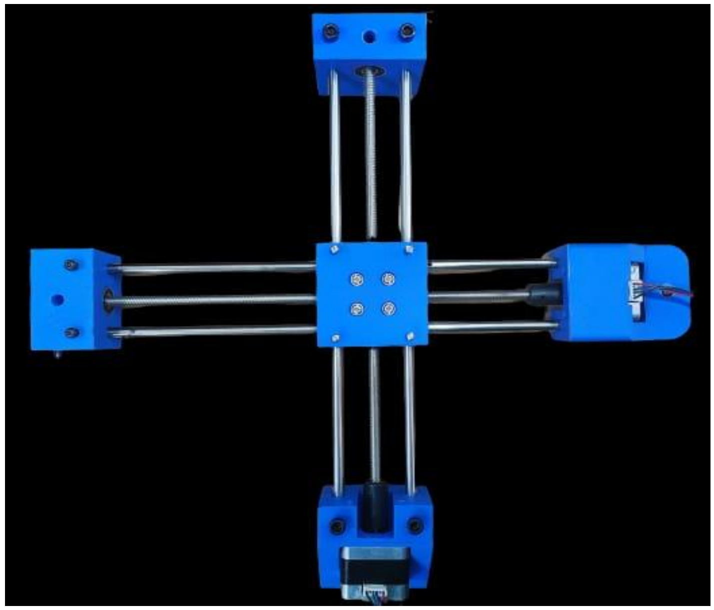

Fig. 4.8. Top view of robot

o Component Views:

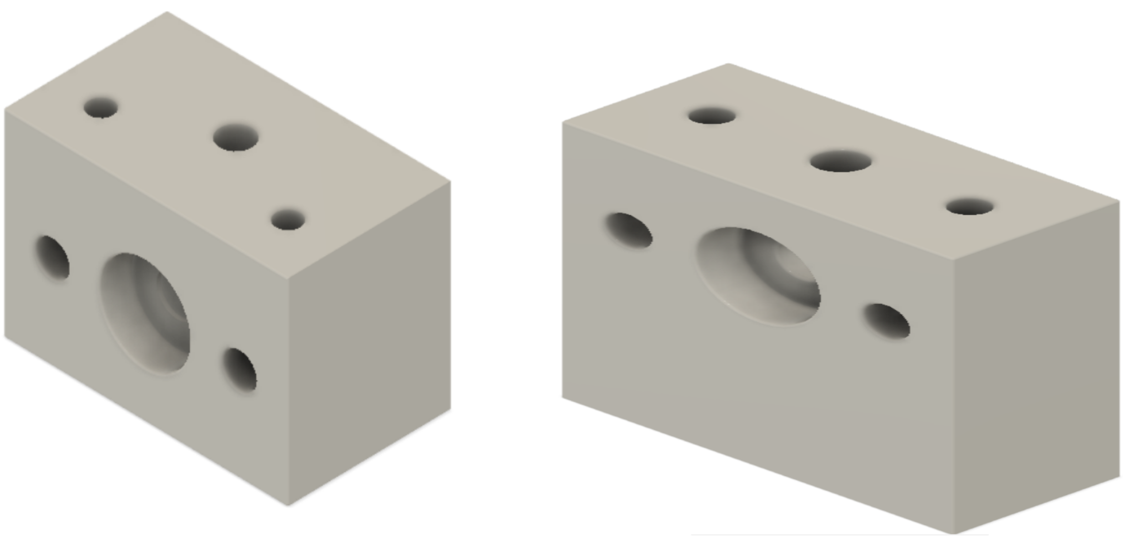

Fig. 4.9. Orthographic view of block bearings

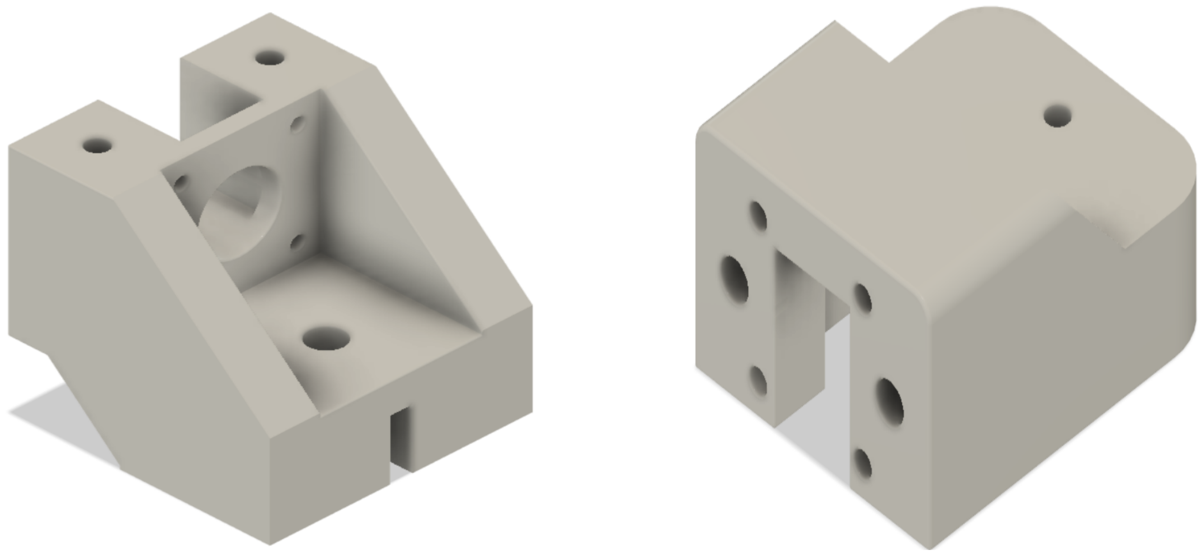

Fig. 4.10. Orthographic view of block motors

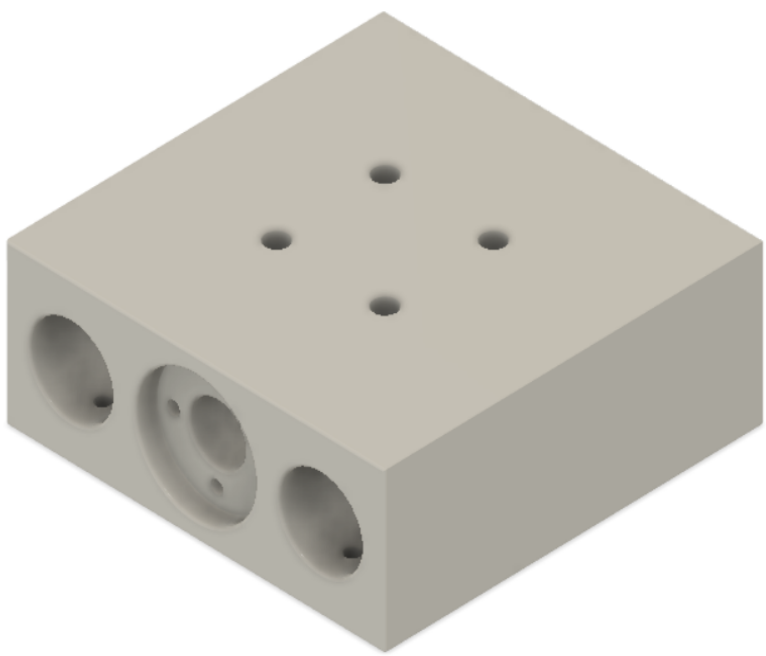

Fig. 4.11. Orthographic view of centered chassis

Overall, the electrical/electronics, software, and mechanical aspects of the design work together to create a wall-climbing robot that can move efficiently and accurately on metal surfaces and provide safe and efficient inspection of metal tanks and other metal structures.

5. Results and Discussion

The robot successfully climbed metal walls and utilized a camera to identify cracks or holes. The robot demonstrated reliable adhesion to the metal surfaces, allowing for stable movement during the inspection. The integrated high-resolution camera provided clear and detailed images of the tank's inner surface, facilitating the detection of even small structural weaknesses. The robot's control system enabled precise navigation, ensuring comprehensive coverage of the metal walls. Overall, the robot's performance highlights its potential to enhance inspection processes, contributing to improved safety and maintenance of metal tanks.

Chapter 5

Fabrication and Assembly

After making a well-versed plan, we moved towards the final part of our journey. Fabrication and Assembly.

Bill of Materials

S.No	Item	Quantity	Price
1	Battery Lipo 11.1V 2200ma	1	1690
2	Buck Converter	1	107
3	Big wheels(11cm)	2	590
4	Small Wheels(4cm)	2	70
5	Magnets(large)	70	2200
6	Magnets(small)	20	500
7	Camera	1	2000
8	Motor stepper NEMO	2	1800
9	Stepper motor wire	2	240

10	**Smooth Rod BMMX500mm**	4	1920
11	**Lead Screw**	2	780
12	**Coupling MS Black 5mm X 800mm**	2	240
13	**Bearing Liner LM10UU**	8	1200
14	**Magnet Electro 8X G**	4	2200
15	**Screw**	1	40
16	**Arduino UNO 328 SDM Board**	1	590
17	**Arduino UNC Shield for**	1	300
18	**Motor Driver Board Stepper**	2	320
19	**Adapter 12V 5A 5mps DVM**	1	600
20	**Filament PLA 1.75mm 1KG Blue**	1	1200
21	**Bolt C5 M5 25mm**	4	60
22	**Speaker wire Thin**	2	40
23	**Bearing 608**	2	90
24	**Brass Nut Bmm**	2	180

25	**3D Printing**		**8260**
	TOTAL		**27,217**

The Manufacturing Process

Our robot uses the following manufacturing processes

3D Printing:
It is a type of additive manufacturing process. It allows for quick and cost-effective production of complex shapes and designs. We used the FDM type of 3D printing for manufacturing our chassis. We used this method mainly due to 2 reasons, the 1st one being that it is an easy method and secondly it was a good option to manufacture for lightweight chassis as our material was PLA.

Assembly

After the fabrication and testing of each individual electronic and mechanical part, we begin with the integration and assembly of our product. We went on to assemble the product in the following steps:

1. The blocks made by 3D printing were put together with three rods each using screws.
2. The middle rod was threaded while the rods in the sides were kept smooth in order to manage frictional force and motion.
3. Electromagnets were attached to the bottom of each of the blocks for adhesion to the metallic surface.
4. Stepper motors were then assembled to the blocks for the motion in the desired direction.
5. The control unit was then programmed suitably.

Limitations

- The bot can only work on straight metallic surfaces.
- Still requires some human interaction.
- Slow motion
- Can't work on ceilings

Challenges

- Magnetic strength of magnets
- Motor selection
- Selection of body material
- Camera position
- Battery selection

Scheduling plan

In this section, we present the actual timeline that was decided for the project. The project, according to the actual deadline and plan, could have been completed within 45-60 days.

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Assignment-1																	
Problem identification																	
Deciding the final problem																	
Budget Estimation/ Product Research																	
Purchase initiation																	
Project fabrication																	

Adding electrical components								■	■								
Testing										■							
PreOpen House											■						
Changing the approach												■					
Designing													■				
Assembly														■	■		
Fabrication														■	■		
Final Testing																■	■

Contribution:

Name	Area of Contribution
Achint Dhama	**Mechanical Aspect** ➢ Worked in the assembly ➢ Major contribution towards the stabilization of the bot ➢ Worked out the ratios of the lengths of rods to be used and also came up with ideas to limit the effect of friction **Electrical Aspect** ➢ Contributed towards the circuit design
Aman Ali Khan	**Mechanical Aspect** ➢ Worked in the fabrication ➢ Managed the 3D printing and other important tasks of the fabrication of the robot ➢ Helped in the selection of bearings and other components **Design Aspect** ➢ Helped in creating the CAD Model of the robot

Rohit Yadav	**Mechanical Aspect** ➢ Worked in the assembly ➢ Significant contribution towards the motion and motors used in the bot ➢ Analyzed all of our requirements with the ratings of the major parameters of the available motors and decided accordingly **Software Aspect** ➢ Helped in implementing the control over the robot
Shreya Garg	**Mechanical Aspect** ➢ Worked in the assembly ➢ Vital contribution towards the adhesion and electromagnets used in the bot ➢ Worked out the required magnetic strengths and sizes of the magnets. **Software Aspect** ➢ Helped in implementing the control over the robot
Deepak Kumar	**Electrical Aspect** ➢ Worked towards the circuitry of the robot ➢ Worked out towards finding a suitable battery for the proper functioning of the robot ➢ Contribution towards making major electric connection **Mechanical Aspect** ➢ Helped in assembly of the robot
Adarsh Santoria	**Design Aspect** ➢ Helped in creating the CAD Model of the robot ➢ Contributed significantly in the calculations of all the aspects of the robot **Mechanical Aspect** ➢ Helped in the fabrication of the robot ➢ Helped in the calculation of friction and torque required for the motion

Conclusion

In this work, we present a project which can easily navigate on metallic walls/surfaces and perform inspection to find cracks, rust, etc. It is based on the principle of magnetism mounted with a camera to help in inspection. During the coursework, we learned a lot of things. It was an excellent experience.We got to learn about various innovative ideas and products already existing in the market and got an opportunity to work on a project that can further become a startup.

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