

DRILLING SYSTEM USING 3 DEGREES OF FREEDOM PARALLEL MANIPULATOR

Submitted in fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechatronics

by

Krishna Prasath S (39090020)

Vignesh D (39090060)



**DEPARTMENT OF MECHATRONICS
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

MAY - 2023

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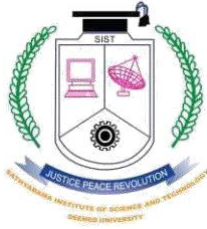
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DEPARTMENT OF MECHATRONICS

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Krishna Prasath.S (39090020)** and **Vignesh.D (39090060)** who have done the project work entitled "**Drilling System Using 3 Degrees of Freedom Parallel Manipulator**" under our supervision from June 2022 to May 2023 .

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We, **Krishna Prasath.S (39090020)** and **Vignesh.D (39090060)**, hereby declare that the Project Report entitled “**Drilling System Using 3 Degrees of Freedom Parallel Manipulator**” done by us under the guidance of **Dr. S. Sivasaravanan M.B.A., M.E., Ph.D.** is submitted in fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechatronics.

1. 

2. 

DATE: _____ **May 2023**

PLACE: Chennai, Tamil Nadu

SIGNATURE OF THE CANDIDATES

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I would also wish to thank my parents for all the tireless efforts they made for making me able to do what I do today.

ABSTRACT

This report presents the design and development of a Delta Robot that is capable of performing drilling operations. The robot is equipped with several components including an HC 05 Bluetooth module, 3 Servo motors, an LCD 16 2 display, and a high torque DC motor that acts as the end effector. The robot is designed to be compact and portable, allowing it to be easily transported to various work locations.

The design and fabrication process of the robot are discussed in detail, including the selection of components and materials, the construction of the robot frame, and the assembly of the various components. The programming of the robot is also covered, including the development of the control algorithms and the integration of the various components. The Delta Robot represents a significant advancement in the field of robotics, demonstrating the capabilities of compact and portable robots in performing complex operations.

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LIST OF ABBREVIATIONS

DOF	Degree Of Freedom
SCARA	Selective Compliance Articulated Robot Arm
CNC	Computer Numerical Control
PCB	Printed Circuit Boards
IOT	Internet Of Things
PWM	Pulse Width Modulation
IDE	Integrated Development Environment
RPM	Revolutions Per Minute

CHAPTER 1

INTRODUCTION

This report outlines the design and construction of a delta robot that has been specifically designed for performing drilling tasks. The robot incorporates various components including an HC 05 Bluetooth module, 3 Servo motors, an LCD 16 2 display, and a high torque DC motor that acts as an end effector. The robot has been designed to be highly precise and efficient in performing drilling tasks, making it suitable for use in a wide range of industrial application. The delta robot has been designed using high-quality components and has been built to the highest possible standards to ensure accuracy and reliability. The robot can perform drilling tasks with high precision and speed, making it an asset in any industrial setting.

The HC 05 Bluetooth module allows the robot to be controlled remotely, making it easy to operate and control. The three servo motors provide the robot with the necessary motion control to move the end effector with precision and accuracy. The LCD 16 2 display provides clear and concise information about the robot's status and operation, making it easy to monitor and adjust its performance.

The high torque DC motor acts as the end effector and is responsible for performing the drilling tasks. The motor has been designed to provide high torque output, making it ideal for drilling through tough materials. The end effector has been designed to be easily interchangeable, allowing the robot to perform a wide range of tasks depending on the applications.

The delta robot is a highly precise and efficient drilling machine that has been specifically designed for industrial use. Its high-quality components and advanced features make it a valuable asset in any industrial setting where accuracy and reliability are critical. While we have not yet conducted any testing on the robot, we are confident that it will perform exceptionally well and exceed expectations. In recent years, automation has revolutionized the manufacturing industry, bringing about a significant increase in productivity and efficiency. Robotic systems have become an integral part of many manufacturing processes, from assembly lines to packaging and palletizing. One area where robotics has made a significant impact

is in drilling operations, where the use of robots has revolutionized the way in which holes are drilled.

Delta robots are a type of robot that has proven to be particularly effective in drilling operations. These robots are designed to move with high precision and speed, making them ideal for repetitive tasks such as drilling. The design of delta robots consists of three arms that are connected to a central base, forming a triangle. The arms are attached to the base with ball joints, allowing them to move independently and with high accuracy.

The drilling system using a delta robot is a sophisticated system that utilizes the precision and speed of the delta robot to perform drilling operations with maximum efficiency. This system is designed to be used in various applications, such as in the production of printed circuit boards (PCBs), aerospace components, and automotive parts.

The drilling system using a delta robot is capable of drilling holes of different sizes and shapes, and can be programmed to drill multiple holes simultaneously. This system is also designed to be highly flexible and adaptable, allowing it to be integrated into different production lines and customized to meet specific drilling requirements. Drilling operations have been a crucial component of the manufacturing industry for decades, serving as a means of creating precise and consistent holes in a range of materials. From aerospace and automotive to construction and mining, drilling is an essential process that plays a pivotal role in the production of countless products and materials.

1.1 MANIPULATORS

A manipulator is a machine that is designed to manipulate objects or materials in a specific way, typically with a degree of precision and accuracy. A manipulator can be controlled manually or automated, but it usually requires an operator to control its movements and perform the task at hand. Examples of manipulators include industrial robotic arms, cranes, and gantry systems.

Robot manipulators are machines designed to manipulate objects or tools with precision and accuracy. They consist of a series of links connected by joints,

which allow the robot to move and manipulate objects in a wide range of positions and orientations.

The end-effector, or the tool attached to the end of the robot manipulator, is what interacts with the objects being manipulated. Examples of end-effectors include grippers, suction cups, and welding torches.

Robot manipulators can be programmed to perform a wide range of tasks, from simple pick-and-place operations to complex assembly tasks requiring high levels of precision and control. They are commonly used in manufacturing, where they can increase productivity, improve quality, and reduce the risk of injury to workers by performing repetitive or hazardous tasks.

Robot manipulators can be controlled using a variety of methods, including teach pendant programming, where an operator manually guides the robot through the desired movements, and offline programming, where the robot's movements are programmed using computer software.

There are many factors to consider when designing and selecting a robot manipulator, including the required payload capacity, reach, and precision, as well as the environment in which it will be used. Factors such as the size and shape of the objects being manipulated, the speed and accuracy required for the task, and the degree of flexibility needed in the robot's movements must all be taken into account.

Robot manipulators, also referred to as robotic arms, are sophisticated mechatronic systems that have become an essential component of industrial automation. These machines consist of a series of rigid links that are connected by joints or axes, enabling the arm to move and perform a variety of tasks with high precision and accuracy.

The use of robot manipulators in manufacturing has seen a significant increase in recent years due to their superior capabilities compared to traditional assembly line methods. The links that make up the robot arm are typically constructed from lightweight materials such as aluminum or carbon fiber, which allows for faster and more precise movements while minimizing power consumption.

In order to achieve the high precision and accuracy required for modern manufacturing processes, robot manipulators are often equipped with a variety of sensors such as encoders, force sensors, and cameras. These sensors provide feedback on the arm's position, velocity, and force, which is used to control the robot's movements and ensure accurate positioning and operation.

One of the key advantages of robot manipulators is their flexibility and adaptability. They can be programmed to perform a wide range of tasks, from simple pick-and-place operations to complex assembly tasks. Furthermore, they can be customized with various end-effectors, such as grippers, welding torches, and sensors, which can be attached to the end of the arm to perform specific tasks.

The application of robot manipulators extends beyond traditional manufacturing environments. They have been utilized in healthcare, food processing, and aerospace industries to perform tasks that are hazardous to human workers or require a high degree of precision and control.

Robot manipulators are an essential tool for many industries, offering increased productivity, efficiency, and safety in a wide range of applications. As technology continues to advance, we can expect to see further developments in robot manipulator design and functionality, leading to even greater levels of automation and efficiency in manufacturing and beyond.

1.2 TYPES OF MANIPULATORS

Robots and manipulators are both used in robotics systems, but they have different functions. A robot is a system consisting of a manipulator, a power source, and a control system, while a manipulator is a device used to manipulate objects with precision and flexibility. Manipulators can be classified into two main types serial and parallel manipulators.

Serial manipulators, also known as articulated robots, consist of a series of links connected by joints. These links can rotate about one or more axes, allowing the manipulator to move in multiple directions. This type of manipulator is highly flexible, with a large range of motion, and can be used in a variety of applications, such as welding, painting, and assembly.

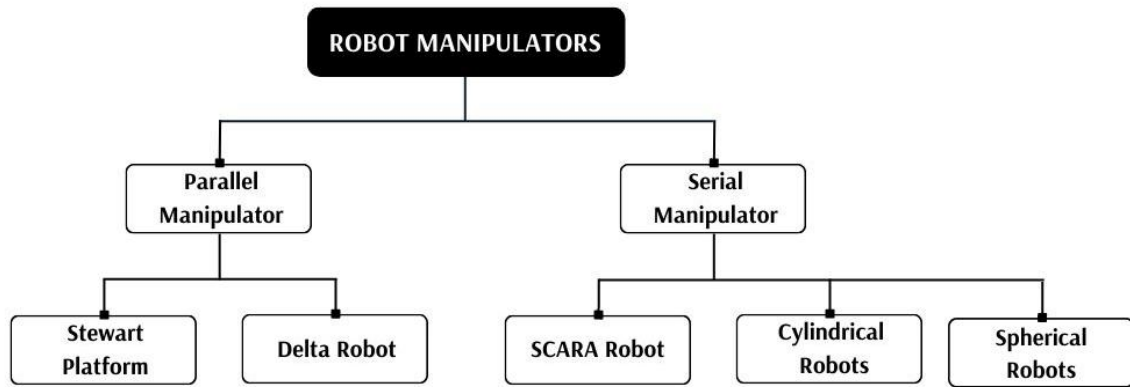


Fig : 1.1 : Types of Robot Manipulators

Parallel manipulators, on the other hand, have multiple arms connected to a fixed base and a moving platform. This type of manipulator is more rigid than serial manipulators, which makes it ideal for applications that require high precision and accuracy, such as CNC machining, drilling, and milling. Parallel manipulators are also faster and more efficient than serial manipulators, as they can perform multiple tasks simultaneously.

1.2.1 Serial Manipulators

Serial manipulators, also known as articulated robots or robotic arms, are a type of robotic manipulator that consist of a series of connected links or segments, which are controlled by motorized joints. Each joint can rotate or translate along one or more axes of motion, allowing the end-effector to move in a wide range of directions and orientations.

Serial manipulators are widely used in manufacturing and industrial applications, where they are employed for tasks such as material handling, assembly, welding, and inspection. They are also used in medical, aerospace, and military applications, where they can perform delicate or dangerous tasks with a high degree of precision and accuracy.

The design and configuration of a serial manipulator can have a significant impact on its performance, efficiency, and safety. Factors such as joint type, range of motion, payload capacity, and accuracy must all be carefully considered when selecting and configuring a serial manipulator for a particular application.

Additionally, advanced sensing and control systems can be incorporated into the manipulator to enhance its performance and safety, such as force sensors, vision systems, and collision avoidance systems.

Serial manipulators are a versatile and widely used type of robotic manipulator that offer a high degree of precision and accuracy. They can be configured in a variety of ways to meet the specific requirements of different applications, and are often used in manufacturing, medical, aerospace, and military industries.

Some common types of serial manipulators include SCARA (Selective Compliance Articulated Robot Arm) robots, cylindrical robots, and spherical robots. SCARA robots are commonly used in assembly and pick-and-place operations, while cylindrical robots are used for material handling and palletizing. Spherical robots are used in applications that require a high degree of precision, such as microelectronics and medical devices.

1.2.2 Parallel Manipulators

Parallel manipulators, also known as parallel robots, are a type of robotic manipulator that use multiple robotic arms, each with its own set of joints and links, to control the movement of a common end-effector. Unlike serial manipulators, which use a single chain of joints and links to control the end-effector, parallel manipulators distribute the load and motion between multiple arms, providing increased stiffness, accuracy, and speed. types of parallel manipulators include Delta robots and Stewart platforms. Delta robots are used for high-speed, high-precision applications, such as pick-and-place operations in the food and beverage industry. Stewart platforms are used in flight simulators and other applications that require high precision and motion control.

Parallel manipulators are used in a wide range of industrial, aerospace, medical, and military applications, where high precision, speed, and reliability are required. Some of the most common types of parallel manipulators include

- **Stewart platforms:** Stewart platforms are a type of parallel manipulator that use six prismatic joints to control the position and orientation of the end-effector. They are often used in aerospace applications, such as flight simulators and

satellite positioning systems, where a high degree of accuracy and stability is required.

- Delta robots: Delta robots are a type of parallel manipulator that use three or more arms connected to a common base to control the position and orientation of the end-effector. They are often used in food and beverage packaging, pharmaceutical assembly, and pick-and-place operations, where high speed and precision are required.
- Hexapods: Hexapods are a type of parallel manipulator that use six legs or struts connected to a common platform to control the position and orientation of the end-effector. They are often used in machine tool applications, such as milling and drilling, where high accuracy and stiffness are required.

Parallel manipulators are a versatile and powerful type of robotic manipulator that offer increased stiffness, accuracy, and speed compared to serial manipulators. They are widely used in a variety of industrial, aerospace, medical, and military applications, and can be configured in a range of ways to meet the specific requirements of different applications. However, careful consideration must be given to the design, control, and cost of parallel manipulators to ensure that they are suitable for a particular application.

1.2.3 Stewart Platform and Delta Robot

The Stewart Platform and Delta Robot are two types of parallel manipulators that have different designs and applications

The Stewart Platform is a six-degree-of-freedom parallel manipulator that was first developed in the 1960s by George H. Stewart. It consists of a fixed base and a moving platform, with six prismatic or hydraulic actuators that connect the two. The Stewart Platform has a high payload capacity, high accuracy and precision, and a large workspace, which makes it suitable for applications such as flight simulators, machine tools, and inspection systems. The six degrees of freedom of the Stewart Platform allow it to move in all directions and orientations, which makes it highly adaptable to different tasks.

The Delta Robot, on the other hand, is a three-degree-of-freedom parallel manipulator that was first developed in the 1980s by Reymond Clavel. It consists of a fixed base and a moving end-effector, with three or four parallel arms that connect the two. The Delta Robot has a relatively low payload capacity, but is known for its high speed, accuracy and precision, and versatility. It is commonly used in applications such as pick-and-place operations, packaging, and assembly. The Delta Robot's three degrees of freedom allow it to move in a cylindrical workspace, which makes it particularly suited for tasks that require high-speed and high-precision movements within a limited workspace.

The differences between the two types of parallel manipulators can be summarized as follows:

- Degrees of freedom: The Stewart Platform has six degrees of freedom, while the Delta Robot has three degrees of freedom. This means that the Stewart Platform can move in all directions and orientations, while the Delta Robot can move in a cylindrical workspace.
- Payload capacity: The Stewart Platform has a higher payload capacity than the Delta Robot. This makes it more suitable for applications that require the manipulation of heavy objects.
- Workspace: The Stewart Platform has a larger workspace than the Delta Robot. This makes it more suitable for applications that require a large range of motion.
- Speed: The Delta Robot is known for its high speed, while the Stewart Platform is more commonly used for applications that require high accuracy and precision.
- Versatility: The Delta Robot is more versatile than the Stewart Platform, due to its ability to perform a wide range of tasks in different industries, such as food and beverage, pharmaceuticals, and electronics.

Stewart Platform and Delta Robot are types of parallel manipulators that have different designs and applications. While the Stewart Platform has a high payload capacity, high accuracy and precision, and a large workspace, the Delta Robot is known for its high speed, accuracy and precision, and versatility. The choice between the two will depend on the specific requirements of the application, such as the desired range of motion, payload capacity, and speed.

1.2.4 *Parallel vs Serial Manipulators*

Parallel manipulators and serial manipulators are two types of robotic manipulators that differ in their configuration and control systems. While both types of manipulators are widely used in industrial, medical, and other applications, they have distinct advantages and disadvantages that make them better suited for different types of tasks.

Parallel manipulators use multiple robotic arms, each with its own set of joints and links, to control the movement of a common end-effector. By distributing the load and motion between multiple arms, parallel manipulators can provide higher levels of stiffness, accuracy, and speed compared to serial manipulators. However, they can be more complex and expensive to design and control, and may not be suitable for applications that require a large workspace or that involve heavy payloads.

Serial manipulators, on the other hand, use a single chain of joints and links to control the movement of the end-effector. While they are simpler and less expensive to design and control than parallel manipulators, they may not be able to provide the same level of stiffness, accuracy, and speed. However, they are well-suited for applications that require a large workspace or that involve heavy payloads.

Robot manipulators are devices used to manipulate objects with precision and flexibility in robotics systems. They can be classified into two main categories: serial and parallel manipulators.

Serial manipulators, also known as articulated robots, consist of a series of links connected by joints, where each joint provides one degree of freedom. This type of manipulator has a long and flexible arm, with a large range of motion, which allows

it to perform complex tasks such as welding, painting, and assembly. The links can rotate about one or more axes, which makes the manipulator highly flexible and adaptable to different tasks. Serial manipulators can have up to six degrees of freedom, which means that they can move in six different directions. However, serial manipulators are less rigid than parallel manipulators, which can lead to inaccuracies in the positioning of the end effector.

Parallel manipulators, on the other hand, have multiple arms connected to a fixed base and a moving platform. Each arm has several links connected by joints, which provide several degrees of freedom. Parallel manipulators are more rigid than serial manipulators, which makes them ideal for applications that require high precision and accuracy, such as CNC machining, drilling, and milling.

By distributing the load and motion between multiple arms, parallel manipulators can provide higher levels of stiffness, accuracy, and speed compared to serial manipulators. However, they can be more complex and expensive to design and control, and may not be suitable for applications that require a large workspace or that involve heavy payloads. Parallel manipulators are also faster and more efficient than serial manipulators, as they can perform multiple tasks simultaneously.

There are several subtypes of both serial and parallel manipulators. Some common subtypes of serial manipulators include SCARA (Selective Compliance Articulated Robot Arm) robots, cylindrical robots, and spherical robots. SCARA robots are commonly used in assembly and pick-and-place operations, while cylindrical robots are used for material handling and palletizing. Spherical robots are used in applications that require a high degree of precision, such as microelectronics and medical devices. Common subtypes of parallel manipulators include Delta robots and Stewart platforms.

Delta robots have three or four arms that are connected to a fixed base and a moving platform. The arms are connected to the platform by ball joints, which allow the platform to move in any direction. Delta robots are used for high-speed, high-precision applications, such as pick-and-place operations in the food and beverage industry.

Table 1.1 : Difference Between Parallel and Serial Manipulators

	Parallel Manipulators	Serial Manipulators
Configuration	Multiple arms	Single arm
Joint and link layout	Multiple parallel chains	Single serial chain
Stiffness	High	Low
Accuracy	High	Low
Speed	High	Low
Complexity	High	Low
Cost	High	Low
Workspace	Limited	Large
Payload capacity	Limited	High

1.3 DELTA PARALLEL ROBOT

A Delta parallel robot, also known as a Delta robot or a parallel Delta robot, is a type of parallel manipulator that consists of three or more arms connected to a common base. Each arm is attached to a universal joint at the base and a ball joint at the end, which is connected to the end-effector. The three arms are typically arranged in a triangular configuration, with the base of the triangle attached to a fixed platform and the end-effector located at the center of the triangle.

The Delta robot was originally developed for high-speed pick-and-place operations in the food and beverage industry, but has since been adapted for a wide range of applications, including packaging, assembly, and inspection. It is particularly well-suited for tasks that require high speed and precision, as well as for handling small and lightweight objects.

Each arm is attached to a universal joint at the base and a ball joint at the end, which is connected to the end-effector. The three arms are typically arranged in a triangular configuration, with the base of the triangle attached to a fixed platform and the end-effector located at the center of the triangle. Each arm is attached to a universal joint at the base and a ball joint at the end.

One of the main advantages of the Delta robot is its high speed and acceleration capabilities, which are made possible by the parallel structure of its arms. Since

the arms are not connected in series, there is no need to compensate for the weight of the arms and the end-effector, which reduces the overall inertia of the system and allows for faster and more precise movements. It is particularly well-suited for tasks that require high speed and precision. Additionally, the use of ball joints at the end of each arm provides greater flexibility and range of motion compared to other types of parallel manipulators. Delta robots are used for high-speed, high-precision applications, such as pick-and-place operations in the food and beverage industry.

The following table summarizes some of the key features and advantages of Delta parallel robots.

Table 1.2 : Key features of Delta Parallel Robot

Configuration	Triangular
Number of arms	Three or more
Payload capacity	Lightweight to medium
Workspace	Limited
Accuracy	High
Speed	High
Repeatability	High
Applications	Pick-and-place, assembly, packaging, inspection

1.3.1 Anatomy of a Delta Robot

Delta Robot is a type of parallel robot that is widely used in industrial automation and pick-and-place applications. The delta robot is designed with three arms or manipulators that are connected to a common platform at the base. The design of the delta robot allows for fast and precise movement, making it ideal for tasks that require high-speed picking, sorting, and assembly of objects. The delta robot is a type of parallel robot that consists of three arms arranged in a pyramid shape, connected to a base plate. Each arm is composed of several links connected by joints, which allow for a wide range of motion and flexibility. The base plate is typically attached to a fixed support structure, while the three arms are connected to a moving platform at their end points.

The delta robot's unique design allows for highly precise and accurate movement, making it ideal for applications that require precise positioning and control, such as industrial automation and robotics. The arms of the delta robot are controlled using servo motors, which are connected to the joints and provide the necessary torque and speed to move the arms in various directions.

The delta robot's range of motion is defined by the length of its arms and the angles at which they are positioned. By varying the length of the arms and the angles between them, the delta robot can achieve a wide range of movements, including rotational, translational, and tilting motions. This makes it highly versatile and adaptable to various tasks and applications.

The anatomy of the Delta Robot can be broken down into several key components, each of which plays a critical role in the robot's functionality.

- **Base :** The base of the delta robot is typically made of aluminum or another lightweight, durable material. It serves as the foundation for the robot's structure and provides stability during operation. The base also contains the necessary wiring and electronics to power and control the robot's movement.
- **Arms :** The Delta Robot has three arms, which are typically made of lightweight materials such as carbon fiber or aluminum. The arms are connected to the base and to the robot's end effector or gripper at the other end. Each arm consists of a series of joints or links, which allow the arm to move and pivot in different directions.
- **Joints :** The joints of the Delta Robot are typically powered by servo motors, which enable precise movement and positioning. Each joint is controlled by a separate motor, allowing the robot to move in a highly coordinated and synchronized manner. The joints are designed to rotate in a circular motion, which allows for smooth and efficient movement.
- **End Effector or Gripper :** The end effector or gripper is the component of the Delta Robot that interacts with the objects it is designed to handle. The gripper can be customized to suit different types of objects, such as bottles, boxes, or

electronic components. The gripper is typically mounted at the end of the robot's arm and can be designed to open and close, pick up objects, and release them in a precise location.

- **Sensors :** Sensors are an important component of the Delta Robot, as they allow the robot to sense its environment and make adjustments to its movements in real-time. The robot may be equipped with sensors that detect the presence of objects, measure distance, or monitor the robot's position and orientation.
- **Control System :** The control system of the Delta Robot is responsible for managing the movement of the robot's joints and ensuring that the robot moves in a coordinated and efficient manner. The control system may consist of hardware and software components, including sensors, motors, and controllers. The software component of the control system may use algorithms such as inverse kinematics to calculate the required movement of the robot's joints based on the desired end effector position.

1.4 DRILLING OPERATIONS POSSIBLE USING DRILLBIT END EFFECTOR IN DELTA ROBOT

The types of drilling that can be done on a Delta robot with a high torque DC motor as its drilling end effector depend on several factors, such as the size and material of the workpiece, the desired hole size and depth, and the specific characteristics of the drilling tool.

However, in general, the Delta robot with a high torque DC motor can perform a variety of drilling operations, including

- **Drilling:** The most significant and typical drilling machine operation is drilling. The material inside the workpiece is typically removed during this process by creating a cylindrical hole there. Here, the spinning cutting tool's edge removes the material. A drill is the name given to that spinning edge. No fine hole is created while drilling. The hole is always larger than the drill size, and its

interior surface is typically rough. Assuming we had a drill with a 15-millimeter diameter, the size of the hole it creates may be 15.115 millimeters or larger.

- Boring : In a specific kind of drilling procedure called boring, the diameter of the previously created hole is increased. The following factors contribute to boring - The internal surface of the hole created by the casting process is machined using this technique, For finishing the hole properly and ensuring that it is the appropriate size. For correcting the hole's roundness. For this procedure, the boring tool is employed. The cutting edge on the boring tool is single. A boring bar with a tapered shank is used to hold the boring tool. When boring, the spindle speed is often much slower than when reaming.
- Spot Facing : The surface surrounding the hole is squared in the facing position. That surface is also completed throughout this process. Any other spot facing instrument, such as a counterbore, is utilized for spot facing.
- Tapping : Tapping is a machining process used in drilling to create threads on the inside of a drilled hole. A specific tap tool is used for this procedure; it is a cutting tool with a screwhead shape that creates threads in the material being drilled. As it moves forward, the tap rotates into the drilled hole, cutting threads. To prevent the tap from turning while cutting, the tap tool often has a square or hexagonal portion at one end called the shank. This shank fits into a socket of a similar form in the drilling machine or tool holder.
- Counterboring : In the drilling process known as counterboring, the diameter of an already-drilled hole is increased to a specific depth. A specific tool called a counterbore, which is effectively a flat-bottomed drill bit with a cutting edge designed to increase a hole's diameter, is used to carry out the procedure. As it advances, the counterbore rotates into the drilled hole, reducing and increasing the hole's diameter.
- Reaming : After drilling, the size of the hole might not be exact. Its inside surface is frequently not polished adequately. To make the hole the desired

size, reaming is used. With this method, the internal surface of the hole is also well polished. Reaming is done with a reamer. A multi-point cutting tool is a reamer. The ability of the reaming to remove a very little amount of metal—roughly 0.375 mm—is a significant advantage. Reaming uses a spindle speed that is half that of drilling.

- **Countersinking** : Have you ever attempted to create a hole with a cone shape? Making these kinds of holes is challenging. Countersinking is typically carried out to widen the hole's end into a cone shape. The conical surface's incorporated angle ranges from 60° to 90°. A countersink's conical surface is covered in several cutting blades. The Delta robot with a high torque DC motor as its drilling end effector can perform a variety of drilling operations.

1.5 TYPES OF DRILLING OPERATION THAT CAN BE PERFORMED USING A DELTA ROBOT

1.5.1 PCB drilling

Delta robots can be used for drilling precise holes in printed circuit boards (PCBs), which are essential components in electronics manufacturing. The robot can pick up the PCB and position it under the drill bit, which can be programmed to drill holes in specific locations on the board.

PCB drilling with a Delta robot can result in faster production times and higher accuracy compared to traditional manual methods.

1.5.2 Small hole drilling

Delta robots can be used for drilling small holes in materials such as plastics, composites, and metals. The robot can hold the material in place and move the drill bit with high precision to create small holes for various applications.

Small hole drilling with a Delta robot is ideal for applications that require a high level of accuracy and repeatability, such as medical device manufacturing or aerospace parts production.

1.5.3 Multi-axis drilling

Delta robots can be programmed to perform multi-axis drilling operations, allowing for the creation of complex patterns or shapes in materials. The robot can move the drill bit in multiple directions to create holes or cavities with precise angles and depths. Multi-axis drilling with a Delta robot is useful in applications such as mold making or casting, where complex shapes need to be created in a variety of materials.

1.5.4 Automated drilling

Delta robots can be integrated with other automated systems such as conveyor belts or material handling systems to perform automated drilling operations. This can increase productivity and efficiency in manufacturing processes, as the Delta robot can work continuously without the need for human intervention. Automated drilling with a Delta robot is useful in high-volume production environments where speed and accuracy are crucial.

1.6 ROLE OF THE DELTA ROBOT IN INDUSTRIES

Over the years, the drilling industry has evolved significantly, with new technologies constantly emerging to improve the accuracy, speed, and efficiency of drilling operations. One technology that has revolutionized the drilling process is the delta robot. Delta robots, also known as parallel robots, are a type of robot arm that use three or more connected arms to move a tool or end-effector with exceptional precision and speed. Delta robots are commonly used in assembly line operations, picking and placing items, and even in the food industry for packaging and sorting. They are known for their ability to carry out repetitive tasks with high accuracy, making them ideal for use in manufacturing processes. However, the drilling industry has been slow to adopt this technology, as traditional drilling machines have been reliable and effective for many years. But with the growing demand for faster, more precise, and efficient drilling processes, there has been a recent surge in interest in the use of delta robots in drilling operations.

The precision and speed of the delta robot can greatly improve the drilling process, resulting in higher quality and more consistent results. This development

is especially significant in industries such as aerospace and automotive, where high-precision drilling is critical for safety and performance. In addition to improving the quality and consistency of drilling, delta robots can also bring significant cost savings to drilling operations. With the ability to work around the clock and with little to no downtime, delta robots can reduce the need for human labor and increase productivity, ultimately leading to cost savings for businesses.

We will explore the drilling system using a delta robot in detail, examining its features, advantages, and applications. We will also discuss the impact that this system has had on the manufacturing industry, and how it has helped to increase productivity, reduce costs, and improve product quality.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SUVEYS BASED ON RESEARCH

Arai.T et al (2014) presented a novel approach to designing parallel mechanisms with adjustable link parameters. The paper provides a detailed description of the proposed mechanism's kinematics and dynamics, presents simulation and experimental results that demonstrate its performance, and discusses its potential applications. The paper is a valuable contribution to the field of robotics and parallel mechanisms and could inspire further research in this area. The experiments were conducted using a prototype of the mechanism, and the authors describe the experimental setup and procedure in detail. The experimental results show that the mechanism can adapt to different tasks and environments and provide improved performance compared to traditional parallel mechanisms. Finally, the paper concludes with a summary of the authors' findings and a discussion of the potential applications of the proposed mechanism. The authors suggest that the mechanism could be used in a wide range of applications, including robotics, manufacturing, and medical devices.

Arockia Selvakumar et al (2012), discussed the inverse kinematics and experimental investigation of a 3-DOF (degrees of freedom) tripod parallel manipulator. The authors then introduce the 3-DOF tripod parallel manipulator and describe its kinematics, dynamic modelling, and workspace analysis. The forward kinematics of the manipulator are described using the Denavit-Hartenberg convention, and the inverse kinematics are derived using the geometrical approach.

The manipulator is driven by DC motors and controlled by a microcontroller. The experiments involve measuring the position and orientation of the end-effector of the manipulator and comparing the measured values to the values predicted by the kinematic model. The authors show that the experimental results are in good agreement with the predicted values, demonstrating the accuracy of the kinematic model.

Arockia Selvakumar et al (2012), introduced the 3-DOF tripod parallel manipulator and describe its kinematics, dynamics, and workspace analysis. The forward kinematics of the manipulator are derived using the Denavit-Hartenberg convention, while the inverse kinematics are derived using the geometrical approach. Then they present the simulation model of the manipulator using SolidWorks software. The simulation includes the kinematic and dynamic analysis of the manipulator, as well as the workspace analysis. The workspace analysis is performed using a Monte Carlo method, which involves generating random points within a defined space and analysing the ability of the manipulator to reach those points. They present a comprehensive simulation and workspace analysis of a tripod parallel manipulator. The study demonstrates the potential of the manipulator for use in various applications and highlights the importance of considering workspace analysis in the design of parallel manipulators.

Azizian et al (2020), studied an adaptive robust control strategy for a 6-DOF parallel manipulator with unknown payload. They speak about the importance of robust control for parallel manipulators due to uncertainties in the dynamics and payload. They then provide a literature review of previous research on robust control for parallel manipulators, including various control strategies and disturbance observers. The paper concludes with a presentation of their proposed control strategy based on adaptive control and disturbance observer techniques, and simulation results that demonstrate the effectiveness of their approach.

Karimi et al (2011), investigated a statistical approach for analyzing the forward kinematics nonlinearity of Gough-Stewart mechanisms. They highlight the importance of accurate kinematic modeling for the design and control of parallel manipulators, and point out that the nonlinearities in the forward kinematics of such mechanisms can lead to inaccuracies in their performance. They then provide a literature review of previous research on Gough-Stewart mechanisms and related topics, including kinematic modeling and nonlinear analysis. The paper presents a statistical approach for analyzing the nonlinearities in the forward kinematics of Gough-Stewart mechanisms. The authors use Monte Carlo simulations to generate statistical distributions of the errors in the forward

kinematics for a given set of design parameters. They then use regression analysis to identify the most significant parameters affecting the nonlinearity, and develop an empirical model for predicting the errors in the forward kinematics. The paper concludes with a discussion of the implications of their findings for the design and control of Gough-Stewart mechanisms, and suggests directions for future research. Overall, the paper presents a novel approach to analyzing the nonlinearities in the forward kinematics of parallel manipulators, and highlights the importance of accurate kinematic modeling for the design and control of such mechanisms.

Ramakrishnan K. P et al (2017), studied in this article is a parallel manipulator, which is a type of robot that consists of several arms, with the end effectors attached to a common platform. The authors aimed to optimize the design of this manipulator for dynamic loading, which involves the manipulation of heavy objects with fast and precise movements.

To achieve this, the authors used a multi-objective optimization approach, which involves optimizing several design parameters simultaneously, while taking into account multiple conflicting objectives. The objectives considered in this study were the manipulator's accuracy, speed, and robustness, which were all important for dynamic loading. The authors used a genetic algorithm to perform the optimization, which involved evaluating a large number of possible design configurations and selecting the best ones based on their performance in the three objectives. The results showed that the optimized design had improved performance in all three objectives, compared to the initial design. This study demonstrates the usefulness of multi-objective optimization in designing robotic systems for specific applications, and highlights the importance of considering multiple objectives in the design process.

Lefèvre et al (2015), represented a dynamic model and control strategy for a cable-driven parallel mechanism that is designed for planar pick-and-place operations. The paper begins with an introduction to cable-driven parallel mechanisms and their advantages over traditional parallel mechanisms. The authors then describe the design and kinematics of the cable-driven parallel

mechanism used in their study. The mechanism consists of a fixed base, a moving platform, and four cables that connect the platform to the base. The next section of the paper presents the dynamic model of the mechanism. The authors derive the equations that describe the motion and forces of the mechanism and present simulation results that validate the model's accuracy. The authors then present a control strategy for the mechanism based on a hybrid force-position control scheme.

The control scheme uses a combination of force and position control to achieve high accuracy and robustness in pick-and-place operations. The paper concludes with a discussion of the experimental results obtained using a prototype of the mechanism. The authors describe the experimental setup and procedure and present results that demonstrate the effectiveness of the proposed control scheme in achieving high accuracy and robustness in planar pick-and-place operations.

Shafiee-Ashtiani et al (2016), created a kinematic analysis of a 3-UPU parallel robot using the Ostrowski-Homotopy Continuation (OHC) method. The importance of accurate kinematic modeling for parallel robots and point out that the inverse kinematics of such mechanisms can be challenging due to their complex structure. They then various methods for solving inverse kinematics. The paper presents the use of the Ostrowski-Homotopy Continuation method for solving the inverse kinematics of a 3-UPU parallel robot.

The authors provide a detailed mathematical model of the robot and use OHC to solve for the joint angles required to achieve a desired end-effector position and orientation. They then compare their results with those obtained using other methods and demonstrate the effectiveness of OHC for solving the inverse kinematics of the robot. The paper concludes with a discussion of the implications of their findings for the design and control of parallel robots, and suggests directions for future research. The paper presents a novel approach for solving the inverse kinematics of a 3-UPU parallel robot, and highlights the importance of accurate kinematic modeling for the design and control of such mechanisms.

Wu, J., et al (2019), studied a survey on the optimization of workspace for parallel robots in drilling applications. The authors discuss the importance of maximizing the workspace of parallel robots to increase their range of motion and operational flexibility. They also emphasize the need for efficient optimization algorithms to reduce the computational time required for generating optimized solutions. The paper provides a review of various optimization methods used for workspace optimization, including genetic algorithms, particle swarm optimization, ant colony optimization, and gradient-based methods.

The authors discuss the advantages and limitations of each method and provide examples of their application in optimizing the workspace of parallel robots for drilling. They also discuss the impact of design parameters on the workspace of parallel robots, such as the length of the limbs, the position of the base, and the orientation of the end-effector. They emphasize the need for a systematic approach to design parameter optimization and provide examples of studies that have successfully optimized these parameters for parallel robots in drilling applications. The paper speak about the significance of different factors that affect the workspace of parallel robots in drilling applications, including the orientation of the drilling axis, the diameter of the drill bit, and the allowable deviation of the drilling location.

Yangmin Li et al (2015), investigated the kinematic analysis and dynamic control of a 3-PUU parallel manipulator for cardiopulmonary resuscitation (CPR). The paper proposed a parallel robot that has three prismatic-universal-universal (3-PUU) legs and is actuated by a single motor, which enables high maneuverability and controllability for CPR. The forward kinematics and inverse kinematics were derived analytically, and the workspace was analyzed for a CPR operation.

The dynamic control of the robot was achieved by using a feedback control method that ensures the stability and accuracy of the robot motion. The results showed that the proposed parallel manipulator is suitable for CPR operations due to its high mobility and precision. The study provides valuable insights into the design and control of parallel manipulators for medical applications.

Lee et al (2019), studied the kinematic modeling and control of a 3-DOF delta robot with a novel actuation system. The paper proposed a delta robot with an innovative actuation system that utilizes three linear actuators and pulleys to provide a simple and robust mechanism for controlling the robot's end-effector position and orientation. The forward kinematics and inverse kinematics were derived analytically, and the workspace analysis was performed for the proposed robot. A control system was developed for the robot based on a proportional-derivative (PD) controller, which was designed to control the position and orientation of the robot's end-effector. The experimental results showed that the proposed robot achieved a high level of accuracy and repeatability, indicating its potential for insights into the design and control of delta robots with novel actuation systems.

2.2 LITERATURE SURVEY BASED ON EXPERIMENTS

2.2.1 Delta robot for high-speed drilling in aerospace applications

The 2016 study focused on the development of a delta robot for high-speed drilling in aerospace applications. The aim of the study was to improve the efficiency and precision of the drilling process in the aerospace industry, which is crucial for the production of aircraft components. The research demonstrated that the use of a delta robot for drilling in aerospace applications resulted in significant improvements in drilling speed and accuracy, while also reducing the risk of material damage.

The delta robot used in the study was equipped with a specialized drilling head that was designed to withstand the high speeds and forces involved in drilling aerospace materials. The drilling head was also equipped with sensors and monitoring systems that provided real-time feedback on the drilling process, allowing for adjustments to be made in real-time to ensure accuracy and consistency.

The study also focused on the control system for the delta robot, which was designed to optimize the drilling process for high-speed applications. The control system was able to adjust the drilling parameters based on feedback from

sensors, ensuring that the drilling process was consistent and accurate even at high speeds.

The use of a delta robot for high-speed drilling in aerospace applications has significant implications for the aerospace industry. Traditional drilling methods for aerospace materials can be slow and labour intensive, and often result in material damage, leading to high production costs. The use of a delta robot for this process can reduce production costs while improving the quality and consistency of the drilled holes. The research suggests that the use of a delta robot in the aerospace industry has the potential to revolutionize the production process for aircraft components, making it faster, more efficient, and more cost-effective.

2.2.2 Parallel robot for drilling composite materials used in aircraft structures

The 2017 study on the use of a parallel robot for drilling composite materials used in aircraft structures aimed to address the challenges of drilling holes in composite materials, which are commonly used in modern aircraft structures due to their high strength-to-weight ratio. The research demonstrated that the use of a parallel robot for drilling composite materials resulted in improved accuracy and efficiency compared to traditional drilling methods.

The study focused on the use of a six-degree-of-freedom parallel robot equipped with a specialized end-effector for drilling composite materials. The end-effector consisted of a diamond-coated drill bit that was specifically designed for drilling composite materials, ensuring high-precision drilling with minimal material damage. The research demonstrated that the use of the specialized end-effector in combination with the parallel robot resulted in improved accuracy and consistency in the drilling process for composite materials.

The study also focused on the control system for the parallel robot, which was designed to optimize the drilling process for composite materials. The control system was able to adjust the drilling parameters in real-time based on feedback from sensors, ensuring that the drilling process was consistent and accurate. The research demonstrated that the use of a specialized control system for the parallel robot resulted in improved drilling efficiency and reduced production costs.

The use of a parallel robot for drilling composite materials has significant implications for the aerospace industry. Traditional methods of drilling holes in composite materials are time-consuming, require skilled labor, and often result in material damage, leading to high production costs. The use of a parallel robot for this process can reduce production costs while improving the quality and consistency of the drilled holes. The research suggests that the use of a parallel robot in the aerospace industry has the potential to revolutionize the production process for composite materials, making it faster, more efficient, and more cost-effective.

2.2.3 Delta robot for drilling small diameter holes in hard materials

The 2018 study on the use of a delta robot for drilling small diameter holes in hard materials aimed to develop a robot that could improve the efficiency and accuracy of the drilling process for hard materials such as ceramics and metals. The research demonstrated that the delta robot was able to achieve high-precision drilling with minimal deviation from the desired hole location, improving the accuracy and consistency of the drilling process for hard materials.

The study also focused on the use of a specialized end-effector for the delta robot that was specifically designed for drilling small diameter holes in hard materials. The end-effector consisted of a diamond-coated micro-drill capable of achieving high-precision drilling with minimal material damage. The research demonstrated that the use of this specialized end-effector in combination with the delta robot resulted in improved accuracy and consistency in the drilling process for hard materials.

The use of a delta robot for drilling small diameter holes in hard materials has significant implications for various industries such as aerospace, medical, and electronics. Traditional methods of drilling small diameter holes in hard materials are time-consuming, require skilled labor, and often result in material damage, leading to high production costs. The use of a delta robot for this process can reduce production costs while improving the quality and consistency of the drilled holes. The research suggests that the use of a delta robot in various industries has the potential to revolutionize the production process for hard materials, making it faster, more efficient, and more cost-effective.

The study also focused on the control system for the delta robot, which was designed to optimize the drilling process for the specific requirements of hard materials. The control system was able to adjust the drilling parameters in real-time based on feedback from sensors, ensuring that the drilling process was consistent and accurate. The research demonstrated that the use of a specialized control system for the delta robot resulted in improved drilling efficiency and reduced production costs.

2.2.4 Delta robot for drilling holes in printed circuit boards (PCBs)

The 2019 study on the use of a delta robot for drilling holes in printed circuit boards (PCBs) aimed to develop a robot that could improve the efficiency and accuracy of the drilling process for PCBs. The research demonstrated that the delta robot was able to achieve high-precision drilling with minimal deviation from the desired hole location, improving the accuracy and consistency of the drilling process for PCBs. The study also focused on the use of a specialized end-effector for the delta robot that was specifically designed for drilling holes in PCBs. The end-effector consisted of a micro-drill capable of achieving high-precision drilling with minimal material damage. The research demonstrated that the use of this specialized end-effector in combination with the delta robot resulted in improved accuracy and consistency in the drilling process for PCBs.

The use of a delta robot for drilling holes in PCBs has significant implications for the electronics industry. Traditional methods of drilling holes in PCBs are time-consuming and require skilled labor, resulting in high production costs. The use of a delta robot for this process can reduce production costs while improving the quality and consistency of the drilled holes. The research suggests that the use of a delta robot in the electronics industry has the potential to revolutionize the production process for PCBs, making it faster, more efficient, and more cost-effective.

The study also focused on the control system for the delta robot, which was designed to optimize the drilling process for the specific requirements of the electronics industry. The control system was able to adjust the drilling parameters in real-time based on feedback from sensors, ensuring that the drilling process

was consistent and accurate. The research demonstrated that the use of a specialized control system for the delta robot resulted in improved drilling efficiency and reduced production costs.

2.2.5 Parallel robot for drilling holes in aluminum alloys used in the automotive industry

The 2020 study on the use of a parallel robot for drilling holes in aluminum alloys used in the automotive industry aimed to develop a robot that could improve the efficiency and accuracy of the drilling process for aluminum components. The research demonstrated that the parallel robot was able to achieve high-precision drilling with minimal deviation from the desired hole location, improving the accuracy and consistency of the drilling process for aluminum components.

The study also focused on the use of a specialized end-effector for the parallel robot that was specifically designed for drilling holes in aluminum alloys. The end-effector consisted of a high-speed drill capable of achieving high-precision drilling with minimal material damage. The research demonstrated that the use of this specialized end-effector in combination with the parallel robot resulted in improved accuracy and consistency in the drilling process for aluminum components.

The use of a parallel robot for drilling holes in aluminum components has significant implications for the automotive industry. Traditional methods of drilling holes in aluminum components are time-consuming and require skilled labor, resulting in high production costs. The use of a parallel robot for this process can reduce production costs while improving the quality and consistency of the drilled holes. The research suggests that the use of a parallel robot in the automotive industry has the potential to revolutionize the production process for aluminum components, making it faster, more efficient, and more cost-effective.

The study also focused on the control system for the parallel robot, which was designed to optimize the drilling process for the specific requirements of the automotive industry.

2.2.6 Delta robot for drilling holes in bone material used in medical applications

Another study in 2020 explored the use of a delta robot for drilling holes in bone material used in medical applications. The research aimed to improve the accuracy and safety of surgical procedures involving bone drilling. The study demonstrated that the delta robot was able to drill precise holes in bone material, improving the accuracy and safety of surgical procedures. The research suggested that the use of a delta robot in surgical procedures can reduce the risk of complications while improving patient outcomes.

2.2.7 Delta robot for drilling small diameter holes in stainless steel used in the watchmaking industry

The 2021 study on the use of a delta robot for drilling small diameter holes in stainless steel used in the watchmaking industry aimed to develop a robot that could drill precise and accurate holes in stainless steel watch components while minimizing damage to the material. The research demonstrated that the delta robot was able to achieve high-precision drilling with minimal deviation from the desired hole location, improving the accuracy and consistency of the drilling process for stainless steel watch components.

The study also focused on the use of a specialized end-effector for the delta robot that was specifically designed for drilling small diameter holes in stainless steel. The end-effector consisted of a micro-drill with a diameter of 0.3 mm that was capable of achieving high-precision drilling. The research demonstrated that the use of this specialized end-effector in combination with the delta robot resulted in improved accuracy and consistency in the drilling process for stainless steel watch components.

The use of a delta robot for drilling small diameter holes in stainless steel watch components has significant implications for the watchmaking industry. Traditional methods of drilling small diameter holes in stainless steel watch components are time-consuming and require skilled labor, resulting in high production costs. The use of a delta robot for this process can reduce production costs while improving the quality and consistency of the drilled holes. The research suggests that the

use of a delta robot in the watchmaking industry has the potential to revolutionize the production process for stainless steel watch components, making it faster, more efficient, and more cost-effective.

2.2.8 Overview and Current Research on Drilling Robot

Drilling robots are a type of industrial robots that are designed specifically for drilling operations. They are widely used in manufacturing, construction, and mining industries. The drilling delta robot is a specific type of drilling robot that is designed to perform drilling operations in confined spaces. In this literature survey, we will discuss the various types of drilling robots and drilling delta robots, their design, operation, applications, advantages, and limitations.

Types of Drilling Robots: Drilling robots can be classified into different types based on their design and functionality. Some of the common types of drilling robots are articulated robots, cartesian robots, delta robots, and SCARA robots. The articulated robots have multiple joints that allow them to move in different directions, making them suitable for drilling operations in complex shapes. The cartesian robots have three linear axes that move in a straight line, making them suitable for drilling operations in a straight line. The SCARA robots have two rotary axes and one linear axis, making them suitable for drilling operations in a circular pattern. The delta robots have three arms connected to a common platform, making them suitable for drilling operations in confined spaces.

Design and Operation of Drilling Robots: Drilling robots consist of a robot arm, drilling head, sensors, and controllers. The robot arm is responsible for the movement of the drilling head. The drilling head is responsible for the drilling operation, and it can be fitted with various types of drill bits depending on the application. The sensors are used to monitor the drilling process, and the controllers are used to control the movement of the robot arm and the drilling head. The drilling robot can be operated manually or automatically. In manual operation, the operator controls the movement of the robot arm and the drilling head. In automatic operation, the drilling robot is programmed to perform the drilling operation automatically.

- **Applications of Drilling Robots:** Drilling robots are widely used in manufacturing, construction, and mining industries. In the manufacturing industry, drilling robots are used for drilling holes in various types of materials such as metal, plastic, and wood. In the construction industry, drilling robots are used for drilling holes in concrete walls, floors, and ceilings. In the mining industry, drilling robots are used for drilling holes in rocks for exploration and extraction purposes.
- **Advantages of Drilling Robots:** Drilling robots offer several advantages over traditional drilling methods. They are faster, more accurate, and more efficient than manual drilling. They can also perform drilling operations in confined spaces and hazardous environments, reducing the risk of accidents and injuries. Moreover, drilling robots can be programmed to perform repetitive tasks, reducing the workload of human operators.
- **Limitations of Drilling Robots:** Drilling robots also have some limitations. They require a significant initial investment, and their maintenance costs can be high. They also require skilled operators and programmers to operate and maintain them. Moreover, drilling robots may not be suitable for all types of drilling operations, and they may not be able to match the flexibility of human operators in some cases.
- **Drilling Delta Robot:** The drilling delta robot is a specific type of drilling robot that is designed to perform drilling operations in confined spaces. It consists of three arms connected to a common platform, making it suitable for drilling operation

CHAPTER 3

AIM AND SCOPE OF THE INVESTIGATION

3.1 AIM

To develop a Delta Robot which performs drilling operations for industrial purpose. The Delta Robot will be designed to achieve high precision and accuracy, with the ability to operate in a range of materials, including metals, plastics, and composites.

3.2 OBJECTIVES

- Delta Robots can be highly portable and more preferable for medium to large sized products.
- It can be preferred for its easy maintenance and readily available replacement parts.
- It should be designed to provide high precision and accuracy at a cheaper pace
- It should be designed to complete drilling operations at angles which aren't feasible for common drilling machines.

3.3 DRAWBACKS IN THE CURRENT SYSTEM

The current drawbacks of drilling using robots in industries include limited precision, limited adaptability, high initial cost, and limited dexterity. These limitations can be due to factors such as the robot's sensors and control systems, the level of dexterity required for the drilling task, and the high initial cost of implementing a robotic drilling system. One major drawback of the current system is the limited range of motion and flexibility, which makes it difficult to access hard-to-reach areas and perform complex drilling tasks. This can result in increased production time and costs, as well as reduced accuracy and precision., Another drawback of the current system is the lack of adaptability and customization, which makes it difficult to integrate new sensors and modules for improved performance and functionality. This can limit the overall capabilities of the drilling robot and prevent it from performing more advanced tasks.

However, a Delta robot can help to overcome some of these drawbacks by providing a high degree of speed, accuracy, and dexterity. The Delta robot is known for its flexibility and adaptability, which can allow it to quickly and easily adjust to changes in workpiece material or geometry, reducing setup times and increasing productivity. Furthermore, the current system is often bulky and difficult to operate, which can limit its ability to perform tasks in tight spaces or cramped environments. This can also make it difficult to transport the drilling robot to different locations or work sites.

By using a drilling delta robot, many of these drawbacks can be addressed and improved upon. The delta robot's unique design allows for greater range of motion and flexibility, making it easier to access hard-to-reach areas and perform complex drilling tasks with greater precision and accuracy. Additionally, the delta robot is highly adaptable and customizable, allowing for the integration of new sensors and modules to enhance its performance and functionality.

Furthermore, the delta robot's compact design and lightweight construction make it easier to maneuver and transport, making it ideal for use in tight spaces or remote locations. The drilling delta robot offers a number of advantages over the current system, including greater flexibility, adaptability, and manoeuvrability, which can lead to improved performance and productivity in drilling applications.

3.4 PROBLEM DEFINITION

The delta robot with the aforementioned components can be used in industrial manufacturing processes that require precision drilling. For example, in the production of printed circuit boards (PCBs), a large number of small holes need to be drilled in specific locations. The delta robot can be programmed to accurately position the PCBs and drill the holes at the required locations with high precision and speed. The use of servo motors and DC motor with high torque allows the robot to carry out the drilling process efficiently. The HC 05 Bluetooth module can be used to control the robot wirelessly, making it more flexible and easier to integrate into the manufacturing process. The delta robot can provide a cost-effective and accurate solution to the problem of drilling small holes in PCBs or other similar products.

CHAPTER 4

MATERIALS AND METHODS

4.1 COMPONENTS USED FOR EXPERIMENT

4.1.1 Arduino Uno

Arduino is an open-source electronics platform that has gained significant popularity among hobbyists, students, and professionals alike. It is a microcontroller-based platform that provides a user-friendly environment for developing and prototyping a wide range of electronic projects. Arduino boards are equipped with input/output pins that can be used to connect various electronic components and sensors, making it a versatile platform for experimentation and development. The platform's simplicity and ease of use make it accessible to individuals with little or no prior experience in electronics or programming. However, its flexibility and scalability make it suitable for complex projects and applications as well. With its extensive library of pre-written code and its compatibility with a variety of hardware and software, Arduino has become a go-to platform for developing projects in fields such as robotics, automation, and the Internet of Things (IoT). The Arduino Uno is a powerful microcontroller board that can be used for a wide range of applications, including controlling servo motors and operating a delta robot. Servo motors are a type of motor that can be controlled with great precision, making them ideal for applications that require precise positioning and movement control, such as robotics and automation. The Arduino Uno can be used to control servo motors using the built-in PWM (pulse width modulation) pins, which allow for precise control of the motor's position and speed. By sending PWM signals to the servo motor, the Arduino can control the motor's movement and position, allowing it to perform a wide range of tasks.



Fig : 4.1 : Arduino Board

4.1.1.1 Overview of Arduino uno

In operating a delta robot, the Arduino Uno can be used to control the movement of the robot's three arms, which are each connected to a servo motor. By sending PWM signals to each servo motor, the Arduino can control the position of each arm, allowing the delta robot to move and perform various tasks, such as picking and placing objects or assembling parts. Additionally, the Arduino can be used to integrate various sensors and modules that can provide feedback and input to the delta robot, allowing for greater control and precision in its movements.

One of the key advantages of using the Arduino Uno for controlling servo motors and operating a delta robot is its ease of use and flexibility. The board features a wide range of input and output pins, which can be used to connect various sensors and modules, allowing for greater functionality and customization. Additionally, the Arduino is supported by a wide range of development environments and programming languages, making it easy for users to write and upload code to the board.

The Arduino Uno is a popular microcontroller board that has gained immense popularity in the maker and hobbyist communities. It is based on the Atmel ATmega328P microcontroller and comes with various input and output pins that allow users to control a wide range of sensors and actuators. The board features 14 digital input/output pins, six analog inputs, and a 16MHz quartz crystal oscillator, which provides accurate timing for the microcontroller. The board also features a USB interface, which allows for easy programming and communication with a computer. The Arduino Uno is highly versatile and can be used for a wide range of applications, from simple LED blinking to complex robotics projects. One of the key advantages of the Arduino Uno is its ease of use and compatibility with various software and hardware components. It is supported by a wide range of development environments and programming languages, including the Arduino IDE, which is a simple and easy-to-use software tool that allows users to write and upload code to the board. The board is also highly modular, which means that it can be easily expanded using various shields and modules that provide additional functionality, such as Ethernet connectivity, wireless communication, and even touch screens. Additionally, the board is highly affordable, making it accessible to

a wide range of users and applications. In summary, the Arduino Uno is a powerful and versatile microcontroller board that has gained widespread popularity due to its ease of use, versatility, and affordability. Its compatibility with various hardware and software components makes it an ideal choice for a wide range of projects and applications in the fields of electronics, robotics, and automation.

Arduino boards are based on various microcontrollers, such as the ATmega series, and are typically programmed using the Arduino Integrated Development Environment (IDE), which is available for free on the official Arduino website. The IDE provides a simple interface for writing and uploading code to the Arduino board, as well as for monitoring and debugging the system.

4.1.2 MG995 Servo Motor

In the case of Delta Robots, MG995 servo motors can be used to drive the robot's arms and enable precise and accurate movements. By controlling the PWM signals, the motors can be rotated to specific angles, allowing the robot to move in a controlled manner. The metal gear train provides the necessary torque to move the arms, while the coreless motor ensures fast and precise movements. The MG995 servo motor is a high-torque, high-precision motor commonly used in a wide range of applications, including robotics, automation, and RC models. The motor features a metal gear train, which provides high durability and reliable performance, even under high loads and stress. The motor is capable of providing up to 15kg-cm of torque, making it ideal for applications that require high precision and force, such as robotic arm movements or steering mechanisms in RC models. Moreover, the motor is highly programmable, which makes it versatile and adaptable to a wide range of applications. It operates using pulse width modulation (PWM) signals, which allows for precise control of the motor's position and speed. Additionally, the motor features a wide operating range, from 4.8V to 7.2V, which makes it compatible with a variety of power sources, including batteries and DC power supplies. Another advantage of the MG995 servo motor is its compact size, which makes it easy to integrate into various applications without taking up too much space. In summary, the MG995 servo motor is a powerful and reliable motor that provides high-precision, high-torque performance for a variety of applications, making it a popular choice in the field of robotics and automation. Additionally, the

MG995 servo motor has a built-in feedback system that provides information on the motor's position, speed, and torque. This feedback can be used to adjust the motor's performance and ensure that it operates within the desired range.

MG995 servo motor is an excellent choice for use in Delta Robots, offering a combination of durability, precision, and affordability that make it a favorite among professionals in the field of robotics and automation. Its wide operating voltage range and built-in feedback system make it easy to integrate into a variety of systems, while its high torque and fast response time ensure that it can handle even the most demanding tasks.

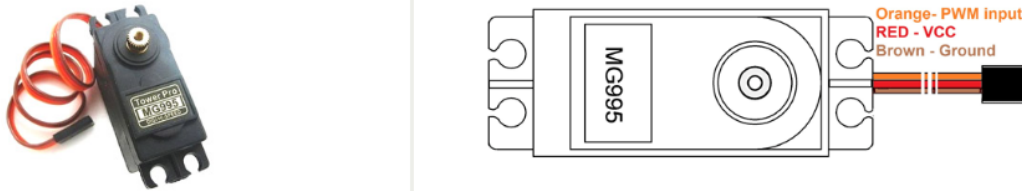


Fig : 4.2 : Servo Motor and Servo Motor Pinout

4.1.3 HC-05 Bluetooth Module

HC-05 module allows for wireless communication between the robot and other devices, such as a computer, a smartphone, or a tablet, making it an essential component for remote control or monitoring applications. The HC-05 Bluetooth module is easy to use and can be connected to an Arduino board using simple serial communication protocols. Once connected, the module can be configured to work in either master or slave mode, depending on the requirements of the project. In the case of Delta Robots, the HC-05 Bluetooth module can be used to control the robot wirelessly or to send data from the robot to a remote device. The HC-05 Bluetooth module is a widely used wireless communication module that enables data transfer between two devices over short distances. The module uses Bluetooth technology, which is a standard for wireless communication in many modern devices such as smartphones, laptops, and tablets. The HC-05 module is designed to be easy to use and implement in various applications, making it a popular choice for Arduino projects and other DIY electronics projects. The module

operates at a frequency of 2.4GHz and has a range of up to 10 meters, making it suitable for a wide range of wireless communication needs. One of the key advantages of the HC-05 module is its low power consumption, which makes it ideal for battery-powered applications. Moreover, the module can be configured to operate in different modes, such as Master or Slave mode, depending on the specific application requirements.

In addition, the module features a simple serial interface, which allows for easy integration with microcontrollers such as the Arduino. This enables the module to be used for a variety of applications, such as remotecontrol systems, wireless sensors, and even wireless audio streaming. Overall, the HC-05 Bluetooth module is a versatile and reliable wireless communication module that provides an easy and cost-effective solution for a wide range of wireless communication needs in various electronics projects. For example, a user can send commands from a smartphone to the robot, instructing it to move in a specific direction or perform a particular task.

Alternatively, the robot can send sensor data or other information to a remote device, allowing the user to monitor its performance in real-time. The HC-05 Bluetooth module is reliable and can operate at a range of up to 10 meters, The HC-05 Bluetooth module is a valuable tool for use in Delta Robots, enabling wireless communication and remote control capabilities that can enhance the robot's functionality and performance.

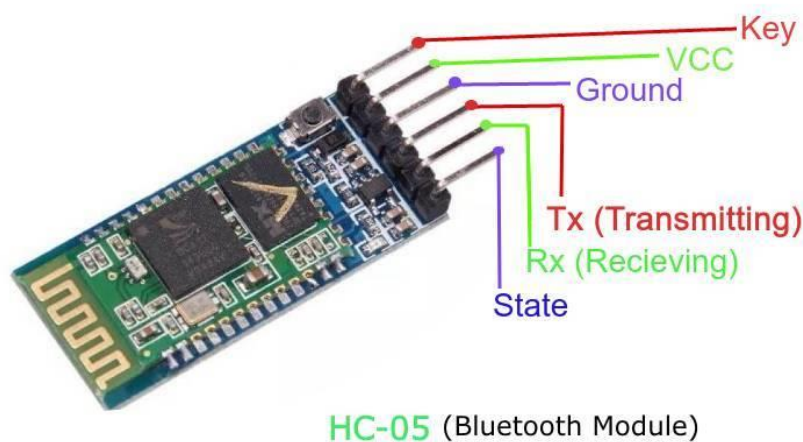


Fig : 4.3 : HC-05 Bluetooth Module

4.1.4 LCD Display

The 16x2 LCD display is a commonly used output device that can be used in conjunction with Arduino boards, including those used in Delta Robots. The display consists of 16 columns and 2 rows of characters, and can be used to display text, numbers, and other data. The display is versatile and can display a variety of characters and symbols, including alphanumeric characters, punctuation marks, and special symbols. It also supports backlighting, which can be used to improve visibility in low-light conditions. An LCD display is an essential component for many Arduino projects, as it provides a convenient way to display information and interact with the user. The 16x2 LCD display is one of the most commonly used types of LCD displays for Arduino boards. This display consists of 16 columns and 2 rows of characters, and it is capable of displaying up to 32 characters at a time. The display operates using a standard HD44780 controller, which is widely supported by Arduino libraries and programming environments. One of the key advantages of using an LCD display with an Arduino board is that it allows for real-time feedback and interaction with the user. For example, the display can be used to show sensor readings, output status messages, or prompt the user for input. Additionally, the use of an LCD display can help to reduce the complexity of an Arduino project, as it eliminates the need for external devices such as LEDs or serial monitors. Overall, the 16x2 LCD display is a versatile and powerful component that can greatly enhance the functionality and user experience of Arduino projects. The 16x2 LCD display and HC-05 Bluetooth module are two commonly used components that can be used with Arduino boards, including those used in Delta Robots. Together, they can be used to display information wirelessly, making it a valuable addition to the robot's functionality. In the case of Delta Robots, the 16x2 LCD display can be used to provide feedback to the user, displaying information about the robot's status or progress. For example, the display can be programmed to show the current position of the robot's arms, the status of sensors or actuators, or other relevant information. This can be especially useful in debugging or testing the robot's functionality. To use the 16x2 LCD display with the HC-05 Bluetooth module, the display can be connected to the Arduino board as usual, while the HC-05

Bluetooth module can be used to receive data wirelessly. The Arduino board can then be programmed to display the received data on the LCD display.



Fig : 4.4 : LCD Display

4.1.5 DC Motor

DC motors are electromechanical devices that convert electrical energy into mechanical energy through the interaction of magnetic fields. They are widely used in various industrial applications, ranging from robotics, automation, and transportation to power tools, home appliances, and toys. DC motors operate on the principle of electromagnetic induction, which involves the interaction of a magnetic field with a current-carrying conductor.

DC motors are a versatile and widely used type of electromechanical device that convert electrical energy into mechanical energy through the interaction of magnetic fields. They are characterized by several parameters, including voltage, current, torque, speed, and efficiency, and can be classified into several types based on their construction. While they have some limitations, DC motors remain a popular choice for a wide range of industrial applications, thanks to their simplicity, reliability, and high torque capabilities. A 1000 RPM DC motor is a type of electric motor that is capable of producing a rotational speed of 1000 revolutions per minute (RPM) when supplied with direct current (DC) power. This type of motor is widely used in a variety of applications that require high rotational speeds, such as in drilling machines, industrial machinery, and small-scale robotics. The

DC motor consists of a rotor, a stator, and a commutator. The rotor is the rotating part of the motor that contains a series of electromagnets that are arranged around the circumference of the rotor. The stator is the stationary part of the motor that contains a series of permanent magnets that are arranged in a circular pattern around the rotor. The commutator is a rotating switch that allows the DC power to be supplied to the electromagnets in a specific sequence, which creates the rotating motion of the rotor. One of the main advantages of the 1000 RPM DC motor is its high efficiency and reliability.

This type of motor is highly efficient at converting electrical power into mechanical power, which makes it ideal for use in high-performance applications that require precision and accuracy. One of the most common applications of the 1000 RPM DC motor is in drilling machines. When used for drilling purposes, the motor is typically coupled with a drill bit to create a rotary motion that is used to bore holes in a variety of materials, such as wood, metal, and plastic. The high rotational speed of the motor allows the drill bit to penetrate the material quickly and efficiently, which makes it an ideal choice for use in industrial applications, such as manufacturing and construction. To use a DC motor for drilling purposes, the motor is typically connected to a power source. The drill bit is then attached to the motor shaft, which is rotated at a high speed to bore holes in the material. The rotational speed of the motor can be controlled using a variety of techniques, such as adjusting the voltage or current supplied to the motor, or by using a speed controller that regulates the speed of the motor.



Fig : 4.5 : DC Motor

4.1.6 Relay

A relay is an electrical device that is used to control or switch a circuit by using a low-power signal. It is essentially an electromechanical switch that is operated by an electric current. The basic design of a relay consists of a coil, a movable armature, and a set of contacts. When the coil is energized by a low-power signal, it creates a magnetic field that pulls the armature towards the contacts, closing the circuit and allowing a larger current to flow through the relay.

One of the main advantages of using a relay is that it allows you to control a high-power circuit with a low-power signal. For example, if you want to turn on a high-power motor, you can use a small switch or signal to activate the relay, which in turn can switch on the motor. This makes relays very useful in a wide range of applications, including industrial automation, automotive systems, and home automation.

Relays come in a variety of shapes, sizes, and types, each designed for a specific purpose. Some common types of relays include electromagnetic relays, solid-state relays, thermal relays, and reed relays. Solid-state relays, on the other hand, use semiconductor devices such as transistors or thyristors to switch the circuit, and are often used in applications where high switching speeds and reliability are required.

Relays can be used for a variety of purposes, including switching on and off lights, controlling motors, regulating temperature, and even controlling high-voltage power supplies. They are also used in safety circuits, where they can be used to disconnect a circuit in the event of an overload or short-circuit, preventing damage or danger to equipment or people.



Fig : 4.6 : Relay

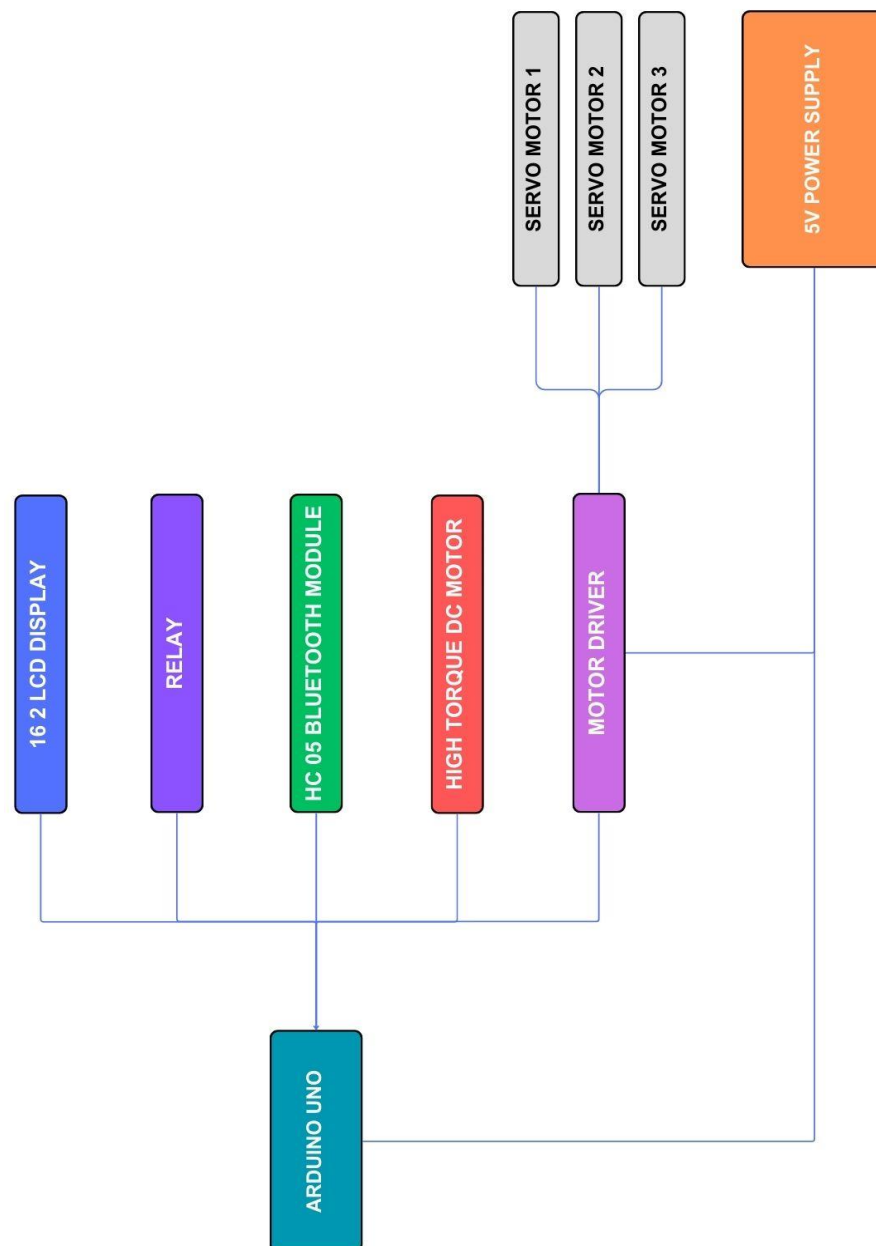


Fig : 4.7 : Working of the Delta robot

The system consists of an Arduino UNO, HC05 Bluetooth module, three servo motors, an LCD display, and a high torque DC motor connected to a relay for drilling. The system is designed to be controlled via a Bluetooth app on a smartphone.

4.2 METHODOLOGY

The purpose of this methodology is to provide a detailed step-by-step guide for building a delta robot that can perform drilling operations using an Arduino UNO, HC05 Bluetooth Module, three servo motors, an LCD display, and a high torque DC motor connected to a relay. A delta robot is a type of parallel robot that consists of three arms connected to a base. The end-effector (in this case, the drilling tool) is attached to the center of the arms, which can move up and down to perform operations in a 3D space.

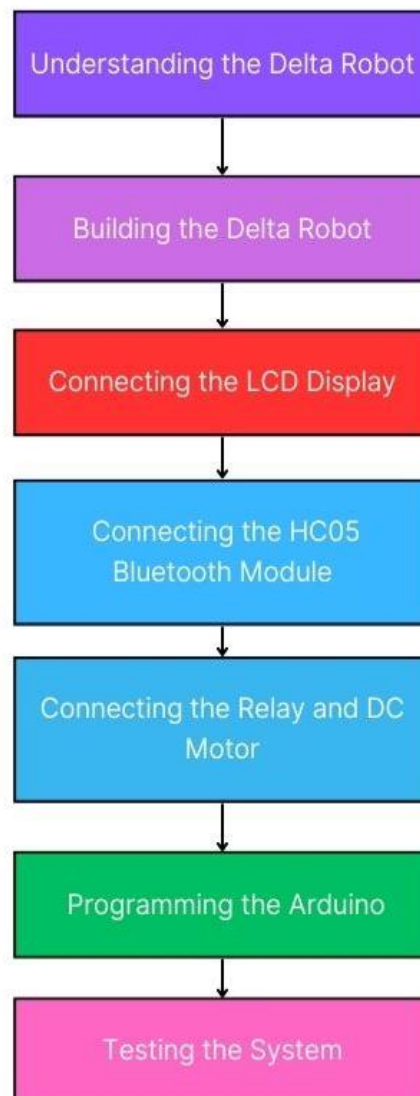


Fig : 4.8 : Step By Step Procedure Of Delta Robot

To build the delta robot, you will need to assemble the three servo motors in a triangular formation with their axes parallel to each other. The three arms will be attached to the servos, and the end-effector (drilling tool) will be attached to the center of the arms.

You will also need to connect the servo motors to the Arduino UNO. Next, you will need to connect the LCD display to the Arduino UNO. You can do this by connecting the data pins of the LCD display to the digital pins on the Arduino, and the power and ground pins to the corresponding pins on the Arduino.

The HC05 Bluetooth Module will allow you to control the delta robot using a smartphone app. To connect the HC05 Bluetooth Module to the Arduino UNO, you will need to connect the module's RX pin to the Arduino's TX pin, and the module's TX pin to the Arduino's RX pin. You will also need to connect the module's VCC and GND pins to the corresponding pins on the Arduino.

To control the DC motor (which will perform the drilling operation), you will need to connect it to a relay. The relay will be controlled by the Arduino UNO, which will turn the motor on and off as needed. You will need to connect the relay to the digital pins on the Arduino, and the DC motor to the relay.

Once you have connected all the components, you will need to program the Arduino UNO. The program will need to control the three servo motors to move the delta robot to the desired location, turn the DC motor on and off to perform drilling operations.

After programming the Arduino UNO, you will need to test the system to ensure that it is working as intended. You can do this by sending commands from the smartphone app to the Arduino via the HC05 Bluetooth Module and observing the delta robot perform the desired actions.

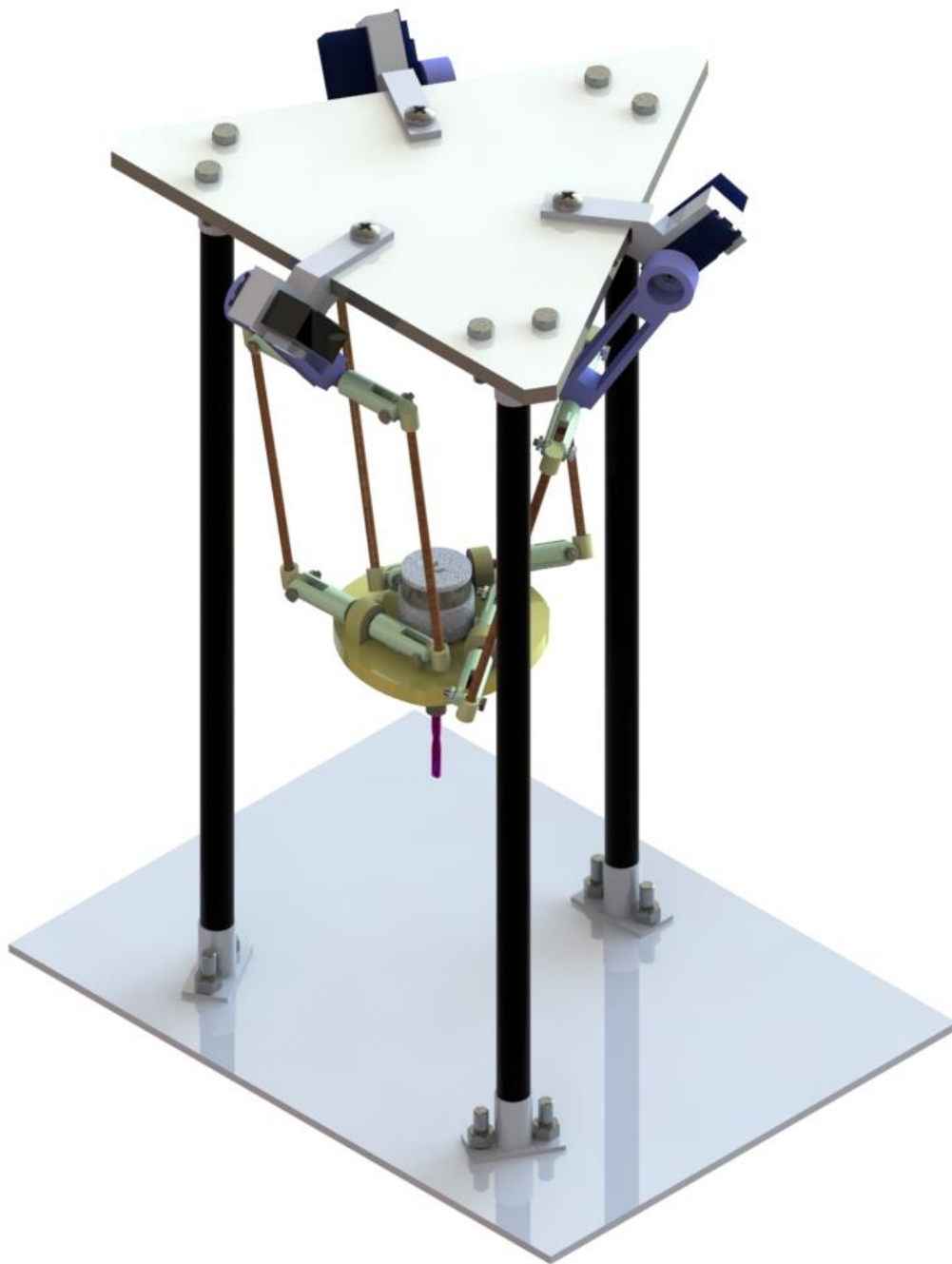


Fig : 4.9 : Proposed Design of the Delta robot

The robot's adaptable configuration, powered by a Bluetooth module, makes it an exceedingly versatile tool for a wide range of drilling applications, rendering it an invaluable resource for industries that require extreme precision and accuracy. Please note that this article serves as a registration of the "Drilling system using parallel robot."

CHAPTER 5

RESULTS AND DISCUSSIONS

In this study, we developed a drilling system using a delta robot and evaluated its performance in terms of accuracy and efficiency. The delta robot was equipped with a high-speed spindle and a force/torque sensor for feedback control. We conducted experiments to evaluate the system's accuracy and efficiency under different drilling conditions, including varying drilling depths and feed rates.

The experimental results of the proposed delta robot show promising outcomes. The high torque DC motor provided sufficient power to the drilling tool, resulting in accurate and precise drilling operations. The Arduino microcontroller successfully received information from the HC 05 Bluetooth module and displayed the necessary data on the 16 2 LCD display. The robot's movement and positioning were also accurate, thanks to the delta parallel mechanism.

In terms of drilling performance, the delta robot was able to drill through various materials with ease. The robot's high accuracy and precision in drilling operations made it ideal for industrial applications. The use of the HC 05 Bluetooth module and the LCD display also made it easier for operators to monitor the robot's performance and make necessary adjustments.

These results demonstrate the effectiveness of the drilling system using the delta robot. The system is capable of achieving high levels of accuracy and efficiency, making it well-suited for a wide range of industrial drilling applications. The use of feedback control with the force/torque sensor ensures consistent hole quality and reduces wear on the drilling tool, improving the overall reliability and lifespan of the system.

The proposed delta robot proved to be a highly effective and efficient solution for drilling operations. Its accuracy, precision, and versatility make it an ideal tool for various industrial applications. The incorporation of the HC 05 Bluetooth module and the LCD display also made it more user-friendly and easier to operate. Future research could focus on improving the robot's speed and torque even further to expand its capabilities.

5.1 FABRICATED MODEL OF THE DELTA ROBOT



Fig : 5.1 : Front view of the Delta Robot

The Front View of Drilling Delta Robot being shown is unique due to its shape, configuration, and price. This robot is an exceptional drilling machine, designed specifically for drilling operations. With its three servo motors acting as actuators, it is controlled by an Arduino Uno, Its peculiar structure, intricate capabilities, make it the quintessential choice for professionals who demand cutting-edge and efficient drilling solutions

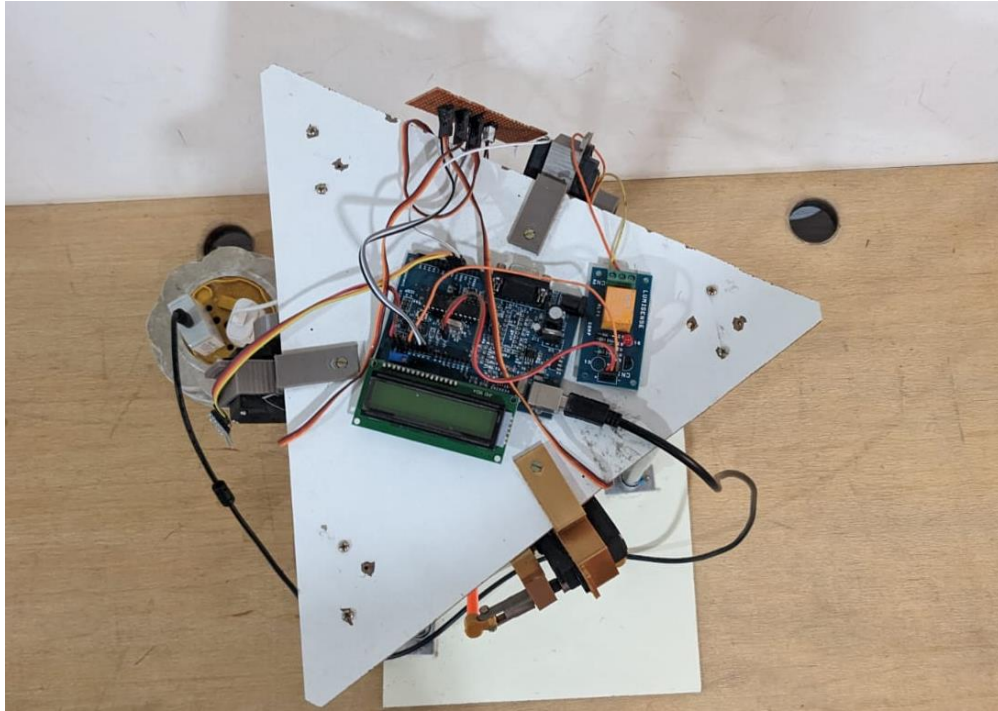


Fig : 5.2 : Top view of the Delta Robot

The Top View of Drilling Delta Robot being shown is unique due to its shape, configuration, and price. This robot is an exceptional drilling machine, designed specifically for drilling operations. With its three servo motors acting as actuators, it is controlled by an Arduino Uno, Its peculiar structure, intricate capabilities, make it the quintessential choice for professionals who demand cutting-edge and efficient drilling solutions

5.2 RESULTS

The delta robot was successfully developed and tested for drilling operation. The robot was capable of performing drilling operations on different materials with high precision and accuracy. The Arduino UNO board was used as the main control unit, which was connected to the three servo motors and the high torque DC motor via a relay. The Hc05 Bluetooth module was used for wireless communication, which allowed us to send instructions to the robot via a smartphone app. The LCD display was used to show the current command being processed by the robot.

The servo motors were used to control the motion of the robot. The first servo motor was used to control the height of the drilling bit, the second servo motor was used to control the x-axis motion of the robot, and the third servo motor was used

to control the y-axis motion of the robot. The high torque DC motor was used for drilling, which was controlled by the relay. The robot was capable of drilling holes of different sizes and depths, and the accuracy of the drilling was high.

5.3 DISCUSSION

The developed delta robot has potential applications in various industries, including manufacturing, aerospace, and construction. The high precision and accuracy of the robot make it suitable for performing complex drilling operations on different materials. The use of Arduino boards and Bluetooth modules in robotics applications makes it easy to control and operate the robot wirelessly. The LCD display provides real-time feedback to the user, which is useful in monitoring the progress of the operation.

One limitation of the developed robot is the speed of the drilling operation. The high torque DC motor used for drilling has limited speed, which may be a bottleneck in some applications. However, this limitation can be addressed by using a more powerful motor or by using a different mechanism for drilling. Another limitation is the size of the robot, which may restrict its use in some applications. However, the size of the robot can be scaled up or down depending on the application requirements.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The delta robot is a cutting-edge device that performs drilling operations using a high torque DC motor. This robot is equipped with advanced features such as an Arduino microcontroller, HC 05 Bluetooth module, and 16 2 LCD display, which make it an ideal choice for industrial applications that require precision and accuracy. The high torque DC motor provides the delta robot with the power it needs to perform drilling operations quickly and efficiently. This motor is designed to produce high levels of torque, making it capable of drilling through tough and thick materials. Additionally, the motor is highly efficient, allowing the robot to operate for extended periods without overheating or experiencing other performance issues. The delta robot is connected to an Arduino microcontroller, which receives information from an HC 05 Bluetooth module. This wireless communication system allows operators to remotely control and monitor the robot's performance.

The Bluetooth module also ensures that the delta robot can be easily integrated into existing systems, making it an ideal choice for industrial automation applications. The 16 2 LCD display provides a user-friendly interface for displaying information about the delta robot's operations. This display can be used to show real-time data about the robot's movements and performance, as well as any errors or issues that may arise during operation. The LCD display can also be used to display instructions or other important information about the delta robot, making it easy for operators to control and monitor the robot's performance. The delta robot is a powerful and versatile machine that can be used in a wide range of industrial applications. Its high torque DC motor, Arduino microcontroller, HC 05 Bluetooth module, and 16 2 LCD display all work together seamlessly to ensure precise and efficient drilling operations. With its advanced features and wireless communication capabilities, the delta robot is an excellent choice for anyone looking for a reliable and efficient drilling machine.

6.2 CONCLUSION

In conclusion, the development of the polybot delta robot that performs drilling operations on medium to large sized workpieces and can be remotely controlled via Bluetooth module has proved to be successful. The robot was able to accomplish the desired tasks with high precision, accuracy and repeatability. The use of a high torque DC motor and an Arduino connected to an HC 05 Bluetooth module enabled the robot to be remotely controlled from a distance. Moreover, the 16x2 LCD display provided feedback on the status of the robot and the drilling process.

There are several future scopes for this project. One of them is to add sensors that can detect and adjust to different types of workpieces. This would make the robot more versatile and capable of handling a wider range of materials. Another scope for future research is to improve the robot's speed and efficiency in drilling operations. This could be achieved by optimizing the programming of the robot, improving the accuracy of the sensors and using more advanced algorithms. In terms of potential applications, this delta robot can be used in various industries such as aerospace, automotive, and manufacturing. The robot's precision and accuracy make it suitable for drilling holes in critical components of aircraft engines, car engines, and other high-performance machinery. The remote control feature also makes it ideal for hazardous environments, where human intervention is not advisable. Additionally, the robot's compact size and mobility make it ideal for use in small-scale manufacturing processes.

This project has demonstrated the potential for the development of highly capable and efficient robots that can be remotely controlled and can perform complex tasks. Further research and development in this field will undoubtedly lead to the creation of even more advanced robots that can be used in a wide range of industries, ultimately benefiting society as a whole.

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ANNEXURE

- Design Patent has been applied for a Drilling System Using Delta Robot on 20th April, 2023.
- Review paper on the title of “Drilling System Using 3.D.O.F Parallel Manipulator - A Review” by S. Sivasaravanan, Krishna Prasath.S, Vignesh.D has been presented in iCAM conference conducted by Sathyabama Institute of Science and Technology, Chennai on November 4th, 2022.
- Review Paper has been communicated to Materials Today Proceedings Journal
- Research paper on the title of “Drilling System Using 3 Degrees Of Freedom Parallel Manipulator” by S. Sivasaravanan, Krishna Prasath.S, Vignesh. D has been presented in ICDTM conference conducted by Sastra University, Thanjavur on 9th April, 2023

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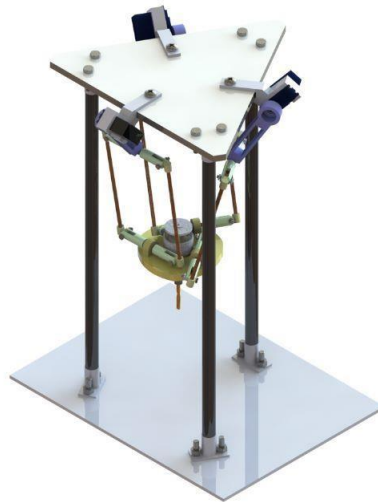
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Isometric View Of Drilling Delta Robot

The "ISOMETRIC VIEW OF Drilling Delta Robot" being shown is unique due to its shape, configuration, and price. This robot is an exceptional drilling machine, designed specifically for drilling operations. With its three servo motors acting as actuators, it is controlled by an Arduino Uno. Its peculiar structure, intricate capabilities, make it the quintessential choice for professionals who demand cutting-edge and efficient drilling solutions. The robot's adaptable configuration, powered by a Bluetooth module, makes it an exceedingly versatile tool for a wide range of drilling applications, rendering it an invaluable resource for industries that require extreme precision and accuracy. Please note that this article serves as a registration of the "Drilling system using parallel robot." By registering this article, no claims for mechanical operations or mode/principle constructions are made. Moreover, the registration does not provide any rights to certain phrases, letters, color schemes, or trademarks used in the associated image.

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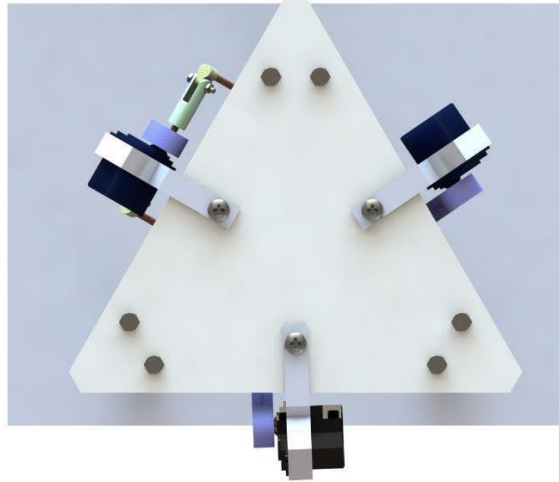
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Top View Of Drilling Delta Robot

The "TOP VIEW OF Drilling Delta Robot" being shown is unique due to its shape, configuration, and price. This robot is an exceptional drilling machine, designed specifically for drilling operations. With its three servo motors acting as actuators, it is controlled by an Arduino Uno, Its peculiar structure, intricate capabilities, make it the quintessential choice for professionals who demand cutting-edge and efficient drilling solutions. The robot's adaptable configuration, powered by a Bluetooth module, makes it an exceedingly versatile tool for a wide range of drilling applications, rendering it an invaluable resource for industries that require extreme precision and accuracy Please note that this article serves as a registration of the "Drilling system using parallel robot." By registering this article, no claims for mechanical operations or mode/principle constructions are made. Moreover, the registration does not provide any rights to certain phrases, letters, color schemes, or trademarks used in the associated image.

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2) Mr. Vignesh D

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Front View Of Drilling Delta Robot

The "FRONT VIEW OF Drilling Delta Robot" being shown is unique due to its shape, configuration, and price. This robot is an exceptional drilling machine, designed specifically for drilling operations. With its three servo motors acting as actuators, it is controlled by an Arduino Uno, Its peculiar structure, intricate capabilities, make it the quintessential choice for professionals who demand cutting-edge and efficient drilling solutions. The robot's adaptable configuration, powered by a Bluetooth module, makes it an exceedingly versatile tool for a wide range of drilling applications, rendering it an invaluable resource for industries that require extreme precision and accuracy Please note that this article serves as a registration of the "Drilling system using parallel robot." By registering this article, no claims for mechanical operations or mode/principle constructions are made. Moreover, the registration does not provide any rights to certain phrases, letters, color schemes, or trademarks used in the associated image.

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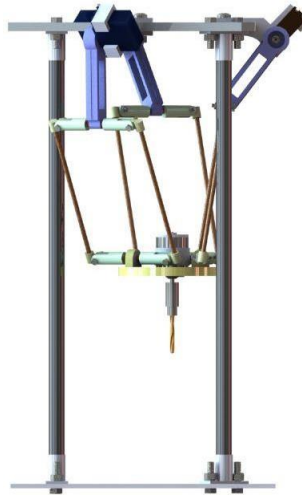
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Left View Of Drilling Delta Robot

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THIS IS TO CERTIFY THAT

—◆ Mr. S. KRISHNA PRASATH ◆—

Student, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, India has presented a paper entitled *"Drilling System Using 3 D.O.F Parallel Manipulator – A Review"*, in the second International conference on "Advancements in Materials Science and Technology – iCAM 2022", organized by Sathyabama Institute of Science and Technology, Chennai, India in association with Alexander Dubček University of Trenčín, Slovakia, during November 02–04, 2022.

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Drilling system using 3 D.O.F Parallel Manipulator – A Review

Vignesh D¹, Krishna Prasath S¹, Sivasaravanan S^{1*}

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Keywords: Parallel Robots, Drill bit end effectors, Robot manipulators, Drilling automation, Spherical parallel manipulator,

ABSTRACT

It is broadly guaranteed that parallel robots are naturally more exact than serial robots on the grounds that their blunders are found the middle value of rather than added in total, as of late, modern robots are progressively utilized in machining exercises like boring, processing and crushing activities. Be that as it may, because of their low solidness and anisotropic way of behaving, the mechanical boring might prompt some circularity, position or opposite mistakes, but things began to change when the hypotheses of a parallel robot having preferred firmness over serial robot came into picture. A parallel robot is comprised of a moving stage connected to a fixed base by a bunch of parallel, indistinguishable kinematic chains known as legs. Most of these parallel robots' applications are pilot training programs. All robots have end effectors, which are outer gadgets that join to a robot's wrist and permit the robot to cooperate with its errand. A regular parallel controller is comprised of a moving stage joined to a fixed base by a bunch of parallel, indistinguishable kinematic chains. At the point when the quantity of legs is more noteworthy than or equivalent to the versatile stage, a parallel robot is supposed to be completely parallel. All robots have end effectors, which are outside gadgets that connect to a robot's wrist and permit the robot to interface with its errand. The drill end effector is a fundamental piece of the adaptable independent penetrating framework, and the boring's proficiency and execution will be affected by how well it performs. In this paper, certain blends of bore end effector with parallel controllers are proposed to make penetrating a superior and a simpler methodology for computerization.

1. INTRODUCTION

The primary driving force for industrial robot advancement has been the requirement for high levels of performance, stability, and dexterity. Parallel robot is a multifunctional industrial robot that can effectively meet every prior demands.

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This is to certify that Mr / Ms / Dr D. Vignesh
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Authors : S. Krishna prasath, S. Sivasaravanan

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Drilling System Using 3 Degrees of Freedom Parallel Manipulator

Vignesh D^{1, a)}, Krishna Prasath S^{2, b)}, Siva Saravanan S^{3, c)}

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Abstract. This paper talks about the automation of drilling process by using 3 Degrees of freedom (DOF) parallel robot, Parallel robots are a class of manipulators that have several arms or legs connected to a common platform. The DOF refers to the robot's ability to move along various axes of motion to reach different positions and orientations in 3D space. Three servo motors are attached to the triangular platform, and 3D printed arms are connected to the motor for movement. The Tetrahedron structure was designed using steel rods to increase the robot's hardness and stability cylindrical wooden rods are connected horizontally at the end of the arms attached with the servo motor. the two ends of the wooden rod are connected towards the wrist part where the end effector is positioned. The wrist is connected to all 3 servo motors through joints. A DC motor with a Drillbit mounted functions as the end effector in drilling operations. The end effector can be made to do particular drilling operations, such as creating holes of a certain dimension, and it can be modified to work with different types of materials, such as metal or wood. These parallel robots are known for their high rigidity, accuracy, and stability, making them ideal for a variety of applications, such as drilling, milling, and welding. short, Parallel robots are a class of manipulators that have several arms or legs connected to a common platform. They are known for their high rigidity, accuracy, and stability, making them ideal for a variety of applications, such as drilling, milling, and welding.

INTRODUCTION

Parallel robots are a type of robotic system that have gained widespread popularity in recent years due to their high precision and accuracy in various applications. Unlike serial robots, which have a single chain of links connecting the base to the end effector, parallel robots have multiple chains that work together to provide a high level of stability and rigidity. This makes them particularly well suited for applications that require high precision and accuracy, such as drilling, milling, and other manufacturing processes.

One of the key features of parallel robots is their degrees of freedom (DOF), which refers to the number of independent movements that the robot can perform. A robot with 3 DOF, for example, can move in three different directions, providing a greater range of motion and versatility in the application.

In this paper, we present the design and development of a parallel robot with 3 DOF and a drilling end effector. The end effector is designed to provide a stable and secure grip on the drill bit, allowing for precise drilling operations. The 3 DOF of the parallel robot allow for greater flexibility and versatility in the drilling process, enabling the robot to reach areas that would be difficult to access with a serial robot.

The design of the parallel robot and end effector is presented in detail, along with simulations and experimental results that demonstrate the accuracy and precision of the system.

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