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Ministry of Higher Education and
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Multi form Automation Production Line.

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A graduation project document submitted to the department of Mechatronics in partial fulfillment to the requirements for Bachelor Degree in Engineering.

2024

Abstract

The Multi form Automation Production Line project aims to develop a flexible automated production system capable of handling products of various shapes and sizes. The system consists of an automatic loading unit, a multifunctional processing unit, an inspection and evaluation unit, and a discharge and packaging unit. The project aims to improve production efficiency, reduce costs, and enhance product quality through precise automated control. The methodology includes requirements analysis, system design, software development, system testing, and implementation and evaluation in a real production environment. The system will improve production efficiency by up to 30%, reduce waste, and increase the flexibility of handling diverse products, thereby enhancing the competitiveness of companies.

Authorization

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Dedication

With all love and gratitude, I dedicate this to my dear family, my parents, and everyone who stood by us. Thank you for your continuous support and encouragement.

A special and heartfelt thank you to our department head and supervisor
Dr. Radwan Al-Bouthigy, **Dr. Farouk Al-Fahidi**
and **Eng. Hajer Al-Makaleh**
who provided us with all their efforts and stood by us to lend a helping hand.

This achievement is the fruit of your efforts and sacrifices. You have my utmost love and appreciation.

Acknowledgment

Dear **Dr. Radwan Al-Bouthigy,**

We would like to express our deepest gratitude and appreciation for your support and valuable guidance throughout the completion of this project.

You have always been a source of inspiration and motivation, never hesitating to give us your time and effort to help us achieve our goals.

Your invaluable advice and precise feedback have significantly improved the quality of our work and ensured the success of the project. We cannot forget your continuous support and encouragement, which have given us confidence in ourselves and our abilities.

This achievement would not have been possible without your wise guidance and insightful directions. We thank you from the bottom of our hearts.

With sincere thanks and appreciation.

Supervisor Certification

I hereby affirm that I have thoroughly reviewed the project entitled "Multi form Automation Production Line"

was mad under my supervision at the Mechatronics department as partial fulfillment of the requirements of bachelor's degree in Engineering.

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List of Appendices

List of Contents

List of figures

List of Tables

Chapter 1

Introduction

Chapter 1: Introduction

1.1 Introduction

In the modern industrial world, automation plays a pivotal role in enhancing efficiency, quality, and reducing costs. The "Multiform Automation Production Line" project aims to design and develop a production line capable of handling a variety of products through integrated automated systems.

1.2 Project Objectives

The primary objective of this project is to create a production line that can quickly adapt to changes in product types without significant modifications to equipment or extended production downtime. This adaptability will result in high flexibility and operational efficiency, thus increasing the competitiveness of manufacturing companies.

1.3 Components of the Production Line

1. Central Control Systems: Utilize PLC (Programmable Logic Controllers) technology to program and manage various operations.
2. Sensors: Monitor quality and detect defects in products.
3. Automated Transport System: Includes conveyors and moving platforms to direct products between different workstations.

1.4 Advantages

1. High Flexibility: Ability to adapt to a wide range of products without major changes to the line.
2. Increased Productivity: Accelerate manufacturing processes and reduce downtime.
3. Improved Quality: Use sensors and automated vision systems to ensure the quality of the final product.
4. Lower Costs: Reduce the need for human labor and minimize human errors.

1.5 Challenges

1. Initial Cost: Investment in advanced technology can be expensive.
2. Training: Need to train employees on how to use the new systems.

3. Maintenance: Automated lines require regular maintenance to maintain their efficiency.

1.6 Future Prospects

- The project is not just about immediate gains in productivity and quality; it also sets the stage for future advancements. With ongoing technological improvements, the production line can be further enhanced with features such as:

1. Artificial Intelligence Integration: Implementing AI for predictive maintenance, quality control, and process optimization.
2. Internet of Things (IoT): Connecting all components of the production line to a network for real-time monitoring and data analytics.
3. Advanced Robotics: Utilizing collaborative robots (cobots) that can work alongside human operators to increase efficiency and safety.
4. Sustainability: Integrating eco-friendly practices and materials to reduce the environmental impact of manufacturing processes.

1.7 Problem Statement

"With the increasing demand for diverse products in the market, companies face significant challenges in achieving efficiency and flexibility in their production lines. Traditional production lines require frequent setup and reconfiguration to meet changing production needs, leading to reduced productivity and increased costs. Therefore, there is a need to develop a multi-form automated production line capable of handling a variety of products efficiently and effectively, while reducing costs and enhancing the speed of adaptation to demand changes."

1.8 Motivation

"The motivation for the 'Multi-form Automation Production Line' project arises from the increasing need to meet diverse market demands in an efficient and flexible manner. As companies face growing challenges in balancing efficiency and cost, developing a production system capable of easily switching between multiple products without costly reconfigurations is crucial. The project aims to enhance companies' competitiveness by improving productivity, reducing costs, and increasing the speed of adaptation to demand changes. This technological advancement can contribute to achieving new levels of innovation and flexibility in manufacturing, supporting sustainable success in a dynamic market environment."

1.9 Contributions

- "Contributions of the 'Multi-form Automation Production Line'

project include:

1. Increased Efficiency: Streamlining production processes to handle various product types with minimal downtime, thus enhancing overall production efficiency.
2. Cost Reduction: Lowering the costs associated with frequent reconfigurations and setups by automating product changes, leading to significant savings in labor and material costs.
3. Enhanced Flexibility: Providing the capability to quickly adapt to changing market demands and product variations, allowing manufacturers to respond more effectively to customer needs.
4. Improved Productivity: Enabling continuous operation with minimal manual intervention, thereby increasing throughput and reducing production lead times.
5. Innovation in Manufacturing: Introducing advanced automation technologies that push the boundaries of current manufacturing practices, setting a new standard for flexible production lines.
6. Sustainability: Reducing waste and resource consumption by optimizing production processes and minimizing the need for manual adjustments and reconfigurations."

1.10 Project Methodology

1. Planning and Analysis Phase:

- Objective Definition: Establish the main goal of the project, such as improving
productivity, reducing errors, and lowering costs.

- Requirement Gathering: Engage with stakeholders to identify the technical and functional requirements of the automated production line.

- Feasibility Study: Analyze the economic and technical feasibility of the project, including the study of costs and expected returns.

2. Design Phase:

- System Design: Develop a detailed design of the system, including the layout of hardware and software components that will be used.

- Process Design: Create a concept for each stage of production and determine how each process will be automated using machines and software.

- Drawing Schematics: Use CAD tools and/or other modeling software to create clear and detailed schematics of the production line.

3. Implementation and Development Phase:

- Component Selection: Identify and purchase the necessary components, such as robots, controllers, sensors, and other parts.

- Software Development: Program the systems that will control the production line, including the development of user interfaces and software responsible for operating the equipment.

- Testing and Integration: Test each component individually, then assemble and test the complete system to ensure that all components work together seamlessly.

4. Testing and Evaluation Phase:

- Performance Testing: Measure the performance of the automated production line against predefined benchmarks.
- Adjustment and Improvement: Make necessary improvements based on test results to ensure optimal performance.

5. Documentation and Delivery Phase:

- Project Documentation: Prepare comprehensive reports detailing every aspect of the project, including design, programming, and testing.
- Training and Handover: Train the team responsible for managing and operating the production line and hand over the complete system.

6. Maintenance and Continuous Improvement Phase:

- Routine Maintenance: Develop a maintenance plan for both hardware and software to ensure the continuous operation of the production line without issues.
- Data Analysis: Collect and analyze data from the system to continuously improve and enhance its efficiency.

1.11 Conclusion

The "Multiform Automation Production Line" project represents a significant step toward the future of smart manufacturing, enabling factories to achieve high flexibility and operational efficiency through comprehensive automation. This project opens new horizons for improving production processes and increasing competitiveness in global markets. By embracing future technologies and sustainable practices, the project not only addresses current industrial needs but also paves the way for long-term growth and innovation.

1.12 Time Line Plan

. First Semester:

Month	Week	Activity
September	*1*	*Project selection and effectiveness evaluation*
September	*2*	*Create an initial prototype or mockup of the project idea*
September	*3*	*Presenting the project to the department committee and selecting a supervisor*
September	4	Prepare a detailed implementation plan for the project and distribute tasks among the team members
October	5	Gather relevant data and information related to the project
October	6	Determine the specific requirement and constraints of the project
October	7	Conduct a literature review to identify and analyze previous studies and projects related to the current project
October	8	Develop the scientific background and theoretical foundation for the project
November	9	Establish the design requirement and desired characteristic of the project
November	10	Organize and prepare the initial documentation for the previous stages of the project
November	11	Develop the initial project seminar
November	12	Present the seminar and submit the initial project documentation

- **Second Semester :**

Month	Week	Activity
May	**1**	**Conduct the manual production process for the final project, including inspection and testing**
May	**2**	**Determine the hardware components, software, and technologies to be used in the project**
May	**3**	**Perform a financial feasibility and cost evaluation for the project equipment**
June	**4**	**Represent the system using design and simulation software**
June	**5**	**Carry out necessary modifications to the project based on the simulation results**
June	**6**	**Design the initial system interfaces and ensure their integration with overall system**
July	**7**	**Design the exterior structure and mechanical components of the system**
July	**8**	**Perform electrical tests and prepare appropriate protection methods**
July	**9**	**Connect the electrical and mechanical systems with system interfaces**
August	**10**	**Carry out the final modification and adjustment to the project**
August	**11**	**Conduct the final testing and evaluation of the completed product**
August	**12**	**Finalize and reviewing the documentation for all the previous stages of the project**

Chapter 2

Background and Literature Review

Chapter 2: Background and Literature Review

2.1 Background

- With the rapid industrial development, automating production lines has become a critical factor in achieving competitive excellence among companies. Automation technologies enable factories to enhance production efficiency, reduce costs, and ensure product quality, especially amidst continuous demand fluctuations and the variety of products required in the market.

- Despite significant advancements in automation technologies, many traditional production lines still lack the flexibility needed to handle multiple products on the same line. The core issue is that traditional lines are often designed to produce only one type of product or a limited range of models, which limits their ability to adapt to rapid market changes.

- As demand for product customization and variety increases, developing manufacturing solutions capable of handling this diversity has become essential. Hence, the concept of "Multi Form Automation Production Line" has emerged, aiming to design and implement production lines that can manufacture multiple different models on the same line without major stops or drastic changes in infrastructure.

- This idea relies on integrating advanced technologies such as industrial robots, digital control systems, and computer vision systems, creating a flexible production line that can adapt to a wide range of production specifications. This type of line provides the capability to quickly and efficiently produce small batches of customized products, giving companies a significant competitive edge.

2.2 Literature Review

- **Development of Production Line Automation**

The concept of automating production lines emerged in the early 20th century, with developments in the automotive industry. The initial systems relied heavily on electromechanical control, which later evolved into electronic and digital control systems. Traditional production lines were characterized by rigidity and inflexibility, making them incapable of adapting to rapid changes in demand or product types.

- **Modern Control Systems**

With the advent of microcontrollers and Programmable Logic Controllers (PLCs), production lines have become more flexible and adjustable. These systems provide high adaptability to changes in product design, making it possible for production lines to produce multiple models on the same line without requiring significant changes in infrastructure.

2.2.1 Packing Machine

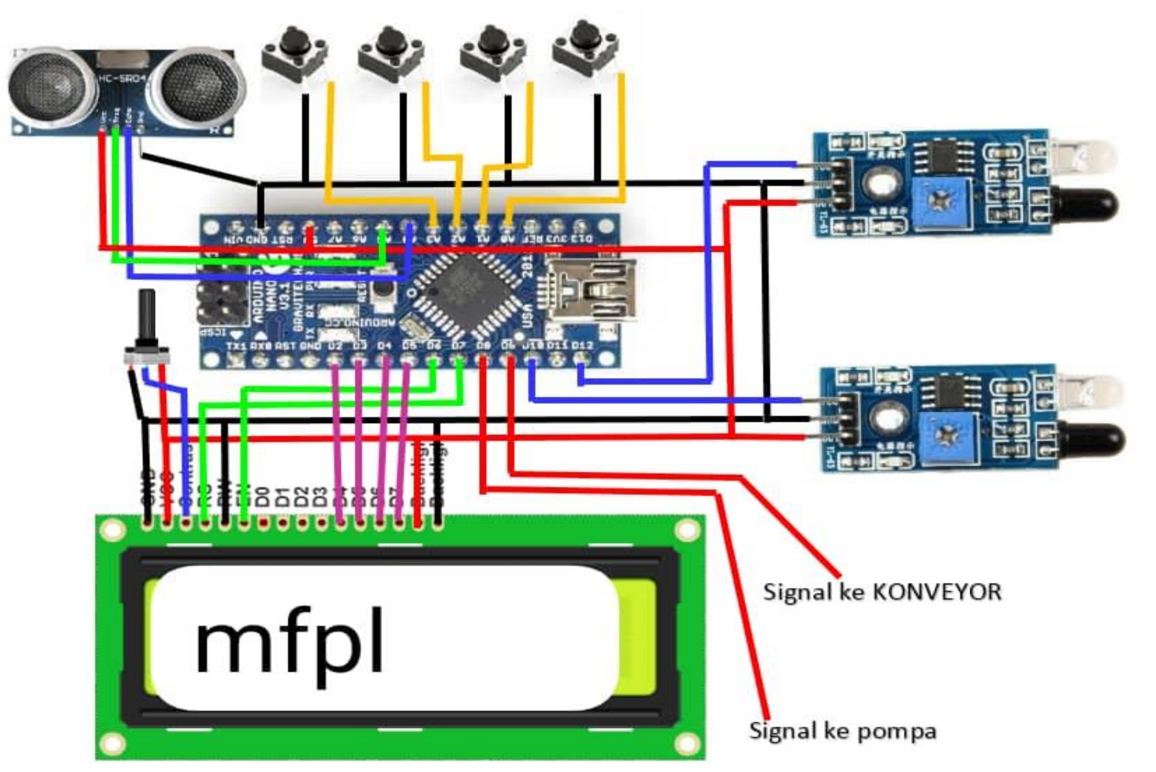

Figure 2.1 The Electronic Circuit of the Filling Machine.

Figure 2.2 Prototype of the Filling Machine.

1. Feeding and Guiding

- Components: Feeding System, sometimes including a vibrating unit or a conveyor belt.
- Description: Products or raw materials are guided to the packing machine through a feeding system that ensures consistent and uninterrupted material delivery. This system may include sorting and arranging technologies to ensure the product arrives in the correct form at the packing station.

2. Filling and Measuring

- Components: Precise measuring system (such as load cells or flow meters), filling valves.
- Description: When the product reaches the filling station, the required quantity is accurately measured using measurement

systems. Then, the filling valves open to dispense the specified amount into the desired package or container. In the case of filling liquids or powders, pumps or pressure systems are used to move the product into the package.

3. Control and Quality Assurance

- Components: Programmable Logic Controller (PLC) and Sensors.
- Description: The filling process is controlled by a Programmable Logic Controller (PLC) to ensure process accuracy and flow control. Sensors connected to the measurement and control systems monitor to ensure that the filled quantities are precise and that the product is properly packed.

2.2.2 Capping Machine

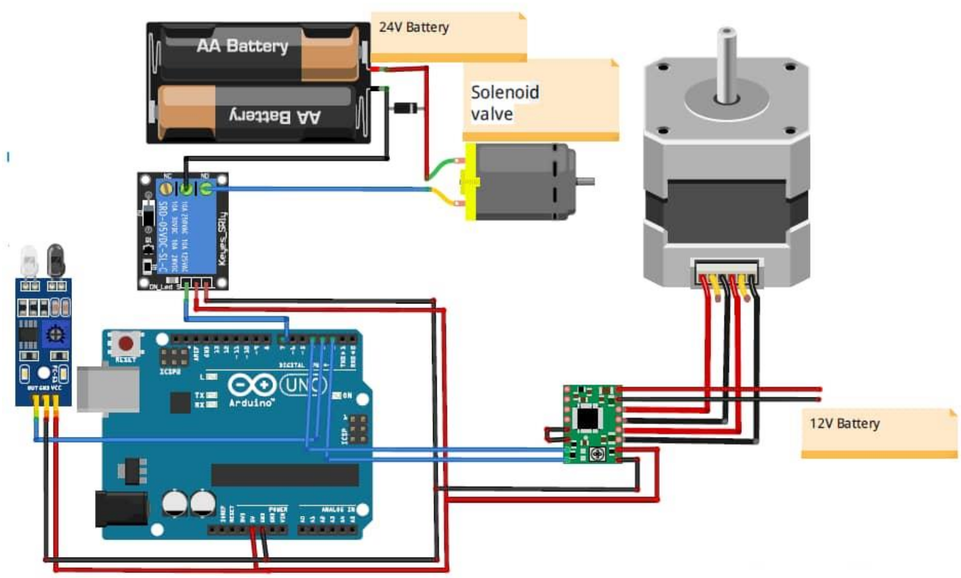

Figure 2.3 The Electronic Circuit of the Capping Machine.

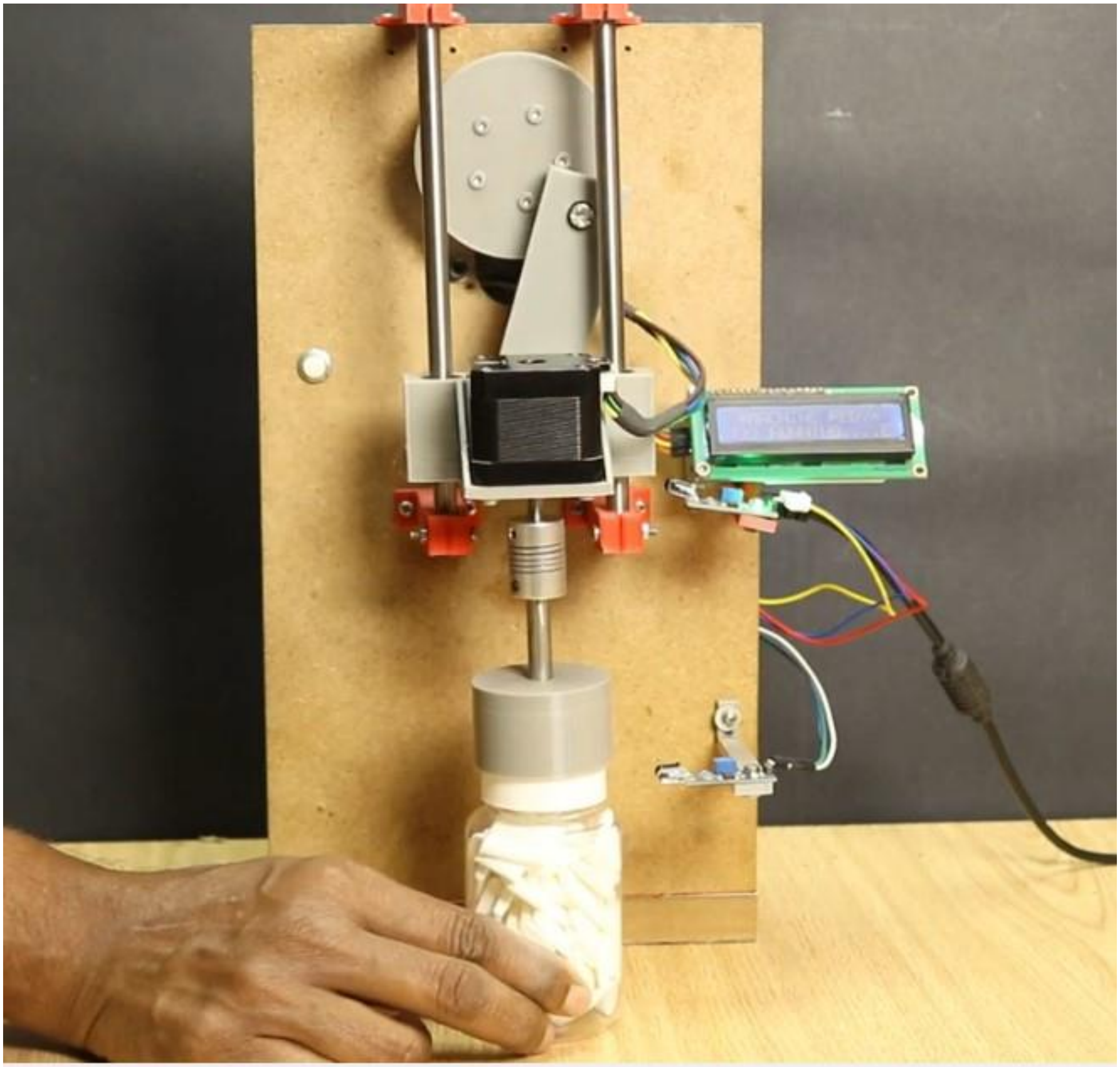

Figure 2.4 Prototype of the Capping Machine.

1. Feeding and Positioning:

- Components: Conveyor, Positioning Unit.

- Description: The process begins by directing the containers or products onto a conveyor belt. The position of each container is accurately determined using a positioning unit, which aligns the container correctly to be ready for the capping process.

2. Cap Preparation:

- Components: Cap Feeder, Cap Orienter.
- Description: The caps are transported through the cap feeder to the cap orienter unit, where it ensures that the caps are oriented correctly before being transferred to the capping station.

3. Cap Placement:

- Components: Robotic Arm or Capping Head.
- Description: After the containers and caps are prepared, the robotic arm or capping head picks up the cap and places it on the container. This step typically involves using either a capping or pressing technique to ensure the cap is securely fastened.

2.2.3 Labeling Machine

Figure 2.5 and Figure 2.6 Prototype of the Labeling Machine.

1. Feeding and Positioning:

- Components: Conveyor, Positioning Unit.
- Description: The process begins with transferring containers or products onto a conveyor belt. Each container's position is accurately determined using a positioning unit to ensure the container is correctly aligned for label application.

2. Label Preparation:

- Components: Label Feeder, Label Cutter.
- Description: Labels are fed into the labeling machine through the label feeder. If the labels are in a continuous strip, they are cut to the required length using the label cutter before being applied to the containers.

3. Label Application:

- Components: Labeling Head, Pressure Roller.
- Description: After preparing the container and the label, the labeling head picks up the label and applies it to the surface of the container. The container then passes through a pressure roller to ensure the label adheres correctly and smoothly.

Table 2.1 Comparison between a Single form and Multi form of Production Line.

Comparison	Single form	Multi form
1. Customization and Flexibility	- Flexibility: Designed to produce only one type of product, which reduces the need for adjustments and customization. - Customization: Limited customization, but easier to control and manage when adjustments to shape or size are needed.	- Flexibility: Can handle a variety of shapes and sizes, making it suitable for production lines requiring diversity. - Customization: Usually requires multiple setups to adjust the machine for each shape or size, increasing complexity in maintenance and operation.
2. Cost	- Initial Cost: Relatively lower as the equipment is designed for only one type of product. - Operational Cost: Lower as there is no need for frequent adjustments or complex maintenance.	- Initial Cost: Typically, higher due to the need for multiple and adjustable equipment. - Operational Cost: Can be higher because of the time and effort required to change settings or tools between products.
3. Productivity	- Productivity: Generally higher because the line is optimized for producing one type of product efficiently. - Efficiency: Higher as all aspects of the process are optimized for continuous production of a single product.	- Productivity: May be slower when switching between different shapes due to setup and adjustment processes. - Efficiency: Can be lower due to time lost in changing machine settings.

4. Maintenance and Operation	- Maintenance: Relatively simpler as the line is designed to handle only one type of product. - Operation: Easier as all settings and adjustments are preset for producing a single product.	- Maintenance: Can be more complex due to handling diverse equipment and tools. - Operation: May require advanced skills for operating and maintaining due to frequent adjustments.
5. Market Applications	- Market Applications: Suitable for producers focusing on a specific product with a stable and consistent demand.	- Market Applications: Suitable for producers who need to manufacture a range of products or adapt to changing market demands.

2.2.4 PLC

Figure 2.7 Programmable Logic Controller

- Programmable Logic Controllers, or PLCs, are solid-state ICSes with programmable memory for storage of instructions that monitor inputs and make decisions based on their internal program or logic for automation. Some systems are PLC-based, where multiple PLCs are networked together to share information. Arranging a system in this way allows for control capability and centralized monitoring, but in our project, we need just one PLC. PLCs can use both high-speed discrete control and analog control capability. It should be noted that PLCs may be merely a component of ICS, but PLCs can also be the control system itself when grouped. the most popular PLC, according to market share, was Siemens Simatic PLC. The second most popular PLC was Rockwell Automation Allen Bradley PLC. Followed by Mitsubishi Melsec PLC, Schneider Modicon PLC, and the Omron Sysmac PLC.

2.3 Classical Control

Is a branch of control theory focused on designing and analyzing control systems using traditional techniques and tools. This approach is aimed at achieving system stability and improving performance by managing inputs to guide the system towards a desired behavior.

1. **Key Components of Classical Control**
    1. System: The entity to be controlled, such as a motor or mechanical system.
    2. Sensors: Measure the system's output and provide feedback data.

3. Controller Unit: Uses sensor data to generate control commands based on control design.
4. Actuator: Applies the commands generated by the controller to the system to adjust its behavior.

2. Basic Principles

- Feedback Control: Relies on comparing the actual output of the system with the desired reference value and adjusting inputs accordingly.
- Model-Based Control: Designs the controller based on a mathematical model of the system, allowing prediction of system responses to inputs.

3. Types of Classical Control Systems

1. Proportional Control (P): Based on the error between the desired value and actual output. It improves response speed but may not fully achieve stability.
2. Proportional-Integral Control (PI): Combines proportional and integral control to reduce steady-state errors and improve stability.
3. Proportional-Integral-Derivative Control (PID): Includes proportional, integral, and derivative control to achieve rapid response and precise control.

4. Advantages and Disadvantages

- Advantages:

- Simplicity: Classical control techniques are generally straightforward and easy to understand.
- Stability and Predictability**: Classical control provides stable and predictable responses when designed correctly.

- Disadvantages:

- Limited Flexibility: May be less effective for nonlinear or rapidly changing systems.
- Limited Capability to Handle Disturbances: May struggle with disturbances and significant system changes.

Chapter 3

Multi form Automation Production Line Design

Chapter 3: Multi form Automation Production Line Design.

3.1 Background

Designing a Multi-Form Automation Production Line is an advanced topic in industrial engineering and production system design. This project involves designing and developing a production system capable of efficiently handling a variety of shapes, sizes, and types of products. This type of system represents a significant advancement in enhancing production flexibility, reducing costs, and increasing efficiency.

3.2 Production processes analysis

3.2.1 Requirement Analysis:

Requirements analysis is the initial and crucial step in designing a multi-form automation production line. This analysis aims to identify all necessary needs, constraints, and specifications to ensure the final system meets the defined goals efficiently and effectively.

Requirements Analysis Steps:

1. Define Project Objectives:
   - Flexibility: Identify the types of shapes, sizes, and different product types that the production line must handle.
   - Efficiency: Improve speed and productivity, and reduce downtime and changeover times.
   - Quality: Ensure high-quality standards for the different products.

2. Collect and Analysis Production Data:

- Product Study: Understand the technical details of each product such as dimensions, materials, and any specific requirements.
- Production Volume Analysis: Determine the quantity of products needed over various time periods.

3. Determine Automation Requirements:

- Technology Selection: Identify suitable automation technologies such as robots, control systems, and sensors.
- Integration: Determine how the automation system will integrate with existing and future systems.

4. Specify Design Requirements:

- Mechanical Design: Determine the types and sizes of necessary equipment such as conveyors, guiding mechanisms, and fixtures.
- Electrical Design: Define power requirements, wiring, and control devices.

5. Specify Software Requirements:

- Programming and Control: Develop control software and user interfaces, and ensure integration with automation systems.
- Digital Integration: Ensure software integration with Enterprise Resource Planning (ERP) systems and supply chain management systems.

6. Define Safety Requirements:
   - Safety Standards: Ensure the system complies with local and international industrial safety standards.
   - Emergency Procedures: Identify emergency strategies and corrective actions for potential failures.
7. Evaluate Maintenance Requirements:
   - Maintenance Plans: Develop regular maintenance plans and procedures to ensure continuous operation.
   - Training Needs: Identify training requirements for staff to operate and maintain the system.
8. Determine Project Budget:
   - Equipment Costs: Estimate costs for purchasing and installing equipment and systems.
   - Programming and Integration Costs: Estimate costs for programming and integrating with other systems.
   - Operational and Maintenance Costs: Estimate ongoing costs for operation and maintenance.
9. Determine Project Budget:
   - Detailed Specifications: A document containing all technical and functional details required for the system.
   - Design Plans: Preliminary designs including mechanical, electrical, and software configurations.

- Cost Estimates: Detailed estimates for equipment, programming, and operational costs.
- Implementation Plan: A detailed timeline for project execution, including design, implementation, and testing phases.

10. Conclusion

Requirements analysis is a critical process for designing a multi-form automation production line. This analysis requires accurate data collection and a comprehensive understanding of objectives and challenges to ensure the final system meets all needs efficiently and effectively.

3.2.2 Modeling:

Modeling is the process of designing and developing a prototype for the multi-form automation production line system. The aim is to test and analyze hypotheses and designs before full-scale implementation. Modeling helps identify potential issues and evaluate system performance before investing in actual production.

Modeling Steps

1. Define Model Requirements:

- Set Objectives: Define the primary goals for the model, such as achieving flexibility in handling various shapes and sizes, improving efficiency, and reducing costs.

- Collect Data: Gather necessary information about different products and production requirements to determine the features that the model should include.

2. Design the Model:
   - Mechanical Model: Design a preliminary model of the mechanical system, including tools, machines, and other mechanical components. CAD software can be used to create accurate designs.
   - Electrical and Electronic Model: Develop an initial design for the electrical system, including wiring, control units, and sensors.

3. Develop Software:
   - Control Programming: Develop the software needed to control the system, including programming for robots and automation systems.
   - Software Simulation: Use simulation tools to test the software and its interaction with mechanical and electronic components.

4. Create a Prototype:

- Build Prototype: Construct a physical prototype of the system or use virtual 3D models to simulate processes.
- Initial Testing: Conduct tests on the prototype to verify design accuracy and ensure performance meets expectations.

5. Analyze Prototype Results:

- Performance Evaluation: Analyze test results to assess whether the prototype meets the defined objectives.
- Identify Issues: Identify any problems or limitations in the design and suggest potential improvements.

6. Modify the Model:

- Update Design: Make necessary adjustments to the design based on prototype analysis results.
- Retest: Test the modified prototype to verify that issues are resolved and performance is improved.

7. Document the Model:

- Prepare Documentation: Document all aspects of the model, including designs, test results, and modifications made.
- Report Findings: Prepare a comprehensive report detailing modeling results and recommendations for the next steps.

8. Applications and Tools

- Design and Modeling Software: Such as Autodesk Inventor, SolidWorks, and MATLAB/Simulink.
- Software Simulation Tools: For simulating interactions between software and mechanical/electronic systems.

9. Potential Challenges

- Estimating Model Accuracy: It can be challenging to estimate how accurately the prototype will represent the actual system.
- Modeling Costs: Creating and testing a prototype can be expensive.
- Integration with Existing Systems: Integrating the model with current systems in the factory may pose difficulties.

Conclusion

Modeling for a multi-form automation production line project is a crucial process aimed at optimizing system design and identifying issues before full implementation. By designing and testing a prototype, performance can be improved, risks reduced, and objectives achieved efficiently and effectively.

3.3 Proposed Design Model for an Automated Multi form Production Line System

3.3.1 Block Diagram

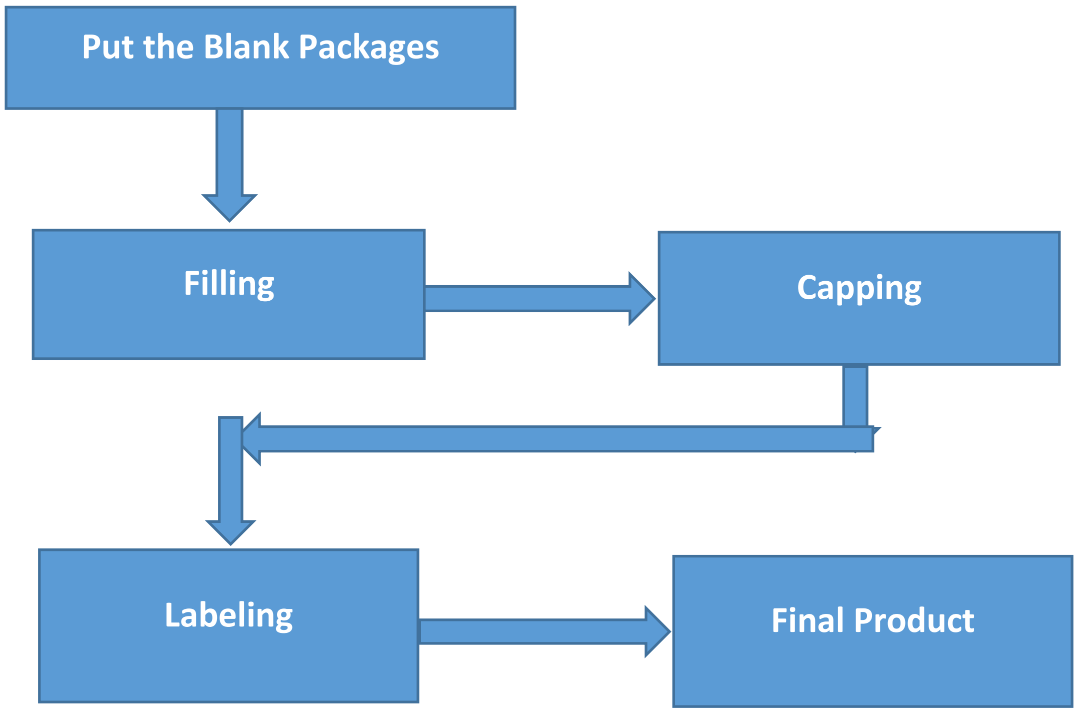

Figure 3.1 Block Diagram for Multi form Automation Production.

This block diagram shown in figure 3.1 graphical tool used to illustrate the structural configuration of a system. In the case of a multi-form automation production line, it shows how different components of the system are organized and their interrelationships. The block diagram helps in understanding the overall design of the system and organizing its components.

Key Elements in the Block Diagram

1. Material Inputs:
   - Feeding Systems: Devices or units used to transport raw materials or initial products to the production line.
2. Processing Units:
   - Shaping Machines: Tools and machines used to shape products according to specified forms and sizes.
   - Assembly Systems: Assemble different parts of the final product. This may include robots or other mechanical systems.
3. Automation Systems:
   - Central Control: Main control unit managing automation processes, including control software and data signals.
   - Sensors: Devices that measure and monitor processes to ensure accuracy and efficiency.
4. Conveying Systems:
   - Conveyors: Conveyor belts or other transport systems that move products between different processing units.
   - Auxiliary Tools: Such as lifts or loading and unloading units.
5. Control and Operation Systems:
   - Electrical Panels: Include devices that control the electrical operation of the production system.
   - Software: Software that manages interactions between different components and coordinates production processes.

6. Inspection and Quality Systems:
   - Inspection Devices: Measure product quality and verify compliance with specified standards.
   - Analysis: Tools for analyzing quality data and generating reports.
7. Power and Cooling Inputs:
   - Power Systems: Provide the system with electricity and energy needed to operate components.
   - Cooling Systems: Cool components that may heat up during operation to maintain optimal performance.
8. Human Control and Interaction:
   - User Interfaces: Control panels and input devices that allow operators to interact with and adjust the system.
   - Training and Support: Training programs and support resources for operators.

3.3.2 The hardware component

Roller Conveyor

This component is a Roller Conveyor Figure 3.2. The primary function of this roller conveyor is to support and facilitate the movement of materials and products along the production line.

The roller conveyor operates in the following manner:

1. The roller conveyor is installed vertically at designated points along the production line.
2. The conveyor is equipped with rotating rollers or cylinders along the length of the vertical column.
3. As products pass through the line, the rotating rollers help to propel and transport the products forward.
4. This system enables a smooth and organized flow of products throughout the production process.
5. The speed of the rollers and the conveyor can be controlled to adjust the pace of product movement.

In general, this roller conveyor plays a crucial role in guiding and managing the flow of materials along the industrial production line.

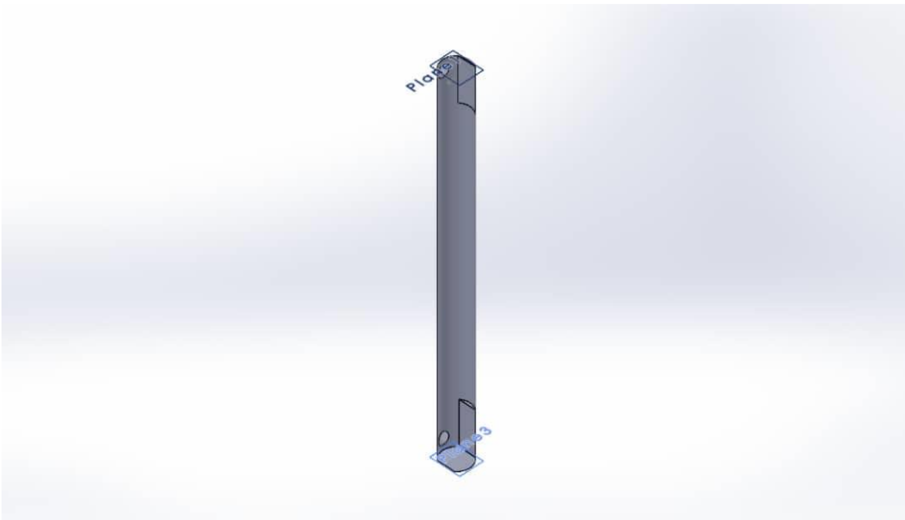

Figure 3.2 Roller Conveyor.

Crucial part of an automated capping

This component is a crucial part of an automated capping mechanism used in packaging and bottling lines Figure 3.3. Its primary function is to accurately position and secure caps or lids onto various products in a seamless and efficient manner.

The specific name for this component is the "Cap Holding Arm" or "Cap Applicator Arm". It is a curved, L-shaped metal piece with a small opening or slot at the lower end to facilitate its attachment to the machinery.

As products move along the production line, the Cap Holding Arm precisely intercepts the cap or lid and guides it to the correct position on top of the container or package. Once the cap is aligned, other automated mechanisms within the system press down on the cap, securing it firmly in place.

This automated capping system offers several advantages over manual capping processes. It significantly increases the speed and consistency of the capping operation, ensuring a high degree of precision and quality control. By automating this task, it also helps to maintain

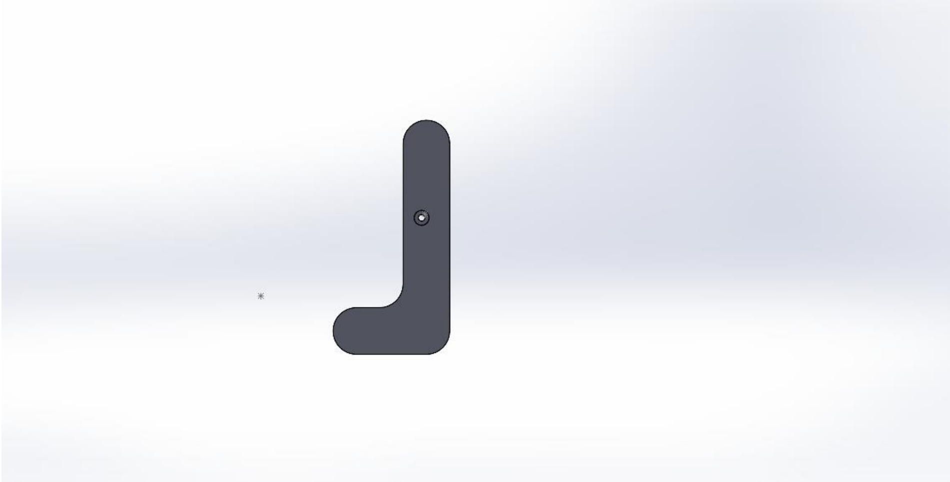

Figure 3.3 crucial part of an automated capping.

Cap Applicator Arm

This component is known as the "Cap Applicator Arm" or "Cover Application Arm" Figure 3.4. Its primary function is to accurately position and secure the caps or lids onto various products during the packaging process.

The cap applicator arm is a vital part of the automated cap application mechanism. It is a curved metallic piece shaped like an "L" with a small opening or slot at the lower end, allowing it to be easily mounted onto packaging machines.

As the products move along the production line, the cap applicator arm precisely intersects with the cap and guides it to the correct position on the container or package. Once the cap is aligned, other automated mechanisms within the system press down on the cap to secure it firmly in place.

This automated cap application mechanism offers numerous benefits compared to manual cap placement. It significantly increases the speed and consistency of the cap application process, ensuring a high degree of precision and quality control. By automating this task, it also helps maintain the cleanliness and integrity of the packaged products throughout the manufacturing and packaging stages.

The cap applicator arm plays a crucial role in streamlining the packaging workflow, reducing the potential for human error, and consistently delivering a high-quality final product to the consumer.

Its reliable and efficient function is essential for the success of the automated cap application system in packaging applications.

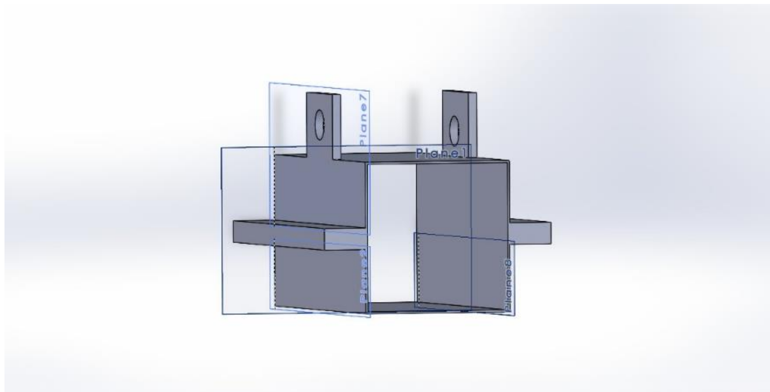

Figure 3.4 Cap Applicator Arm.

The Cap Holding Arm

This component is known as the Cap Holding Arm or the Cap Applicator Arm Figure 3.5. Its primary function is to accurately position and secure caps or lids onto various products during the packaging and bottling process.

The Cap Holding Arm is a critical piece of the automated capping mechanism. It is a curved, L-shaped metal piece with a small opening or slot at the lower end, which allows it to be easily attached to the packaging machinery.

As the products move along the production line, the Cap Holding Arm precisely intercepts the cap or lid and guides it to the correct position on top of the container or package. Once the cap is aligned, other automated mechanisms within the system press down on the cap, firmly securing it in place.

This automated capping system offers several advantages over manual capping processes. It significantly increases the speed and consistency of the capping operation, ensuring a high degree of precision and quality control. By automating this task, it also helps to maintain the cleanliness and integrity of the packaged products throughout the manufacturing and filling stages.

The Cap Holding Arm plays a vital role in streamlining the packaging workflow, reducing the potential for human error, and delivering a consistently high-quality end product to the consumer. Its reliable and efficient functioning is essential for the overall success of the automated capping mechanism in packaging and bottling applications.

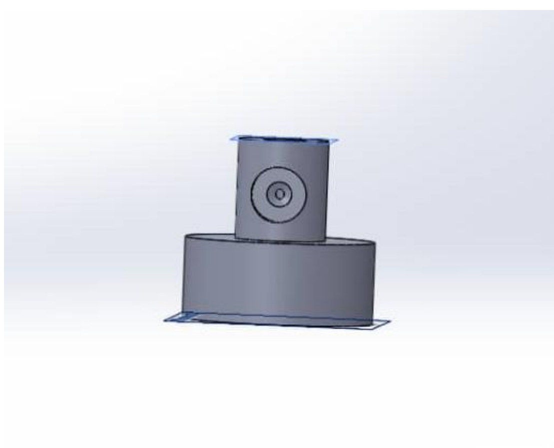

Figure 3.5 The Cap Holding Arm.

Lid Tray

The component displayed in the image is known as a "Lid Tray" or "Lid Holder" Figure 3.6. It is a crucial element in the packaging and sealing process for various products.

The primary role of the lid tray is to provide a stable and uniform platform for the secure attachment of lids or caps onto the containers or packages. The lid is precisely positioned and secured onto the tray, ensuring a tight and reliable seal on the container's opening.

The well-designed lid tray ensures a perfect fit and alignment with the lids and containers used, facilitating the assembly process and enabling a secure and consistent closure. The shape and dimensions of the tray are meticulously engineered to accommodate the standard sizes of the lids and containers.

The use of a lid tray offers several benefits in the packaging operations:

Ensures stability and balance when placing the lid, preventing slippage or misalignment.

Expedites the lid attachment process, enhancing the efficiency of the production line.

Maintains the lid's shape and cleanliness during the assembly operation.

Achieves a tight seal and prevents leakage, thereby preserving the integrity of the product.

Furthermore, the lid tray can be designed to hold the lids in their proper position during transportation and handling, ensuring the product reaches the consumer in excellent condition.

By providing a standardized and reliable assembly mechanism, the lid tray plays a crucial role in the success of the packaging and sealing processes, ensuring product quality and safety throughout the distribution and delivery stages to the end consumer.

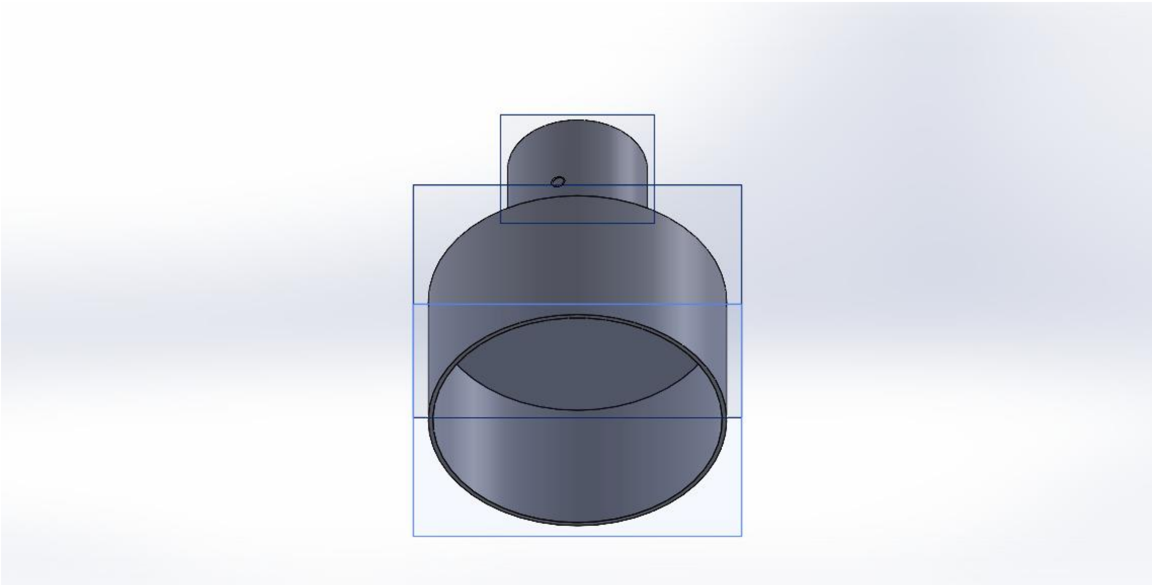

Figure 3.6 Lid Tray.

Capping Mechanism

This component depicted in the image is the Closure Mechanism or Capping Mechanism Figure 3.7. It plays a critical role in the packaging and sealing process for various products.

The primary function of the closure mechanism is to facilitate the secure and consistent attachment of lids, caps, or closures onto the containers or packages. This mechanism ensures a tight and reliable seal, effectively keeping the contents inside the package protected and preserved.

The closure mechanism typically consists of a series of precisely engineered components that work together to streamline the capping process. These components may include:

Alignment Guides: These guide the closure into the correct position on the container's opening, ensuring a perfect fit.

Clamping or Gripping Elements: These hold the closure firmly in place while the sealing process takes place.

Actuation Mechanism: This applies the necessary force and pressure to secure the closure onto the container.

The closure mechanism is designed to deliver the following key benefits:

Consistent Sealing: By maintaining the closure in the optimal position and applying the appropriate pressure, the mechanism ensures a uniform and reliable seal across all packaged units.

Efficiency and Speed: The automated nature of the closure mechanism allows for a fast and efficient capping process, increasing the overall productivity of the packaging line.

Damage Prevention: The controlled handling and positioning of the closure minimize the risk of damage or deformation, preserving the integrity of the closure and the overall package.

Versatility: Many closure mechanisms are designed to accommodate a range of closure sizes and container types, providing flexibility in the packaging operation.

The closure mechanism is a critical component in the packaging industry, contributing to the secure containment, preservation, and overall quality of the packaged products. Its precise engineering and reliable operation are essential for maintaining product safety, extending shelf life, and delivering a consistently high-quality experience for the end consumer.

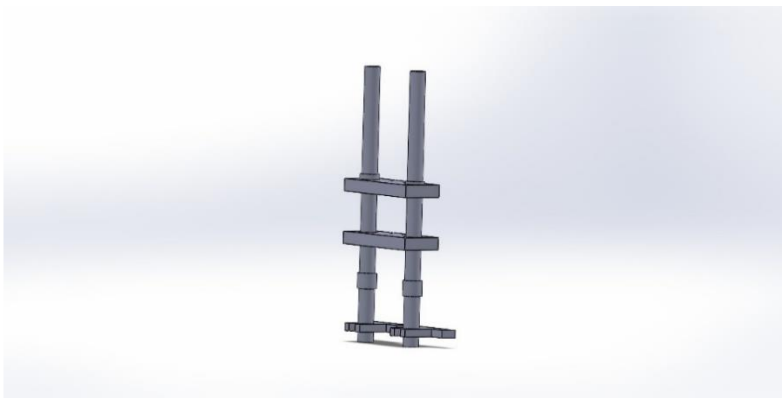

Figure 3.7 Capping Mechanism.

linear rail

This component is a linear guide or linear rail Figure 3.8, which is a widely used mechanical element in various industrial and technological applications. Some common uses of this linear guide in production lines include:

Guiding and controlling the precise and smooth motion of mechanisms and moving components.

Supporting the mechanical loads of the moving parts and allowing for seamless movement.

Providing the ability for accurate and repeatable positioning of different tools, parts, and devices within the production system.

These linear guides are extensively used in areas such as computer numerical control (CNC) machines, robotics, 3D printers, and medical/laboratory equipment. Their design and configuration can vary depending on the specific application requirements, such as load capacity, speed, precision, and operating environment.

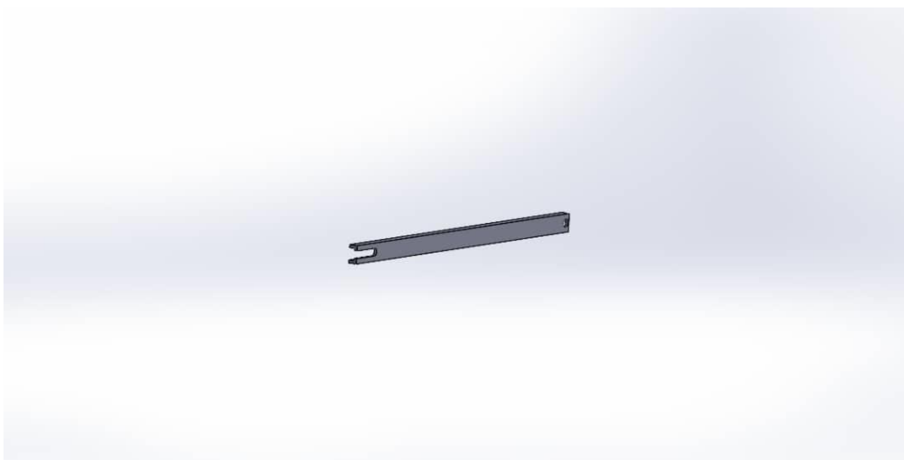

Figure 3.8 linear rail.

Linear Motion Column

This component is a linear guide shaft or linear motion column Figure 3.9, which is a critical part of the fixed roller assembly in a production line. Its main functions are:

Provide linear guidance and support for the moving components, such as carriages, slides, and robotic arms, ensuring smooth and precise linear motion.

Transfer the mechanical motion and power from the gearbox or other drive sources to the moving elements in the production line.

Enable accurate and repeatable positioning of tools, workpieces, and other equipment within the manufacturing system, contributing to the overall precision and productivity of the production process.

The linear guide shaft acts as the backbone for the linear motion control, allowing for controlled and coordinated movements of the various components in the production line. By seamlessly integrating with the gearbox and other drivetrain elements, it plays a vital role in the efficient and reliable operation of the automated manufacturing system.

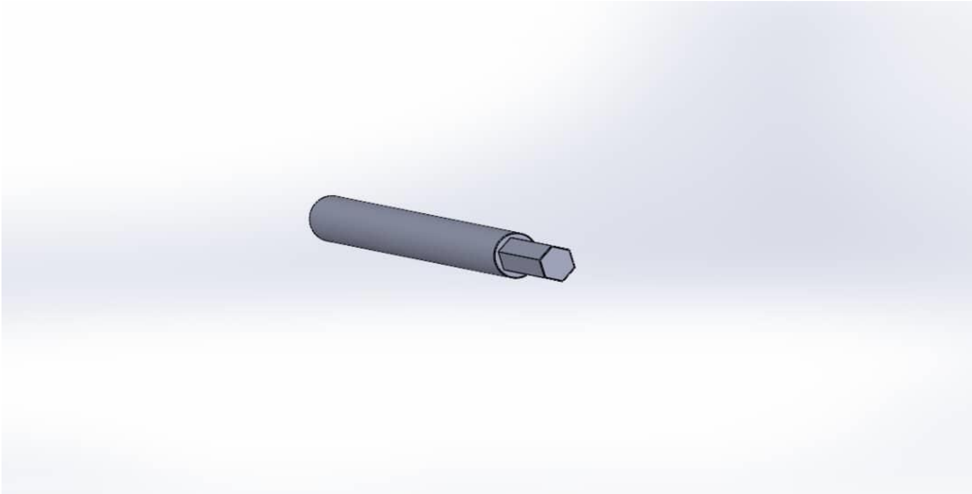

Figure 3.9 Linear Motion Column.

Side Roller Base

This component appears to be a side roller base or side guide rod within the packaging cell of a production line Figure 3.10. Its main functions are:

Providing a stable and reliable guiding surface for the containers, packages, or products as they move through the packaging process.

Ensuring proper alignment and orientation of the items being packaged, which is critical for effective and accurate filling, sealing, and labeling operations.

Facilitating the smooth and controlled lateral movement of the containers or products within the packaging cell, and avoiding any side slippage or misalignment.

Providing structural support and a mounting point for other peripheral equipment such as sensors, actuators, or integrated guiding mechanisms in the packaging system.

The side roller base plays a crucial role in material handling and process control within the packaging cell. By maintaining the correct positioning and steady flow of the containers or products, it contributes to the consistency, efficiency, and reliability of the packaging process.

This component is designed to be robust, durable, and flexible to accommodate various sizes and shapes of packages, ensuring flexibility and adaptability in the production line.

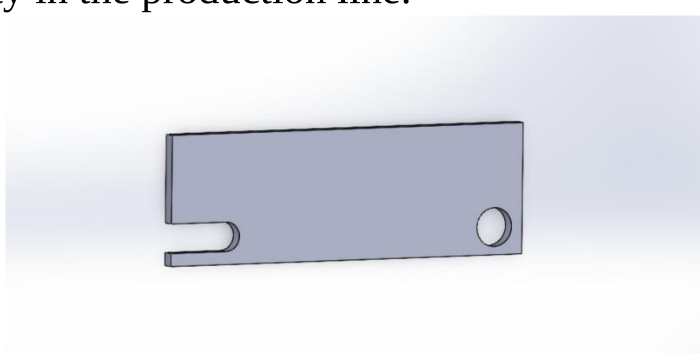

Figure 3.10 Side Roller Base.

Fixed Roller or Moving Guide Bar

Description of the Component as a Fixed Roller or Moving Guide Bar Figure 3.11, and Explaining its Fundamental Role in Production Lines

Functions of the Roller/Guide Bar:

Support and Guide the Movement of Products and Containers:

Provide a stable and smooth surface for the seamless transfer of products.

Ensure proper alignment of the processed elements.

Control Lateral Movement:

Facilitate the controlled lateral movement of products.

Prevent any unwanted slippage or misalignment.

Structural Support for Peripheral Equipment:

Provide a mounting point for sensors and actuators.

Support the integrated guiding mechanisms within the packaging system.

Design and Flexibility:

Adaptability in the design of the roller/guide bar.

Ability to accommodate a diverse range of product sizes and shapes.

Enhance flexibility and adaptability to changing production line requirements.

Importance and Critical Role:

Fundamental contribution to material handling and process control.

Maintain proper positioning and continuous product flow.

Vital role in ensuring the smoothness and efficiency of production and packaging operations.

Summarize the importance of this component as a key element in the design and operation of modern production lines.

Emphasize its role in achieving efficiency and reliability in the production and distribution of products.

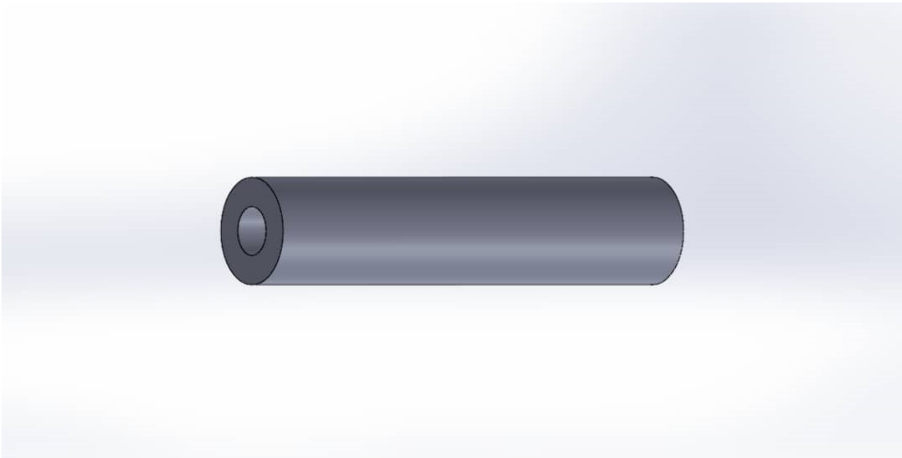

Figure 3.11 Fixed Roller or Moving Guide Bar.

Side Guide

This component is called a "side guide" or "guide rail" Figure 3.12, and it is a key element in production and packaging lines.

The main functions of this side guide are:

Supporting and guiding the movement of products and containers through the production line, providing a stable and smooth surface for transporting the products and ensuring their proper alignment.

Controlling the lateral movement of the products, facilitating controlled lateral motion and preventing any unwanted slippage or misalignment.

Providing structural support for peripheral equipment such as sensors and integrated mechanisms in the packaging system.

This side guide is designed with high flexibility to accommodate a diverse range of product sizes and shapes, enhancing the flexibility and adaptability to changing requirements of the production line.

This component is crucial in ensuring the smooth and efficient operation of the production and packaging processes.

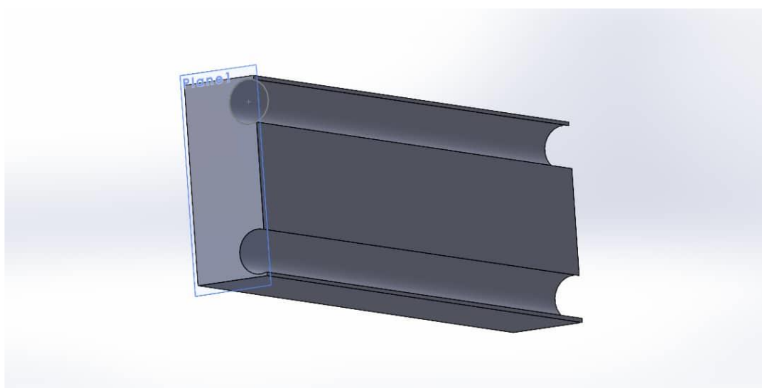

Figure 3.12 Side Guide.

Control panel box

It contains PLC shown in figure 3.13, control push buttons, power supply, conductors, relays, overload, LEDs, switch, and electrical circuit inside them.

Figure 3.13 Control panel box.

Mechanical Components

Pneumatic Cylinder

This is a pneumatic cylinder Figure 3.14, which is a mechanical component that uses compressed air to generate linear motion. Its main function is to provide the necessary force and movement to perform specific tasks within a larger industrial mechanism or device.

Pneumatic cylinders are widely used in various industrial and mechanical applications, compared to hydraulic systems, due to their advantages such as low cost, simple construction, and flexibility in use.

In this specific case, this pneumatic cylinder is likely a part of a larger industrial machine or production equipment, where it provides the power and motion required for operations such as lifting, pushing, and precise positioning of loads and components.

The information provided on the label, such as the model "MAL25X175", specifies the technical specifications of this pneumatic cylinder, allowing it to be properly integrated and matched with the required application within the larger mechanical system.

In general, pneumatic cylinders are essential elements in many automated industrial processes, as they provide precise control over linear motion with reliability and cost-effectiveness.

Figure 3.14 Pneumatic Cylinder.

Koyo Ball Bearing

This is a Koyo ball bearing Figure 3.15, which is a type of rolling element bearing used to support rotating shafts and reduce friction between moving parts. Ball bearings are essential components in a wide range of mechanical systems, including industrial equipment, vehicles, and household appliances.

The main function of a ball bearing is to allow smooth, low-friction rotation by utilizing a set of precision-made rolling balls that are constrained between an inner race (attached to the rotating shaft) and an outer race (fixed to the stationary housing). This design significantly reduces the amount of sliding friction compared to plain bearings, resulting in improved efficiency, reduced wear, and increased service life.

Koyo is a renowned manufacturer of high-quality ball bearings and other rolling element bearings. Their products are known for their durability, precision, and reliability, making them a popular choice in various industrial and automotive applications.

In the specific case of this Koyo ball bearing, it is likely designed to support a rotating shaft or component within a larger mechanical system, such as a motor, gearbox, or machinery. The bearing's geometry and material properties are carefully engineered to withstand the expected loads, speeds, and environmental conditions of its intended use, ensuring smooth and reliable operation over an extended lifetime.

Ball bearings like this Koyo model play a crucial role in the performance, energy efficiency, and longevity of countless mechanical systems that we rely on in our daily lives and industries. Their ability to reduce friction and enable precise, controlled motion is a fundamental aspect of modern engineering and technological progress.

Figure 3.15 Koyo Ball Bearing.

Ball Bearing

The component shown in the image is a Ball Bearing Figure 3.16. Ball bearings are a type of bearing mechanism used in a wide range of mechanical systems and devices.

The primary function of a ball bearing is to reduce friction and allow for smooth rotational movement of shafts and other moving parts. Ball bearings consist of a set of precision metal balls contained between an inner race (ring) mounted on the rotating shaft and an outer race (ring) fixed to the stationary housing.

This design allows the shaft to spin freely with significantly reduced friction and wear compared to other types of bearings. Ball bearings are used extensively in motors, gears, machinery, and household appliances. They play a critical role in improving the performance, efficiency, and longevity of the mechanical systems they are integrated into.

In this case, the ball bearing shown is manufactured by Koyo, a leading producer of high-quality bearing components. This particular bearing has been engineered to meet the specific load, speed, and environmental requirements of its intended application, ensuring reliable and long-lasting operation.

Overall, ball bearings are an essential component in many of the mechanical systems that we rely on in our daily lives and industries. They contribute greatly to enhancing the efficiency, reliability, and reduced maintenance of these systems.

Figure 3.16 Ball Bearing.

DC High Torque Worm Gear Motor

The component shown in the image is a DC high torque worm gear motor Figure 3.17, which is a type of reversible gearmotor. This type of motor is widely used in various applications that require high torque output and precise control of rotational speed and direction.

The datasheet provided gives the key features and specifications of this particular motor model, the NFP-GW4632-370. Some of the key details are:

- Rated Voltage: 6V / 12V / 24V DC
- No Load Current: ≤0.12A / ≤0.15A / ≤0.2A
- No Load Speed: 6rpm - 375rpm
- Maximum Torque: 30kg.cm
- Output Power: 3.5W / 3W / 15W / 20W
- Shaft Diameter: 6mm
- Shaft Length: 18.5mm
- Rotation: CW / CCW (Clockwise/Counter-Clockwise)
- Weight: 200g

These types of DC worm gear motors are commonly used in applications that require high torque, low speed, and precise control, such as:

Robotics and automation: Used in the movement and positioning of robotic arms, grippers, and other actuators.

Industrial machinery: Powering conveyors, valves, dampers, and other industrial equipment that requires controlled, high-torque rotational motion.

Medical devices: Employed in hospital beds, rehabilitation equipment, and other medical instruments that need smooth, controlled movements.

Home appliances: Found in window blinds, curtain systems, and other motorized household devices.

Automotive and transportation: Used in power windows, sun roofs, and other vehicle accessories that require precise, reliable rotational actuation.

The worm gear design of this motor provides a high gear reduction ratio, allowing the motor to generate significant torque while maintaining a relatively small and compact size. The reversible feature enables forward and reverse rotation, making it suitable for applications that require bi-directional motion control.

Overall, this DC high torque worm gear motor is a versatile and reliable component that finds widespread use in a variety of industries and applications where precise, high-torque rotational control is essential.

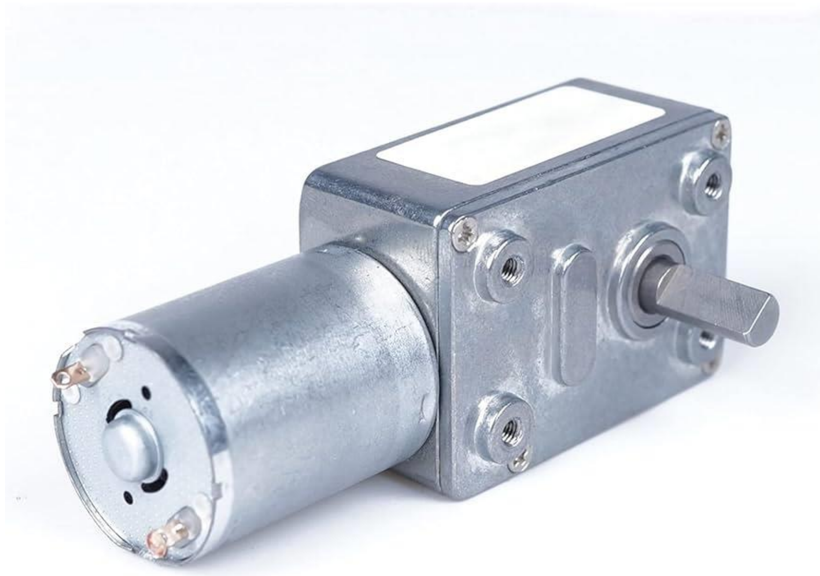

Figure 3.17 DC High Torque Worm Gear Motor.

linear bearing

This unit displayed is a type of linear bearing that is widely used in a variety of industrial and engineering applications Figure 3.18.

Looking at the image, we can see a linear guide bearing of the LMH16UU type. This kind of linear bearing provides precise support and guidance for parts that move linearly, such as robotic arms, industrial machinery, modern manufacturing machines, and other systems that require smooth and reliable linear motion.

The main function of this linear bearing is to reduce friction and provide stable support for linear motion. This is achieved through its design, which includes precise sliding surfaces and steel balls mounted within the housing. This design allows the bearing to slide smoothly along the linear axis with low friction resistance.

In addition, this linear bearing has other features such as:

Ability to withstand high loads in different directions (X, Y, Z axes)

High precision in guiding and linear motion

Quiet operation and smooth sliding

Easy installation and compact design

These characteristics make the LMH16UU bearings suitable for a wide range of engineering and industrial applications, such as:

Manufacturing and production machines: for precise linear motion of components and tools

Robotics and automation: in robot arms and linear stages

Precision machinery and equipment: in linear positioning and motion platforms

3D printing equipment: to move print heads and printing beds Overall, the LMH16UU linear bearing is a critical component for achieving precise and reliable linear motion in a wide variety of advanced industrial and engineering applications.

Figure 3.18 linear bearing.

Solenoid Valve

The Figure a solenoid valve Figure 3.19, which is a device used to control the flow of liquids or gases. It operates electrically by generating a magnetic field through the solenoid coil when an electric current passes through it, causing the valve to open or close.

This type of valve is commonly used in industrial applications to control the flow of air, water, oils, or other liquids and gases. It can be found in pneumatic and hydraulic control systems, as well as in household appliances such as dishwashers and washing machines.

Figure 3.19 Solenoid Valve.

Working Tools

Drill and drill bits

The drill shown in figure 3.20 was used to make round holes in the iron frame, tanks, and control panel box and to install a UV sheet on the iron frame. Different drill bits were used according to the type of surface and the size of the hole needed.

Figure 3.20 preparing cone.

Grinding tool

The grinding tool shown in figure 3.21 was used for cutting holes in the control panel box, cutting sheets, and for surface treatment of steel tanks using a griding brush.

Figure 3.21 Grinding tool.

Wrenches

Wrenches shown in figure 3.22 were used for gripping, fastening, turning, tightening and loosening pipes, pipe fittings, nuts and bolts.

Figure 3.22 Wrenches.

Screwdrivers

Screwdrivers shown in figure 3.23 were used for turning screws with slotted heads.

Figure 3.23 Screwdrivers.

Pliers

Different types of pliers shown in figure 3.24 were used to hold objects firmly, grip objects, reach awkward places, holding wires, cutting wires, and bend and compress materials.

Figure 3.24 Pliers.

Wire cutter stripper

Shown in figure 3.25 It is used to strip the insulation/sheathing from the end of electrical wires so they can be properly seated within an outlet, light switch, light fixture, appliance or anywhere else.

Figure 3.25 Wire Cutter Stripper.

Vertical Milling Machine

A vertical milling machine is a type of machining tool used in workshops and factories for drilling and boring operations on metals and other materials Figure 3.26.

The primary function of this machine is to create holes or apertures in metal, wood, or plastic workpieces. It achieves this by using appropriate drilling tools and motors that drive these tools at high rotational speeds. The operation of the vertical milling machine involves placing the workpiece on the fixed table, then lowering the drill head to create the required hole. The drilling depth and spindle speed can be adjusted according to the process requirements.

This machine is widely used in the fields of mechanical engineering and manufacturing to produce precise and reliable holes in various products and components. It is an essential tool in industrial workshops and factories for carrying out drilling and boring operations efficiently and accurately.

The key features of a vertical milling machine include:

Vertical spindle orientation - the cutting tool is mounted on a vertically oriented spindle, allowing for drilling and milling operations to be performed on the top surface of the workpiece.

Adjustable table - the workpiece is secured on a movable table that can be adjusted in the X, Y, and Z axes to position the workpiece accurately.

Powerful motor - the spindle is driven by a powerful electric motor that can rotate the cutting tools at high speeds for efficient material removal.

Precision controls - the machine includes various dials, levers, and digital readouts to precisely control the speed, depth, and movement of the cutting tools.

Vertical milling machines are indispensable tools in modern manufacturing, enabling the creation of complex and intricate parts with a high degree of accuracy and repeatability.

Figure 3.26 Vertical Milling Machine.

Vertical milling machines are a type of mechanical machinery commonly used in workshops and factories for drilling and milling operations on metals and other materials Figure 3.27.

The primary function of this machine is to create holes or cavities in workpieces made of metals, wood, or plastics. It achieves this by using appropriate drilling tools and motors that rotate these tools at high speeds.

The operation of a vertical milling machine involves placing the workpiece on the stationary table, then lowering the drill head to create the required hole. The drilling depth and spindle speed can be adjusted according to the process requirements.

These machines are widely used in mechanical engineering and manufacturing fields to produce precise and reliable holes in various products and components. They are an essential tool in industrial workshops and factories for efficient and accurate drilling and milling operations.

Key features of a vertical milling machine include:

Vertical spindle orientation - the cutting tool is mounted on a vertically oriented spindle, allowing milling and drilling operations on the top surface of the workpiece.

Adjustable table - the workpiece is secured on a movable table that can be positioned precisely along the X, Y, and Z axes.

Powerful motor - the spindle is driven by a powerful electric motor capable of rotating the cutting tools at high speeds for efficient material removal.

Precision control systems - the machine includes various handles, levers, and digital readouts for precise control of speed, depth, and tool movement.

Vertical milling machines are indispensable in modern manufacturing, as they enable the creation of complex and intricate parts with a high degree of accuracy and repeatability.

Figure 3.27 Vertical Milling Machine.

A vertical milling machine is a type of machining tool used in workshops and factories for drilling and boring operations on metals and other materials Figure 3.28.

The function of this machine is to create holes or apertures in metal, wood, or plastic workpieces. It does this by using appropriate drilling tools and motors that drive these tools at high rotational speeds.

The operation of this machine involves placing the workpiece on the fixed table, then lowering the drill head to create the required hole. The drilling depth and spindle speed can be adjusted according to the process requirements.

This machine is widely used in the fields of mechanical engineering and manufacturing to create precise and reliable holes in various products and components. It is an essential tool in industrial workshops and factories for carrying out drilling and boring operations efficiently and accurately.

Figure 3.28 Vertical Milling Machine.

Sensors

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena.

. The Inductive Proximity Sensor

A type of proximity sensor in Figure 3.29 used to detect the presence of metallic objects without physical contact. This type of sensor is distinguished by its accuracy and ability to operate in harsh industrial environments.

Figure 3.29 The Inductive Proximity Sensor

Electrical Component

we implemented the electrical components that are used in the project such as the power supply, actuators, sensors, valves, buttons, and other components that will be explained below.

Power supply

A switching power shown in figure 3.30 24V 10A supply was used as the power supply of the PLC, valves, and LEDs. Description:
240W switching power can convert AC power to 24V (10A rated current). Favorable price and high-quality SMPS have short circuit protection to make it ideal for wide use in power tools and industrial control.

Figure 3.30 Power Supply

Features:

- Universal AC input range selectable by a switch.
- Protections: short circuit, overload, and overvoltage.
- Forced air cooling by a built-in DC fan.
- LED indicator for power on.
- 100% full load burn-in test.
- Low cost and high reliability

Specification:

Input:

- Voltage Range: 90 ~ 132VAC/180V~264VAC (selected by a switch) or 254 ~ 370VDC.
- Frequency Range: 47~63Hz.
- Efficiency (Typ.): 83%.
- Temperature Coefficient: ±0.03%/°C (0~50°C).

Output:

- DC Voltage: 24v.
- Rated Current :10A.
- Current Range: 0 ~ 25A.
- Rated Power: 240W.

Actuator

This motor in Figure 3.31 and Figure 3.32 are the main motor used to drive the conveyor lines used in our project.

Figure 3.31 Gear Box.

Specifications:

- Working power: 0.18 kw .
- Rated current :0.95 A.
- Working voltage: 230 v.
- Working Frequency: 50 Hz.
- Velocity: 1400 R/min .

Figure 3.32 Dynamo.

Specifications:

- Working power: 0.75 kw.
- Rated current: 5.5A.
- Working voltage: 220 v.
- Working Frequency: 50 Hz.
- Velocity: 2900 min−1.

Electrical safety components

Conductor

A conductor shown in figure 3.33 or electrical conductor, is a substance or material that allows electricity to flow through it. In a conductor, electrical charge carriers, usually electrons or ions, move easily from atom to atom when voltage is applied. Our conductors are 9A.

Figure 3.33 Conductor.

Calculation:

The following equation must be used to select the appropriate contactor:

Appropriate contactor = 4 * The rated current of motor

24V DC Relays

A relay shown in figure 3.34 is an electrically operated switch. It consists of a set of input terminals for single or multiple control signals, and a set of operating contact terminals. It allows line voltage equipment to be controlled by a 24V thermostat circuit.

The relay features a 24V DC coil between A and B contacts. The DC relay will have a polarity assigned to the terminals while an AC relay will not. In this case, the positive terminal is terminal A and the negative one is terminal B.

The contacts are labeled from 1 to 12. By following the diagram, we can identify the contacts as follows:

Normally Open:

Normally Closed:

Figure 3.34 24V DC Relay

A normally open contact will not conduct any electricity while the coil is de-energized. In other words, you may measure an infinite resistance across any of the terminals listed within the “Normally Open” list above while the relay coil is not powered. Once there’s a current drawn by the coil and the relay is energized, the contacts will conduct current.

The opposite is true about normally closed contacts. They will conduct current in the deenergized state and stop conducting when power is applied.

Wiring an Industrial 24 V DC or 110 V AC Relay in Control Systems:

An output from a PLC or an auxiliary device such as Point IO or Flex IO may be used to power the coil of a relay. By programming the coil to turn ON and OFF, the contacts of the relay will transition from de-energized to energized and back. This action will allow the current to circulate. By creating this loop, we may build a circuit that will power a load based on the state of the relay.

We will land the positive terminal on a PLC-based output. The negative terminal landed on the ground of the 24VDC power supply.

Circuit Breaker

Single-Pole

The single-pole circuit breaker (or "single-pole breaker") Figure 3.35 is an electrical device used to protect electrical circuits from overloads or short circuits. The breaker works by cutting off the circuit when the electrical current exceeds a certain limit, protecting the devices connected to the circuit as well as the wires from damage or fire.

Features of the single-pole circuit breaker:

Circuit protection: Prevents damage to electrical equipment and protects circuits from overloads and short circuits.

Ease of use: Features a simple on/off mechanism through a single switch.

Easy reset: If the circuit is interrupted due to an overload, the breaker can simply be reset manually after the fault is corrected.

Compact size: Fits into electrical distribution panels with limited space.

Figure 3.35 Single-Pole.

triple-pole

The triple-pole circuit breaker (or "three-pole breaker") Figure 3.36 is an electrical device designed to protect three-phase circuits. This type of breaker is commonly used in industrial and commercial applications where electrical power is distributed across three phases to provide more stable and efficient energy.

Features of the triple-pole circuit breaker:

Comprehensive protection: Provides protection for three-phase circuits from overloads, short circuits, and any faults in one of the phases.

Synchronized control: Cuts off power to all three phases simultaneously to ensure equal protection for each phase, preventing imbalances in the electrical system.

High capacity: Suitable for handling high currents, making it ideal for use in systems that require large amounts of power.

Manual or automatic control: Can be operated manually or integrated with automated control systems for added safety.

Figure 3.36 triple-pole.

Cables and wires

We used two types of cables:

1. 1.5 mm wire: Shown in figure 3.37 we use it to connect between inputs and outputs plc controller and others as conductor.

Description:

- Wire Size :1.5 sqmm.
- Coil Length: 90m.
- Insulation Material: PVC.
- Number of Cores: Single
- Voltage: 240V
- Diameter:1.5 mm.

Figure 3.37 Cable Wire 1.5mm

2. 5 mm wires Shown in figure 3.38 we use it to connect motors wires with T conductor terminal.

Figure 3.38 Cable Wire 2.5mm

Push buttons that used in our project

Stop and Start Push Buttons:

Shown in figure 3.39 to avoid an operator from pushing the wrong button in error, pushbuttons are often color-coded to associate them with their function. Commonly used colors are red for stopping the machine or process and green for starting the machine or process.

Figure 3.39 Start and Stop Push Buttons.

Emergency push button

Red pushbuttons Shown in figure 3.40 can also have large heads (called mushroom heads) for easy operation and to facilitate the stopping of a machine. These pushbuttons are called emergency stop buttons and for increased safety are mandated by the electrical code in many jurisdictions.

Figure 3.40 Emergency Stop Button.

Electrical wires accessories

Fork Spade Quick Splice Crimp Terminals Connectors

Shown in figure 3.41 High-Quality Copper and PVC ensure excellent safety wire contact for the vehicle, household, and electrical use, Comply with International standards.

Figure 3.41 Fork Spade.

Insulated Red Single Cord End Terminal Crimp

Bootlace Ferrules

Shown in figure 3.42 Cord end ferrules provide a neat end termination to tri-rated cable and multi-stranded wires. These cord end terminals are also known as bootlace ferrules and are perfect for wide range of electrical or electronic applications. Cable ferrules allow visual inspection, prevents corrosion, and provide a waterproof seal. Cord end terminals are manufactured from tin coated high conductivity copper with vinyl insulating sleeves.

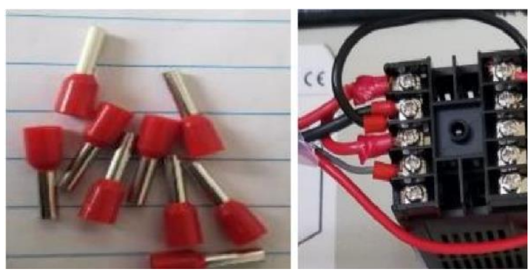

Figure 3.42 Insulated Red Single.

Industrial Control

This will illustrate the two ways of control which are PLC & SCADA control. Process control is the ability to monitor and adjust a process to give the desired output. It is used in industry to maintain quality and improve performance. Also, in this chapter, the flow chart of the process will illustrate and clarify the inputs and outputs. Also, explain the control of the process.

Process control

Many types of process control systems exist, including supervisory control and data acquisition (SCADA), programmable logic controllers (PLC), or distributed control systems (DCS), and they work to gather and transmit data obtained during the manufacturing process.

PLC

Programmable Logic Controllers, or PLCs Figure 3.43, are solid-state ICSes with programmable memory for storage of instructions that monitor inputs and make decisions based on their internal program or logic for automation. Some systems are PLC-based, where multiple PLCs are networked together to share information. Arranging a system in this way allows for control capability and centralized monitoring, but in our project, we need just one PLC. PLCs can use both high-speed discrete control and analog control capability. It should be noted that PLCs may be merely a component of ICS, but PLCs can also be the control system itself when grouped. the most popular PLC, according to market share, was Siemens Simatic PLC. The second most popular PLC was Rockwell Automation Allen Bradley PLC. Followed by Mitsubishi Melsec PLC, Schneider Modicon PLC, and the Omron Sysmac PLC. Siemens! was chosen since it provides analog input for some project sensors such as (temperature sensor, level sensor, pressure sensor) and transistor output.

Figure 3.43 PLC.

I/O Block diagram

This block diagram shown in figure 3.44 illustrates the inputs and outputs that connected with PLC.

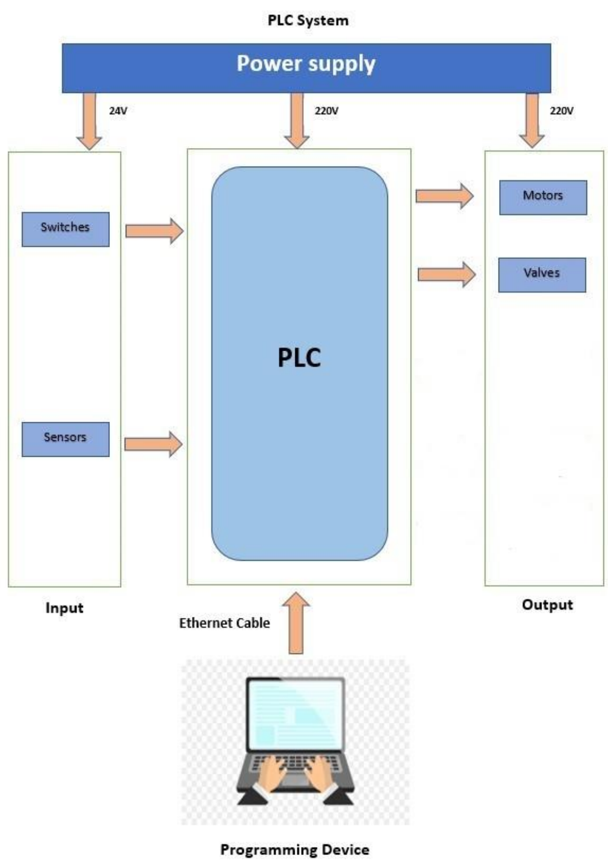

Figure 3.44 I/O Block diagram.

Control Panel

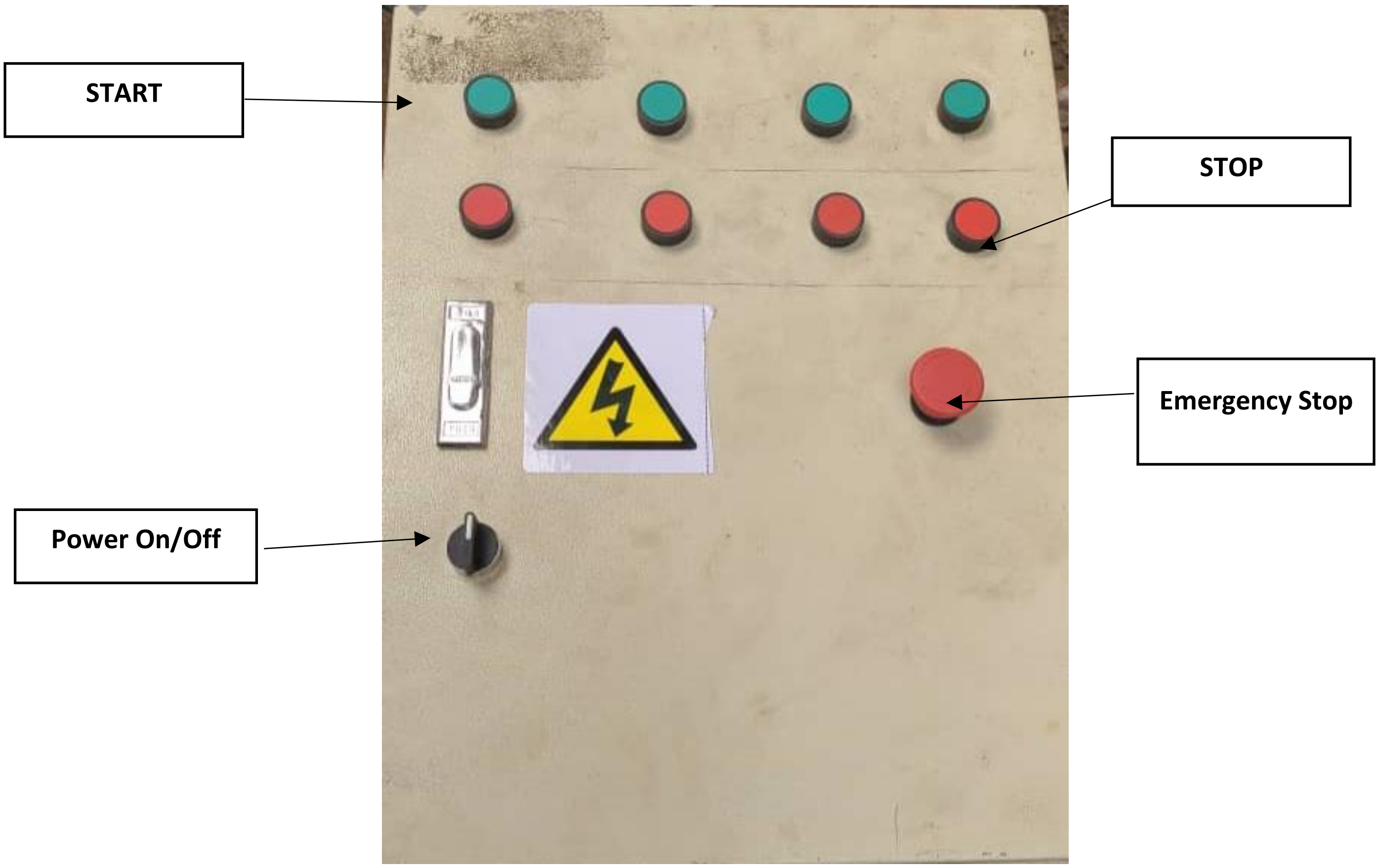

Figure 3.45 Control Panel.

Simulation

Compressed Air Piston Operating Circuit

A compressed air piston operating circuit is a mechanical system that uses compressed air to generate the force required to operate a specific mechanism or tool Figure 3.46. This circuit consists of several key components:

Air compressor: A device that draws in ambient air and compresses it to raise the pressure to the required level.

Compressed air storage tank: Stores the compressed air produced by the compressor for use when needed.

Control valves: Regulate the flow of compressed air and direct it to the desired locations.

Compressed air cylinder: Contains a piston that moves inside it due to the compressed air, converting the pressure energy of the air into mechanical energy.

Working mechanism or tool: Which utilizes the mechanical energy generated by the compressed air cylinder to perform the required tasks.

The circuit operates in an integrated manner where air is compressed in the compressor, then stored in the tank, and subsequently directed through the valves to the compressed air cylinder to generate the necessary mechanical power to operate the mechanism or tool.

Compressed air piston operating circuits are used in many industrial and commercial applications due to their numerous advantages, including pneumatic tools, manufacturing machinery, transportation equipment, control and automation systems, and medical equipment. This technology is characterized by being safe, reliable, and easy to maintain, and it does not require electrical power sources to operate, making it a suitable choice in industrial environments, remote areas, or hazardous locations, in addition to its energy efficiency and low emissions.

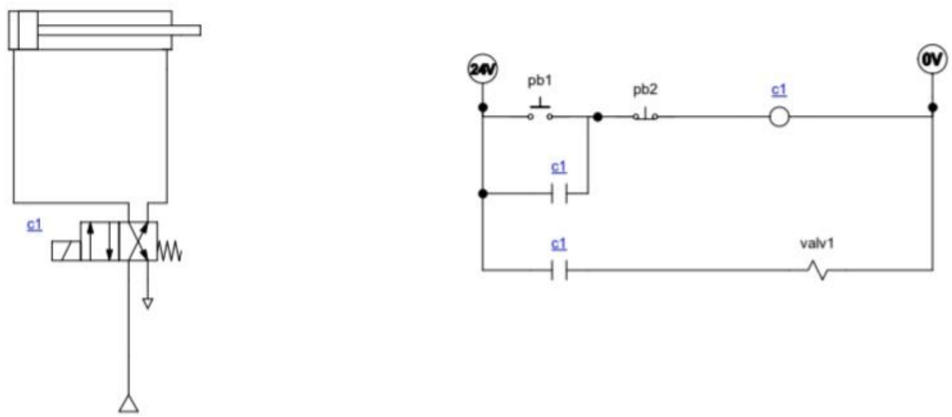

Figure 3.46 Compressed Air Piston Operating Circuit.

Three-Phase Motor

Introduction:

Three-phase electric motors Figure 3.47 are widely used in industry and commercial applications due to their power and high efficiency. To operate these motors, an electrical circuit is used that consists of key components such as a contactor and a push button. In this article, we will discuss in detail the design and installation of a starter circuit for a three-phase motor using these components.

Circuit Components:

Contactor: A contactor is an electrical device used to connect and disconnect the motor's power circuit. It consists of coils and electrical contacts that are activated by applying voltage to the coil.

Push Button: A push button is a control device used to start and stop the motor by sending a signal to the contactor.

Protection Unit: A protection unit is included in the circuit to protect the motor from overloads and high currents.

Circuit Installation:

Connect the contactor coil to the appropriate power source.

Connect the contactor's contacts to the three-phase motor's power circuit.

Connect the push button to the contactor coil to provide the control signal.

Incorporate the protection unit into the circuit to protect the motor.

Ensure all connections are secure and safe.

Operation:

Press the push button to energize the contactor and start the motor.

Press the push button again to de-energize the contactor and stop the motor.

In case of an overcurrent or fault, the protection unit will interrupt the circuit and protect the motor.

Conclusion:

The three-phase motor starter circuit using a contactor and push button is a simple and reliable design widely used in industry. By understanding the circuit components and how to install them, engineers and technicians can effectively and safely design and implement these systems.

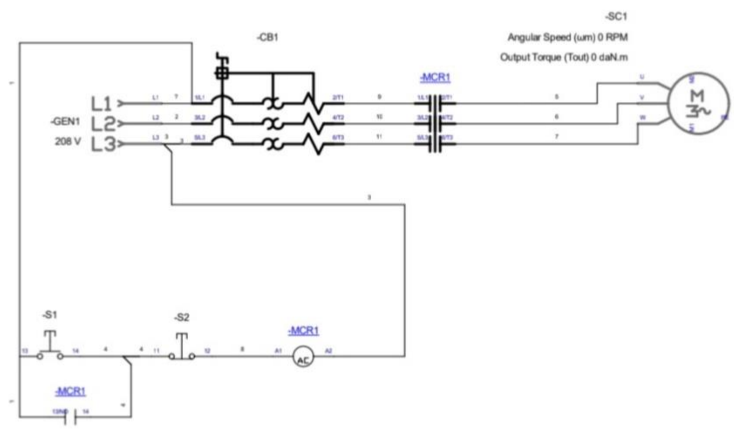

Figure 3.47 Three-Phase Motor.

Chapter 4

Implementation results, and experimental results.

4.1 Background

In this chapter, we will talk about the implementation result, experimental study of calculating operation time, time, and discuss the results that we find.

4.2 Electrical Control Setup

This image to show an electrical control setup Figure 4.1, specifically featuring a contactor device.

A contactor is an electrically operated switch used to control the flow of electrical current to a load, such as a motor, lighting system, or other electrical equipment. It is a common component in industrial, commercial, and even residential electrical control systems.

The contactor in the image has several key components:

The main contactor unit: This is the larger, primary component that houses the electrical contacts and the electromagnetic coil that energizes the contacts to open or close the circuit.

The overload relay: This device monitors the current flowing through the contactor and will automatically disconnect power if an overcurrent condition is detected, protecting the connected equipment from damage.

The control circuit: The smaller components, wiring, and terminal blocks seen in the image likely make up the control circuit that energizes the contactor coil to turn the connected load on or off, typically based on a control signal from a switch, sensor, or programmable logic controller.

The purpose of this setup is to provide a robust, reliable, and safe way to remotely control the operation of an electrical load, such as a motor or other equipment. The contactor allows the load to be switched on and off without the operator having to manually connect or disconnect the power supply.

Contactors are widely used in industrial automation, HVAC systems, elevators, cranes, and many other applications where the ability to remotely control electrical equipment is essential for efficient and safe operation. Their use in this type of control setup is a common and essential practice in electrical engineering and industrial automation.

Figure 4.1 Electrical Control Setup.

4.3 Welding of Side Columns

The bright sparks and the welding torch indicate that a welding operation is taking place Figure 4.2 The welding seems to be focused on the edge or side of the structure, potentially joining or reinforcing structural members or components.

This type of welding is often used to attach side rails, support beams, or other lateral elements to the main frame or body of a larger metal structure.

The purpose of this welding work is to provide structural integrity, strength, and stability to the overall assembly. By welding the side members or supports, the fabricated structure becomes more rigid, durable, and able to withstand various loads and stresses it may encounter during use.

This type of welding is commonly seen in the fabrication of:

Heavy machinery and industrial equipment frames

Automotive chassis and suspension systems

Steel and metal framing for buildings and structures

Scaffolding, platforms, and other temporary support systems

Metal furniture, racks, and storage solutions

The welding process itself helps to permanently join the metal components, creating a strong, cohesive bond that can transfer forces and loads effectively across the structure.

Overall, the welding observed in this image is a critical manufacturing technique used to construct robust, reliable, and load-bearing metal frameworks and assemblies for a variety of industrial and commercial applications.

Figure 4.2 Welding of Side Columns.

4.4 Roller Finishing Machine

The primary function of this roller finishing machine is to refine and smooth the surfaces of metal rollers Figure 4.3 , which are critical components in various industrial applications. These rollers may be used in printing presses, textile mills, paper mills, or other machinery where consistent, high-quality roller surfaces are essential for proper operation and product quality.

The machine utilizes a combination of rotational movement and precision tools to carefully remove small amounts of material from the roller's surface, creating a very smooth, uniform finish. This process helps to eliminate any imperfections, waviness or unevenness that may have developed in the roller over time through normal use and wear.

By maintaining the rollers in peak condition, this machine helps to ensure consistent, reliable performance of the industrial equipment they are used in. The precise control over roller surface quality can have a significant impact on productivity, product quality and equipment lifespan in industries that rely on well-functioning roller systems.

This specialized roller finishing machine is a valuable asset in manufacturing and industrial maintenance workflows, allowing companies to keep critical roller components operating at their best. Its ability to refine large, cylindrical workpieces sets it apart from a standard metal lathe designed for more general metalworking tasks.

Figure 4.3 Roller Finishing Machine.

4.5 Cover Mold Lathe

This is a machine specifically designed for finishing and smoothing the surfaces of industrial rolls or cylinders Figure 4.4

The function of this machine is to reshape and refine the surface of large-scale industrial rolls used in many manufacturing applications, such as printing, textiles, paper mills, and others.

Through precise rotational motion and specialized tools, this machine removes tiny amounts of material from the roll's surface to achieve a perfectly uniform and smooth finish. This process helps eliminate any defects or waviness that may develop on the roll's surface with continuous use.

Maintaining the rolls' surfaces in excellent condition ensures reliable and consistent

performance of the industrial equipment that relies on these roll systems. The precise control over roll surface quality has a significant impact on productivity, product quality, and equipment lifespan in industries dependent on roll-based systems.

This specialized roll finishing machine is a valuable asset in industrial manufacturing and maintenance operations, allowing companies to keep critical components like rolls in optimal condition. What sets it apart from a general-purpose lathe is its focus on handling large-scale cylindrical workpieces.

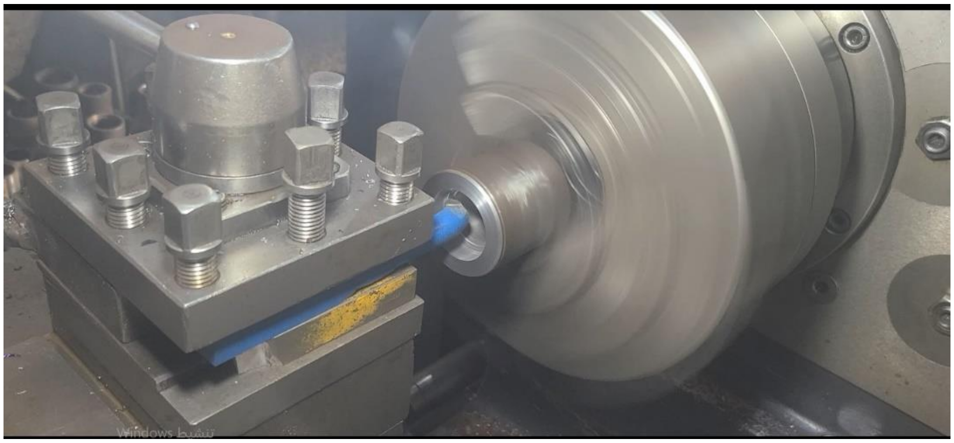

Figure 4.4 Cover Mold Lathe.

Project Photos

Figure 4.5 One Photo.

Figure 4.6 Two Photo.

Figure 4.7 Three Photo.

Chapter 5

Conclusion and Future Work.

5.1 Benefits

Benefits of Designing and Implementing a Versatile Production Line:

Increased Production Flexibility:

Ability to produce a diverse range of products on the same production line

Capacity to adapt to changes in demand and evolving customer preferences

Improved Operational Efficiency and Productivity:

Better utilization of production capacity

Reduced setup and changeover time between production of different product types

Reduced Overall Costs:

Decreased need for separate production lines for each product type

Savings in factory space and capital equipment

Enhanced Competitive Advantage:

Ability to meet customer needs more quickly and flexibly

Offering a wider product assortment to attract a larger customer base

Improved Responsiveness to Market Changes:

Capability to diversify products and add new lines more rapidly

Ease of adjusting production to meet new trends and emerging demands

Enhanced Planning and Scheduling Efficiency:

Improved management and distribution of resources and production capacities

Reduced waste and losses in production

In conclusion, designing and implementing a versatile production line is a valuable investment that can bolster an organization's competitiveness and growth in today's ever-changing and competitive business environment.

5.2 Work Future

Future Advancements for Versatile Production Lines

As manufacturing continues to evolve, the benefits of implementing a versatile production line become increasingly apparent. These flexible production systems not only enhance operational efficiency and responsiveness today, but also hold significant potential for future advancements. Let's explore some of the key areas where versatile production lines are poised for improvement in the years to come.

Increased Automation and Robotics Integration

The integration of advanced automation technologies and robotic systems will play a pivotal role in the future of versatile production lines. Intelligent, programmable robots can streamline material handling, assembly, and quality control tasks across multiple product types. This will lead to faster changeovers, reduced manual labor, and higher overall equipment effectiveness.

Predictive Maintenance and Proactive Optimization

Leveraging the power of data analytics and IoT (Internet of Things) sensors, versatile production lines will evolve to incorporate predictive maintenance capabilities. By monitoring key equipment parameters and performance indicators, manufacturers can anticipate potential issues and schedule maintenance proactively. This will minimize downtime, improve reliability, and extend the lifespan of production assets.

Adaptive Process Control and Quality Assurance

With the aid of machine learning algorithms and real-time data monitoring, versatile production lines will become increasingly adept at self-adjusting production processes. This adaptive control mechanism will enable automatic fine-tuning of parameters to maintain consistent quality and reduce waste, even as product mixes and production volumes fluctuate.

Digital Twins and Simulation-Driven Optimization

The integration of digital twin technology, where a virtual replica of the production line is created, will allow manufacturers to simulate and optimize their versatile systems before implementation. This will enable them to experiment with different process configurations, identify bottlenecks, and fine-tune the production workflow to achieve maximum efficiency.

Improved Human-Machine Collaboration

As versatile production lines become more technologically advanced, the role of human operators will shift towards higher-level decision-making and problem-solving. Intuitive human-machine interfaces, augmented reality (AR) tools, and collaborative robotic systems will enhance the synergy between human expertise and automated capabilities.

By embracing these future advancements, versatile production lines will continue to evolve, offering manufacturers even greater flexibility, efficiency, and responsiveness in meeting the dynamic demands of the global marketplace.

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