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A Review on Semi-Automatic PET Jars Cap Handle Fitting Machine

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ABSTRACT: The Semi-Automatic PET Jars Cap Handle Fitting Machine is designed to improve efficiency and precision in the attachment of handles to PET jar caps. This machine integrates pneumatic, electronic, and mechanical systems to reduce manual effort and ensure consistent quality. The system consists of two pneumatic cylinders (15mm stroke, 16mm bore), a 5×2 solenoid-operated directional control valve (24V), and an Arduino Nano microcontroller. A limit switch is used to detect the correct positioning of the cap and handle. Once detected, the Arduino Nano triggers the solenoid valve via a relay module, causing the pneumatic cylinders to press the handle into the designated cavity of the cap. A precision-machined EN-31 metallic die holds the cap securely in place, ensuring accurate fitting. The entire system is built on a 20mm × 20mm MS pipe frame for durability and stability. This semi-automatic machine enhances productivity by reducing human error, improving consistency, and accelerating the handle-fitting process. It is an ideal solution for small to medium-scale industries involved in PET jar manufacturing and packaging. Future enhancements could include automation upgrades such as a conveyor system or sensor-based quality inspection for increased efficiency.

KEYWORDS: foundry automation, pneumatic cylinders, Arduino Nano microcontroller, 5×2 solenoid-operated directional control valve.

I. INTRODUCTION

The Semi-Automatic PET Jars Cap Handle Fitting Machine is designed to streamline the process of attaching handles to PET jar caps with precision and efficiency. This machine is particularly useful in industries where PET jars are widely used for packaging food products, beverages, and household items.

In the modern packaging industry, the demand for efficient, reliable, and semi-automated solutions is growing rapidly, especially in sectors dealing with large-volume plastic containers such as PET jars. One common challenge in this process is the manual fitting of plastic handles onto PET jar caps, which is often time-consuming, inconsistent, and physically demanding for workers. To address this issue, a Semi-Automatic PET Jar Cap Handle Fitting Machine has been developed.

The system operates using two pneumatic cylinders positioned on either side of a precisely machined EN-31 metallic die, which ensures accurate cap placement. A limit switch detects when an operator has correctly positioned the cap and handle, triggering an Arduino Nano microcontroller to actuate the 5×2 solenoid-operated directional control valve via a relay module. The pneumatic cylinders then press the handle securely into the cap's designated cavity.

Built on a robust 20mm x 20mm MS pipe frame, this machine enhances productivity by reducing manual labor and ensuring consistent quality in handle fitting. With its semi-automatic operation, it optimizes the balance between human supervision and automation, making it a cost-effective and efficient solution for small to medium-scale production lines.



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II. LITERATURE SURVEY

The automation of industrial processes has significantly improved efficiency, consistency, and productivity in manufacturing. Various studies and research papers highlight the importance of **pneumatic automation, precision fixture design, and microcontroller-based control systems** in semi-automated machines.

1. Pneumatic Systems in Industrial Automation:

According to research on **pneumatic automation**, pneumatic actuators are widely used in industrial applications due to their **fast response time, reliability, and cost-effectiveness** (Sharma & Kumar, 2020). Pneumatic cylinders provide uniform force, making them suitable for tasks requiring **repetitive motion and controlled force application**, such as fitting handles onto jar caps. [1]

2. Importance of Precision Fixtures in Manufacturing:

A study by Patil et al. (2019) on fixture design for assembly processes emphasizes that **precision-machined dies and fixtures improve accuracy and reduce defects** in industrial assembly tasks. In the proposed machine, the **EN-31 metallic die** ensures accurate positioning of the PET jar cap, minimizing errors and ensuring consistent handle attachment. [2]

3. Role of Microcontrollers in Semi-Automatic Systems:

The use of **Arduino-based automation** in industrial applications has been well documented in research by Gupta et al. (2021). Their study highlights how microcontrollers like **Arduino Nano** enable precise control over pneumatic and electrical components, leading to **automated yet flexible operations**. The integration of a **limit switch for position sensing** ensures that the handle is placed correctly before actuation, preventing misalignment. [3]

4. Comparison of Manual vs. Automated Handle Fitting Processes:

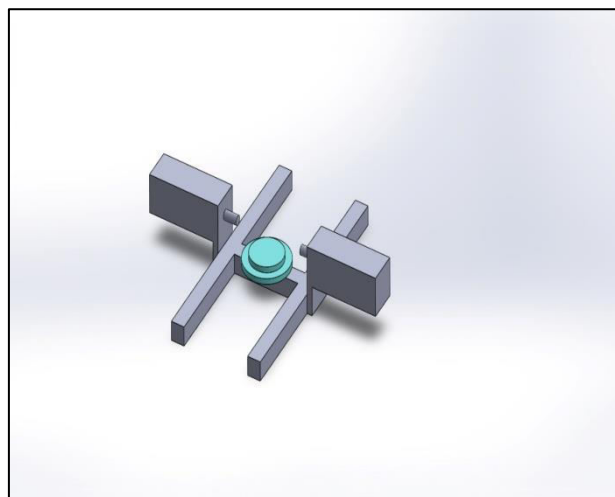
Manual handle fitting in PET jar manufacturing often leads to **inconsistent results, operator fatigue, and higher rejection rates** due to human error (Kumar & Singh, 2022). In contrast, semi-automated systems **reduce dependency on skilled labor, enhance productivity, and ensure quality consistency** by automating critical steps while still allowing operator intervention for flexibility. [4]

5. Semi-Automation in Small-Scale Manufacturing:

Studies on semi-automated machines in small-scale industries (Reddy et al., 2023) suggest that hybrid automation—where human intervention is combined with automated operations—offers a **cost-effective and scalable** solution. The proposed machine follows this approach, **reducing the physical workload on operators while maintaining affordability** for small to medium-sized. [5]

III. DESIGN OF SYSTEM

3D Setup

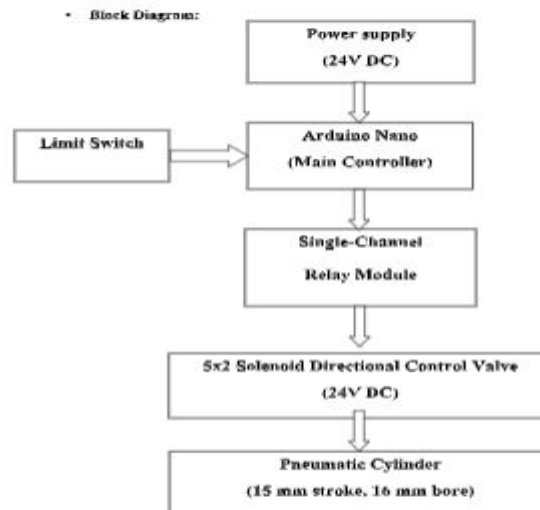




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Block Diagram



Components for prototype:

1. Pneumatic cylinders
2. An Arduino Nano micro-controller
3. A solenoid-operated directional control valve
4. A limit switch for precise positioning
5. A metallic die (EN-31) ensures accurate cap placement

IV. CONCLUSION

The **Semi-Automatic PET Jar Cap Handle Fitting Machine** successfully demonstrates an efficient and cost-effective solution for automating the handle fitting process in PET jar packaging. By integrating pneumatic actuation with microcontroller-based control using an Arduino Nano, the system ensures precise, consistent, and rapid handle placement, significantly reducing manual effort and improving overall productivity. The use of a limit switch for position detection enhances operational safety and accuracy, while the robust MS frame and EN-31 die provide long-term reliability. The machine strikes a balance between manual and fully automatic systems, making it ideal for small to medium-scale industries looking to upgrade their manufacturing process without investing in high-end automation. Overall, the project fulfills its objectives of improving efficiency, ensuring quality, and reducing worker fatigue making it a valuable addition to the semi-automated segment of industrial machinery.

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