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DESIGN AND FABRICATION OF SEMI AUTOMATIC TOOL TROLLEY

Mr. V. Vignesh, Assistant Professor, Department of Mechanical Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India
Dr. S. Gnanasekaran, Assistant Professor, Department of Mechanical Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India
S. Sivapandiyan, K. Jayavardhanavelu, K. Puvizhi Kannan, R. Sarabeshwaran
UG Student Department of Mechanical Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India

ABSTRACT

The creation of a semi-automatic toolkit for managing machine tools denotes a notable progress in automation and tool oversight within the industry. This system combines mechanical, electrical, and software elements to improve the efficiency, safety, and accuracy of machine tool functions. The semi-automatic toolbox decreases manual involvement and reduces human errors by automating repetitive tasks like tool identification, storage, retrieval, and replacement. The toolbox is created to operate alongside different machine tools, accommodating various sizes, shapes, and kinds of tools. Its semi-automatic design offers flexibility in operation, enabling the user to step in when needed, which ensures peak performance and minimizes downtime. The central features of the system comprise automated tool placement, live inventory monitoring, and smooth connectivity with CNC machines. In the end, this toolkit boosts efficiency, minimizes tool degradation, and guarantees consistent operational standards, making it an essential asset for contemporary manufacturing settings

Keywords:
Semi-automatic toolbox, Tool management, Precision, Tool identification, Retrieval, Tool replacement, Manual intervention.

I. Introduction

A semi-automatic toolkit for managing machine tools is a creative approach aimed at optimizing the handling and utilization of the different tools needed in machining tasks. In contemporary manufacturing settings, machine tools are essential for creating high-precision parts and components. Nonetheless, the physical management of tools may result in inefficiencies, a higher likelihood of mistakes, and interruptions. A semi-automatic toolbox tackles these issues by combining automation with human supervision to guarantee more efficient, quicker, and precise tool management.

This system generally integrates mechanical, electrical, and software elements to automate processes like tool recognition, storage, retrieval, and substitution. In contrast to fully automated systems, a semi-automatic toolbox enables the operator to intervene as necessary, providing a balance of autonomy and manual oversight. This toolbox streamlines workflow, boosts safety, and increases overall productivity by minimizing human involvement in routine tasks.

The adaptability of a semi-automatic toolkit allows it to work with different kinds of machine tools and machining processes. Consequently, it minimizes the likelihood of mistakes and improper tool handling while also aiding in the decrease of tool wear and prolonging the durability of essential parts. In the end, the semi-automatic toolbox is an essential enhancement for any contemporary manufacturing environment, promoting increased operational efficiency and reliable, high-quality production.

1.1 Problem statement and solution

In contemporary manufacturing settings, the management and handling of machine tools are essential for maintaining precision and efficiency. Nonetheless, the manual methods used for tool selection, storage, retrieval, and replacement frequently result in various operational difficulties.

Frequent issues involve choosing the wrong tools, losing tools, poor tool organization, and mistakes made by individuals. These problems may lead to considerable downtime, diminished productivity, heightened tool wear, and impaired work piece quality. Mistakenly choosing the wrong tools can result in machining errors, whereas misplaced tools can slow down production as employees look for the right ones. Additionally, incorrect tool replacement after machining activities can adversely affect the configuration of subsequent operations, further diminishing the efficiency of the machining process.
A semi-automatic toolkit for managing machine tools provides a complete answer to these issues by combining automation with human oversight to guarantee precision, productivity, and orderliness. This system automates essential functions like identifying tools, fetching them, replacing them, and managing inventory, thus reducing the likelihood of selecting the wrong tool and misplacing tools. In general, the semi-automatic toolkit improves operational effectiveness, minimizes mistakes, and aids in creating a safer, more structured work environment. It guarantees proper tool choice, averts tool dislocation, and enhances the management and upkeep of machine tools, resulting in increased productivity and minimized downtime.

1.2 Objectives

The main goal of creating a semi-automatic toolbox for managing machine tools is to improve the efficiency, precision, and organization of tool management in production settings. The main objectives encompass Automating Tool Handling, Boosting Productivity, Advancing Tool Tracking and Inventory Management, Reducing Tool Wear and Damage, Ensuring Flexibility and Control, along with Cost Efficiency and Consistency

II Literature

2.1 Tool Management Systems in Manufacturing

Tool management systems (TMS) have been extensively covered in studies as essential elements in contemporary manufacturing settings, especially in Computer Numerical Control (CNC) machining. The study conducted by Wu & Luo et al. (2015) examines the evolution of automated tool management systems, emphasizing real-time monitoring and automated tool selection to minimize mistakes and enhance efficiency. These systems utilize RFID and barcoding technologies to monitor the location and condition of tools, thus reducing the likelihood of tool loss and improper tool selection. Chun & Wang et al. (2017) emphasize the importance of merging tool management with CNC machines, claiming that automating tool handling could greatly decrease cycle times and enhance machining precision. Their study indicates that semi-automated systems, which integrate human supervision with automation, provide a versatile method that enhances productivity while not entirely eliminating the need for operators.

2.2 Tool Selection and Tool Identification Technologies

The problem of improper tool choice has been examined in multiple studies, especially concerning CNC machining processes. Suneel, T and Pande Sanjay et al. (2010) explore the use of smart algorithms and sensor technologies to automate the selection of tools according to the machining task. Their system utilizes data from the CNC machine to automatically select the right tool, thereby avoiding mistakes associated with the use of incorrect tools.

Simultaneously, Wang Rui and Zhao (2016) highlight the importance of visual recognition systems and machine learning algorithms for precise tool identification. They suggest that combining these technologies with semi-automatic toolboxes may aid in ensuring proper tool handling, minimizing operator involvement, and accelerating tool changeovers. Although fully automated systems are efficient, the authors contend that a semi-automatic method with a manual override provides greater flexibility, particularly in intricate or non-repetitive tasks.

2.3 Inventory Management and Tool Tracking

Effective management of tool inventory is crucial for reducing tool downtime and avoiding tool loss. Anusha et al. (2023) investigate automated tracking systems for tools that employ Radio

Frequency Identification (RFID) alongside cloud computing. These systems offer immediate tracking of tool usage and whereabouts, guaranteeing that tools are accessible whenever required. The writers suggest that integrating RFID with semi-automatic systems might offer a mix of automation and human oversight, tackling the difficulties of inventory management in busy manufacturing environments.

Additionally, Praneeth et al. (2015) examine the significance of barcode and QR code technologies in managing tools. These systems allow operators to swiftly search for and access tools from the toolbox, reducing delays associated with manual tool searches. Combining barcode technology with semi-automatic toolboxes can improve tool tracking and minimize mistakes while retrieving tools.

2.4 Flexibility and Operator Intervention

A key advantage of a semi-automatic toolbox is its capacity to merge the benefits of automation with the flexibility of the operator. Georgoulias et al. (2017) explore how semi-automation can lessen the cognitive burden on operators while still permitting manual intervention when necessary. Their research indicates that semi-automatic systems provide enhanced flexibility in settings where machine tools need regular retooling or modification. The human operator retains authority over essential decisions, like tool adjustments, while experiencing decreased physical effort related to tool management.

In accordance with this, Konstantinos et al. (2019) suggest a semi-automatic system for tool storage and retrieval aimed at enhancing the tool change procedure. Their system employs automated methods for retrieving tools, yet permits operators to manually modify the tool storage system according to the specific requirements of the machining task. This adaptability guarantees that the toolbox system is capable of managing a diverse array of tools and machining processes without sacrificing efficiency.

2.5 Impact on Productivity and Tool Wear

A major advantage of automating tool management is the ability to decrease tool wear and maintain consistent tool performance. Zhigao Chen and colleagues (2018) investigate how automated storage and management of tools affects their lifespan. They discovered that automated systems lower the likelihood of tool damage by maintaining appropriate storage conditions and reducing human mistakes during tool management. Li et al. (2021) further highlight that automated tool management systems enhance tool efficiency, decreasing the frequency of unnecessary tool replacements and consequently lowering expenses.

Fei Ding et al. (2020) contend that in semi-automatic systems, the capability to monitor tool usage in real-time aids in recognizing possible wear trends, allowing for intervention before tool failure occurs. This forecasting ability helps minimize downtime and enhances overall performance of the machines.

2.6 Future Directions

New technologies like the Internet of Things (IoT) and artificial intelligence (AI) are anticipated to have a major impact on the future of tool management. W. Eversheim et al. (2022) explore how semi-automatic toolboxes equipped with IoT can engage with various systems within the manufacturing setting, including production scheduling and maintenance systems, to improve tool utilization and boost overall workflow efficiency. By integrating predictive analytics and AI, these systems might deliver more profound insights into tool performance and usage, presenting more proactive approaches for tool management.

The research on semi-automatic toolboxes for managing machine tools emphasizes the notable benefits of combining automation with human supervision to enhance tool management procedures. Main advantages consist of minimized mistakes in choosing tools, improved tracking of tools, superior inventory management, and increased flexibility for operators. As technology advances, upcoming research will probably aim to enhance the automation and smart capabilities of these systems, enabling even higher efficiency and accuracy in tool management.

III Materials and Methods

3.1 Conceptual Design

Fig 3.1 shows the isometric view of the conceptual design and fabricated prototype and get a clear picture of various components used in the manufacturing of the semi-automatic tool trolley.

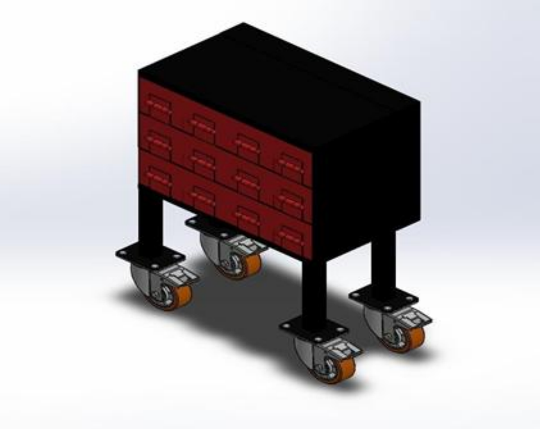

Fig. 3.1 Isometric view

3.2 Components

The major parts that are effectively employed in the design and fabrication of semi automatic tool trolley are

- Frame
- Lead Screw
- I-R Module
- Rack and Pinion Mechanism
- Wheels
- DC Motor
- Relay
- Micro control
- Limit switch
- Tools

3.3 Working Principle

This project includes an MS Frame, Lead Screw, remote control for the I-R Module, Rack and Pinion, Wheels, DC Motor, Relay, Microcontroller, Liquid Crystal Display, Limit Switch, and Tools; it centers on a user-initiated process supported by integrated automation technology in a semi-automatic tool trolley system. When a user triggers the tool trolley, usually by manual means like pressing a button or flipping a switch, the control system in the trolley starts functioning. This control system manages the operation of motorized devices that enable semi-automatic features, including motorized lifting or sliding drawers. These systems aid in the transportation and access of tools and equipment kept in the trolley's sections or drawers. During the operation, the control system guarantees accurate positioning and alignment of the tools, directed to their designated spot for convenient access or storage. Integrated safety mechanisms, such as limit switches or proximity sensors, oversee the trolley's motion to avert accidents or crashes. User feedback metrics offer instantaneous updates on the condition of the semi-automatic process, maintaining user awareness and oversight. Fig 3.2 shows the IR Module remote control and Fig 3.3 shows fabricated prototype.

Fig 3.2 IR Module

Fig 3.3 Fabricated prototype

Furthermore, a manual override feature could be added to enable users to intervene in the event of malfunctions or deviations from the intended operation. After the user finishes their task, the semi-automatic process ends, and the tool trolley goes back to a standby mode, prepared for future use. This operational principle highlights the smooth amalgamation of automation technology with user engagement, improving efficiency, convenience, and safety in managing tools within industrial and workspace settings.

IV Results and Discussion

Cost economics

4.1Labour Cost

Lathe, Drilling, Welding, Grinding, Programing, Painting: Cost = 2300

Overhead Charges

The overhead charges are arrived by "Manufacturing cost" Manufacturing Cost = Material Cost + Labour cost

= 26930+2300 = 29230

Overhead Charges = 20% of the manufacturing cost = 3360

=Material Cost + Labour cost + Overhead Charges

=26930+2300+3360

=32590

Total cost for this project = Rs. 32590

4.2 Break-Even analysis

Break-Even analysis is used to calculate the Break-Even point (i.e., the point or quantity of a product at which zero loss and zero profit will reach). The formula used to calculate the Break-Even point is,

$$Q = \frac{F}{(P - V)}$$

where,
Q - Break-Even quantity
F - Total fixed cost = Rs. 2,300 (Labour cost, Machining cost)
V - Variable cost per unit = Rs. 32,590 (Material cost, overhead expense) P - Unit selling price = Rs. 35,350

$$Q = \frac{F}{(P - V)}$$

$$Q = \frac{2{,}300}{35{,}350 - 32{,}590}$$

$$Q = 0.83$$

Therefore, the Break-Even quantity is 0.83.

4.3 Benefit-Cost ratio

Cost-Benefit ratio is used to summarize the overall value of a project. It is the ratio of project benefits to the project cost.

i. Total cost = Fixed cost per unit + variable cost per unit
= (Total fixed cost/quantity produced) + variable cost per unit
= (2,300/2) + 26,930
Total cost = Rs. 35,350 Total revenue per month
= (Revenue per unit x No. of units per month)
= (35,350 x 2) Total revenue per month
= Rs. 70,700

ii. Discount = 5%

iii. Benefit = Total revenue - (Total cost x No. of units per month)
= 70,700 - (26,930 x 2)
Benefit = Rs. 16,840

iv. Present value of benefit = Benefit / (1+Discount)
= 16,840 / (1+0.05)
Present value of benefit = Rs. 16,420

v. Present value of cost = Cost / (1+Discount)
= 35,350 / (1+0.05)
Present value of cost = Rs. 34,280
Cost-Benefit ratio = Present value of benefit / Present value of cost = 16,420 / 34,280
Cost-Benefit ratio = 0.47
Since the Cost-Benefit ratio is 0.47> 0, this project can be considered for investment with reasonable profit.

4.4 Payback period

Payback period is nothing but the time required to recover the initial cost of an investment. It is the ratio between the initial investment of the project and net monthly cash inflow. It is calculated based on month or years.
Payback period = Initial investment / Monthly cash inflow
Initial investment = Total cost per unit x No. of units developed per month
= 35350 x 2
Initial investment = Rs. 70,700
Annual cash inflow = Rs. 7500 (assumption)

Payback period = 70700 / 35350 = **2**

Payback period = 2 months

Therefore, the initial investment will be recovered in 2 months from initiation of project.

V Conclusion

This document showcases the design of a semi-automatic tool trolley project that marks a notable improvement in tool management systems, providing a flexible and effective solution for different industrial and workspace settings. By incorporating cutting-edge design elements and automation technology, this project has tackled major issues encountered in conventional tool organization techniques, improving mobility, accessibility, and productivity. The semi-automatic features, such as motorized lifting and sliding drawers, enhance user ergonomics while also optimizing workflows, which results in savings in both time and costs. Additionally, the project's future potential offers opportunities for further improvements and modifications, fueled by continuous technological progress and market needs. By utilizing findings from current literature and engaging with stakeholders, his project has established a basis for ongoing innovation and improvement in semi-automatic tool trolley design. In summary, the project highlights the significance of creativity and functionality in creating solutions that address the changing demands of contemporary workplaces, ultimately enabling users to work more productively and efficiently.

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