Prototype Design and Research Collection

Series 1

Universiti Teknologi MARA
Pasir Gudang Campus

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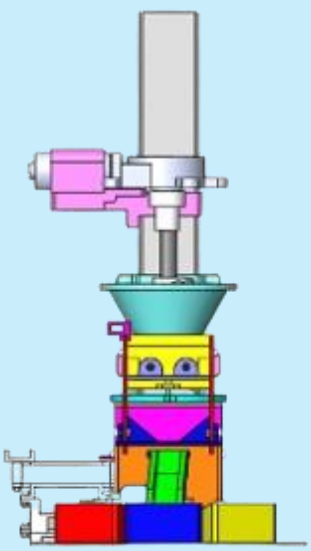

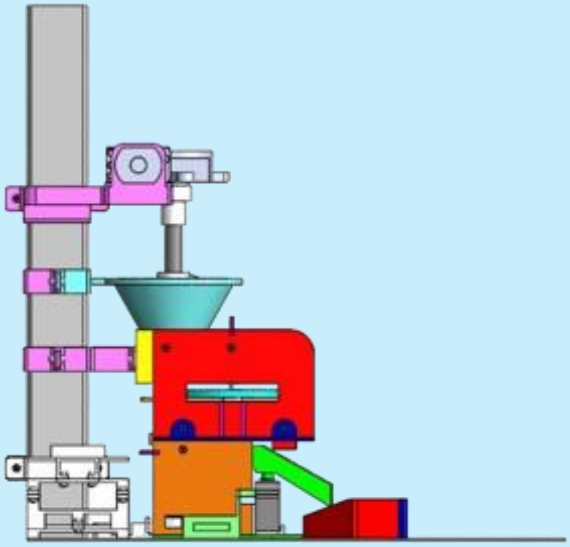

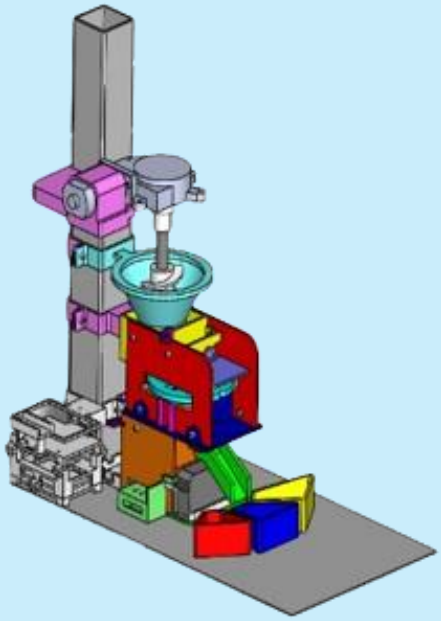

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FOREWORD

This digital book on Prototype Design and Research Collection Series 1 (PDRC Series 1), is designed as a comprehensive reference for mechanical engineering students. The designs featured in this collection undergo an extensive analysis process, incorporating both prototype development and research to ensure a thorough understanding of design principles. Each project is carefully analysed before the prototype fabrication with detailed summaries of the project description and design parameters. The design and research products presented in this series cover a wide range of tools and equipment for various applications including household, workshop and entrepreneurial purposes.

This collection aims to foster innovation by offering students valuable insights into both the technical and research aspects of product design. It is hoped that this book will inspire future engineers and designers to approach product development with a deeper understanding of the design and research processes.

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CHAPTER 2

Designing and Development of a Rechargeable Screwdriver for Assembly Project

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ABSTRACT

This project introduces an automatic rechargeable screwdriver, designed to assist people in assembling and disassembling various items like cupboards, tables, and chairs. The screwdriver operates through rotational motion powered by a DC rotary motor, enabling users to tighten or loosen screws as needed. Consideration for sustainability is a key focus of this project. Materials chosen for the product prioritize affordability and usability, with an emphasis on recyclable and reusable components. The aim is to make the screwdriver accessible to people of all ages, from youngsters to seniors, ensuring its usability across generations. The authors also evaluate the advantages and disadvantages of the screwdriver, particularly in terms of sustainability, primary functionality, and versatility. Notably, the screwdriver's design allows for easy interchangeability of tips to accommodate different screw sizes. Overall, the project aims to create a fully functional screwdriver that simplifies the task of tightening and loosening screws with a simple flip of a switch, catering to the diverse needs of users across various age groups.

Keywords: Rechargeable Screwdriver, Mini Machine, Fabrication process

1 INTRODUCTION

In contemporary consumer culture, the prevalence of online shopping stems from convenience and a desire for ease. Many individuals choose for online purchases due to a preference for convenience over traditional in-store experiences. This shift is driven by a combination of factors, including a reluctance to venture outside and a preference for the simplicity of ordering with just a few taps or clicks.

Recognizing this trend, the aim is to streamline the assembly process for items purchased online, particularly those requiring screws for assembly. This initiative is motivated by an understanding that consumers value simplicity and efficiency in their tasks.

Moreover, traditional screwdriver sets are often perceived as bulky and cumbersome due to the variety of shapes and sizes, leading to inefficiencies in storage and transportation. To address this, a proposal is made for the invention of a portable mini screwdriver, designed to alleviate the burden of carrying multiple tools. By implementing a design where only the tip of the screwdriver needs to be changed, users can enjoy enhanced convenience without sacrificing functionality.

While automatic screwdrivers with interchangeable tips already exist, they often come with a hefty price tag and weight due to their construction materials. The innovation seeks to overcome these drawbacks by utilizing cost-effective materials and prioritizing lightweight design, ensuring accessibility and ease of use for consumers [1].

In the fabrication of the automatic screwdriver, a key aspect of the project involves incorporating a rechargeable battery that can be easily removed from the screwdriver. This feature eliminates the need for consumers to carry the screwdriver while charging, reducing unnecessary weight. Rechargeable batteries offer the advantage of multiple recharging cycles, providing a sustainable and efficient power source for the screwdriver's operation.

Overall, the project aims to enhance the user experience by offering a convenient, lightweight, and cost-effective solution for assembling items that require screws, while also prioritizing sustainability through the use of rechargeable batteries [2].

2 LITERATURE REVIEW

The manufacturing process for this project encompasses several key steps: cutting, shaping, drilling, joining, and 3D printing. Each step contributes to the creation of the final product, ensuring its functionality and effectiveness.

Cutting serves as the foundational step in shaping and sizing the various components of the outer body and the tip of the screwdriver. Precision cutting techniques, such as sawing, are employed to accurately cut PVC pipes according to the required shapes and dimensions. The dimensions are marked on the PVC pipes, and then the cutting process is executed using a hand saw [3].

Drilling is another essential process utilized in the manufacturing of the product. It is employed in drilling holes in the PVC pipes to facilitate connections to the motor's tip, ensuring proper functionality of the final product. Additionally, drilling is utilized to create initial holes that are then shaped to match other parts, thereby impacting the cutting process significantly [4].

Joining plays a crucial role in assembling various components to achieve the final product. This involves connecting different parts of the tool using screws and rivets, such as the body, motor, battery, and tip. Soldering is also integral to the project, as it is necessary to solder the battery and wires to the motor, enabling its function. This process is vital as the motor requires electricity to rotate, allowing for both clockwise and counter-clockwise motion to tighten and loosen screws [5].

The incorporation of electrical components is essential for the project's functionality. Components such as the DC motor, battery, and three-toggle switch are indispensable, as they serve critical roles in providing rotational motion and controlling the direction of the motor's rotation. The DC motor, in particular, functions by converting electrical energy into mechanical energy, facilitating the operation of the screwdriver. Additionally, the six-pin toggle switch allows for the selection of two distinct devices, ensuring flexibility and versatility in operation.

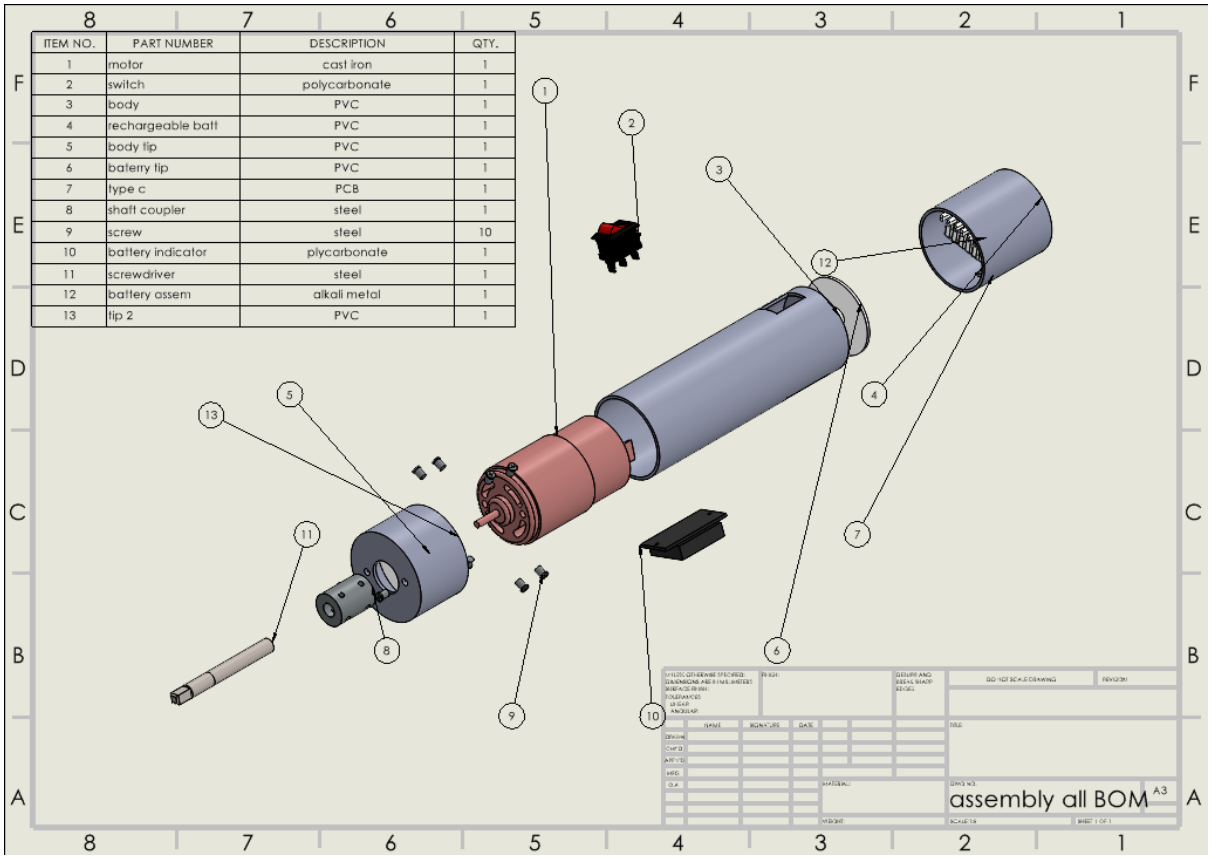
Overall, the manufacturing process involves a combination of traditional techniques like cutting and drilling, alongside modern methods such as soldering and 3D printing, to create a functional and efficient automatic screwdriver. Each step contributes to the seamless integration of components, resulting in a reliable and versatile tool for assembly tasks.

3 METHODOLOGY

3.1 Design of the prototype

The detailed drawing of the final product, once assembled, provides a comprehensive view of its components and structure as in Figure 1. The drawing includes all the components and Bill of Material used

Starting with the tip of the screwdriver, which securely holds the DC motor to prevent rotation when the screwdriver is turned on, instead of the screwdriver shaft. This component requires three drilled holes: two for M4 screws to secure the DC motor and one larger hole in the middle to allow the screwdriver shaft to pass through.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	motor	cast iron	1
2	switch	polycarbonate	1
3	body	PVC	1
4	rechargeable batt	PVC	1
5	body tip	PVC	1
6	baterry tip	PVC	1
7	type c	PCB	1
8	shaft coupler	steel	1
9	screw	steel	10
10	battery indicator	plycarbonate	1
11	screwdriver	steel	1
12	battery assem	alkali metal	1
13	tip 2	PVC	1

Fig.1: Design of the screwdriver

Moving on to the body frame of the project, this component is crucial for housing all the electric components securely. It features two square holes that need to be drilled, accommodating the battery indicator and the 3-toggle switch responsible for driving the DC motor. Additionally, the product includes an oval-shaped hole that needs to be drilled to accommodate a type-C charger, facilitating the recharge of the lithium battery. This part serves as the holder for the rechargeable battery, ensuring its stability within the overall structure of the product.

3.2 Fabrication process

The fabrication process for completing this project follows a sequential order to ensure the final product's quality and safety. It involves various steps to assemble the components effectively

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and prevent accidents during fabrication.

Firstly, the body frame preparation begins by cutting the PVC pipe to the specified dimensions of 250 mm, as determined in Final Year Project 1. After cutting, the PVC pipe's surface is sanded to ensure smoothness, facilitating easy assembly of components in the future.

Holes are drilled into the PVC body to accommodate the switch and battery indicator as in Figure 2. Safety precautions are followed during the drilling process, including the use of safety equipment like gloves, goggles, and safety shoes. The holes are initially drilled to create an opening, which is then widened using a boring process to match the dimensions of the switch and battery indicator.

Fig 2: Holes are drilled into the PVC body

The shaft is shortened to optimize force transfer from the DC motor to the screwdriver shaft, preventing torsion damage. Additionally, the shaft's bottom is modified for compatibility with the shaft coupler.A gear initially installed on the DC motor is removed to ensure proper fitting of the motor tip into the shaft coupler, facilitating efficient force transfer.The end PVC tip is measured and drilled with three holes, two for screws and one for the shaft to pass through. Special attention is given to bore a 17mm hole using a boring process due to the unavailability of a drill bit of that diameter.

Similarly, the battery holder is drilled with a single oval-shaped hole to accommodate the type-C charger. This process requires meticulous drilling and boring to ensure a proper fit for the charger.Wiring is essential to ensure the functionality of the product. The wiring process involves connecting the battery indicator and DC motor to enable proper operation. A three-toggle six-pin switch is utilized to control the rotation direction of the DC motor.

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Fig. 3: Final assembly product

Finally, all components are assembled systematically and neatly into the body frame, ensuring proper alignment and functionality as in Figure 3. However, issues arise post-assembly, as the electrical components fail to function within the body frame, despite working outside the frame. This necessitates rewiring using soldering and copper wire for improved conductivity.

4 RESULTS AND DISCUSSION

Developing a product specification is essential to equip product teams with comprehensive details necessary for incorporating new features or enhancements. In today's dynamic market landscape, customers possess diverse needs, posing challenges for industries, particularly in the tool sector. Hence, it becomes imperative to devise an effective product development approach to ensure products are not only valuable but also competitive on a global scale.

Fig. 4: Final working prototype

For user manuals, adherence to proper procedures is crucial to prevent accidents and ensure the machine's longevity. To charge the automatic screwdriver, connect a type-C charger to the port located at the bottom of the device and power it on. Users have the option to wait

for the battery to charge fully or use the machine immediately.

Upon powering the device, plug in the power supply and select the appropriate screwdriver tip for the task at hand. Attach the chosen tip securely to the screwdriver shaft, leveraging the magnetic properties of the tips to prevent detachment during operation. Test the rotation direction of the screwdriver by toggling the switch to either I (clockwise rotation) or II (counter clockwise rotation).

Position the screwdriver tip onto the target screw and activate the automatic screwdriver. Exercise moderate force to avoid damaging both the screw and the screwdriver tip while ensuring safety during operation. Following these steps diligently ensures efficient completion of screw-driving tasks while maintaining the integrity of both the equipment and the workpiece.

The screwdriver machine presents several notable advantages, primarily in its ability to effortlessly handle screws of various sizes and shapes, both tightening and loosening them with ease. By simply attaching one of the diverse screwdriver tips to the screwdriver shaft, users gain the flexibility to utilize the machine across a wide array of screw types. This adaptability extends to tasks such as assembling or disassembling machines, furniture, and numerous other objects, enhancing its utility across diverse applications.

Moreover, operating the automatic screwdriver is remarkably straightforward, requiring minimal effort and reducing fatigue even during extended use. Users can activate the machine with ease, following simple steps that involve flipping a switch and directing the tip towards the screws needing attention.

Furthermore, the product stands out for its durability and robustness, delivering a heavy-duty performance that ensures longevity. Despite its substantial weight, this characteristic contributes to its swift operation, further enhancing its efficiency and reliability.

5 CONCLUSIONS

This project focused on the development of an automatic rechargeable screwdriver machine, which involved several stages. Initially, three design concepts were sketched out, and the final design was then created using SolidWorks software. Following some modifications, the design was finalized, leading to the fabrication of the automatic screwdriver. The fabrication process spanned approximately 8 weeks.

The resulting automatic rechargeable screwdriver has proven to be highly reliable for both tightening and loosening screws. Its versatility allows it to accommodate various sizes of screws, thanks to a wide selection of screwdriver tips. Through rigorous testing with screws of different shapes and sizes, the machine has demonstrated efficient operation.

The primary objective of this research was to translate the design and analysis conducted during Final Year Project 1 into a functional automatic screwdriver. Moving forward, recommendations are essential to fully maximize the potential usage of the automatic screwdriver. These suggestions aim to enhance its performance and address any potential areas for improvement.

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