FABRICATION OF RECHARGEABLE SCREWDRIVER FOR SMALL-VOLUME ASSEMBLY PROCESS

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ABSTRACT

This project presents the fabrication and concept of a rechargeable screwdriver that helps people assemble and disassemble items like cupboards, tables or chairs. The rechargeable screwdriver uses rotational motion with a DC rotary motor. The screws can be driven to tighten or loosen by pushing a switch. The product aims to give better accessibility to all generations of age, from young people to teenagers, adults, and senior citizens, as it will be much easier to use and does not require much force. Besides that, this project also discusses the product's sustainability, where the product's material is mainly focused on cheap but usable items and recyclable and reusable items. In conclusion, the developed prototype of an electric screwdriver is handy for many tasks and comes with different tips for different screws. Overall, the screwdriver is safe and easy to use and is expected to last longer than a typical rechargeable screwdriver.

Keywords: screwdriver, rechargeable, DC rotary motor

1.0 INTRODUCTION

Screwdrivers are tools that can tighten and loosen screws that exist in many pieces of assembly items such as tables, chairs, cupboards and many more. Screwdrivers are becoming basic equipment nowadays. People need screwdrivers as much as people need houses because screws are becoming a basic component of home furniture and appliances. So, the demand for screwdrivers is increasing with time. From time to time, the availability of new types of screws in the market also increases, so many types of screwdrivers are required to be produced for different purposes.

Most users have basic screwdrivers in many sizes, which causes them to need more space than they are supposed to because their shape and sizes are different from the usual screwdriver. The situation causes a burden to the user to carry all of them when repair work is required. Thus, to solve the problem and increase work efficiency, a portable screwdriver was introduced in the market [1]. This type of screwdriver only must change its tip to the needed type before it can be used.

Other than that, not to deny that there are already automatic screwdrivers with the same concept as this study, where the user only needs to change the screwdriver's tip before using them. However, most are expensive and heavy because of their material. So, the current study focused on fabricating the screwdriver using cheaper materials and making it light to always be easy and ready to use.

Many types of screws are differentiated with sizes. The small size screw is most likely to be used in electronic items such as mobile phones, laptops, computers, and many more. Screws with medium size are most likely to be used in basic items that we handle in life, such as cupboards, cabinets, tables and chairs and such. Moreover, big-sized screws are primarily used in heavy engineering items such as engines and building structures.

The focus point of this project was to make a portable mini screwdriver that can be brought anywhere. It is used whenever users like the medium-sized screws, where the medium-sized screws are focused on home furniture and appliances to assemble and disassemble the items.

Previously, several innovations related to the screwdriver were reported. Henry F. Phillips (Pattern number: US20140305267A1) of the United States patented the flat slot screwdriver in 876, though the screwdriver was invented in the 17th [2]. The invention is a flat slot screwdriver designed for improved performance and usability. It features a durable metal tip that securely fits into flat slot screw heads, reducing slippage. The comfortable handle enhances grip and control; additional features like magnetic tips or interchangeable bits add versatility. The screwdriver optimises torque transfer, making it practical for turning and tightening flat slot screws. Overall, it is a viable and cost-effective tool for various applications.

In addition, John P. Thompson invented the Philip screwdriver and patented it in 1932 (Pattern number: US1908080) [3]. The invention concerns a self-cleaning Phillips screwdriver that offers improved performance and convenience. It features a unique cross-shaped tip made from durable materials for optimal engagement with Phillips screw heads. The handle is designed for comfort and may include additional features like an ergonomic grip, magnetic tips, or interchangeable bits. The self-cleaning aspects are achieved through innovative design elements such as self-clearing channels or flutes that remove debris from the screw head during operation. The invention aims to provide a cost-effective and efficient tool for screw-driving tasks [4].

The first electric screwdrivers were introduced in the early 1900s (Pattern number US7498526B2) [5]. The bulky design operated using electric motors connected to a power source. They were often used in industrial settings where the function was the same as the regular screwdriver, but they prioritised efficiency and speed. Then, the demand for electric screwdrivers went wild, causing developers to invent electric screwdrivers with a battery as the power source called cordless screwdriver, invented in the 1960s. These cordless models offer greater portability and convenience as they no longer rely on limited-distance power sources.

This low-cost screwdriver with the rechargeable project was needed because the number of people buying furniture online has increased rapidly since the pandemic [3]. Thus, screwdrivers are becoming a demanding product for most citizens. Screwdrivers, driven by electrical motors, make it easier to assemble the items, mainly for those who use screws such as tables, chairs, and cupboards [6].

By developing a low-cost automatic screwdriver, this project aims to fulfil the consumer demand for screwdrivers, especially those who do not want to spend more money on such a product when they can use manual screwdrivers. With this product, they can use an automatic screwdriver with less money needed. This project's scope was to design and fabricate a low-cost automatic screwdriver suitable for most generations of consumers to use. The study focused on citizens, especially those incapable of using manual screwdrivers, such as seniors. The period for the study to be conducted is six months.

2.0 RESEARCH METHODOLOGY

The project utilised the theories and principles of mechanical engineering and mechanical parts to design and fabricate the tool. The study involved a design process incorporating computer-aided design (CAD) software. Fabrication involves using readily available materials, welding, and joining processes.

This project follows a systematic approach, examining existing screwdrivers and electric models through a literature review. Follow the design process of a new tool based on the needs expressed by regular users unfamiliar with manufacturing. The project aims to keep costs low and enhance user-friendliness by using PVC pipes as the primary body material. Prototypes are crafted using various manufacturing methods like cutting, sawing, drilling, wiring, and assembly to ensure efficiency and accuracy for users. These prototypes undergo rigorous performance tests and design improvements to prioritise sustainability and functionality based on the test feedback. Finally, the process includes documenting and finalising, resulting in an automatic screwdriver that's both sustainable and easy to use, catering to the needs of diverse users [7].

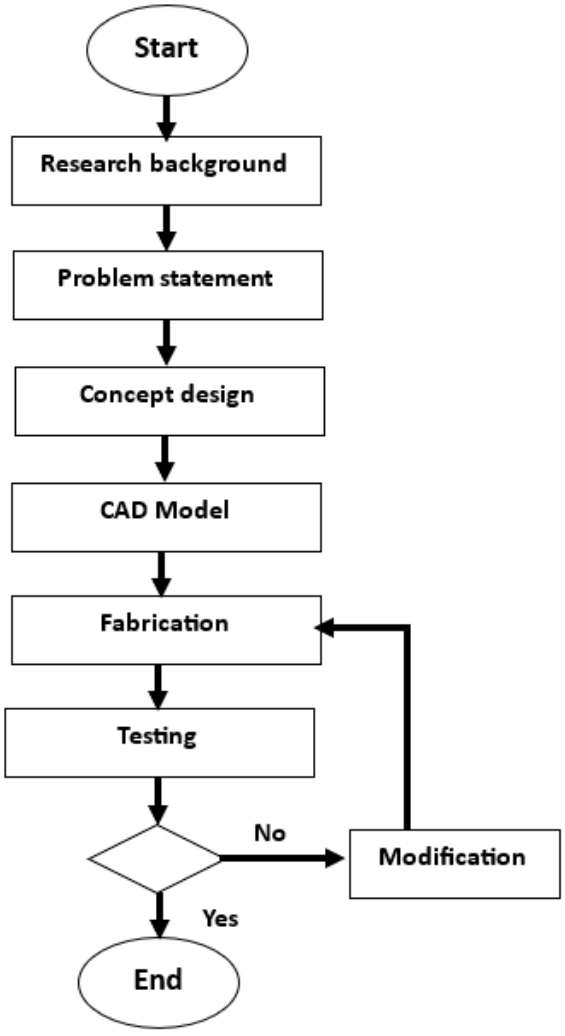

Figure 1: Flow chart of the study

Flowcharts are crucial for enhancing processes. Figure 1 shows the project's journey from the beginning until completion. The process serves as a graphical representation, aiding in recognizing process elements and comprehending how different steps relate [8].

2.1 Concept Design

In order to make this project a success, brainstorming was done, and the outcomes were three different sketches with improvement in each sketch. Concept design sketches were made with freehand, as shown in Figure 2, which designers like architects and engineers use as a summary of the product and a quick way to deliver information about the product. The design sketch below shows the design and its differences.

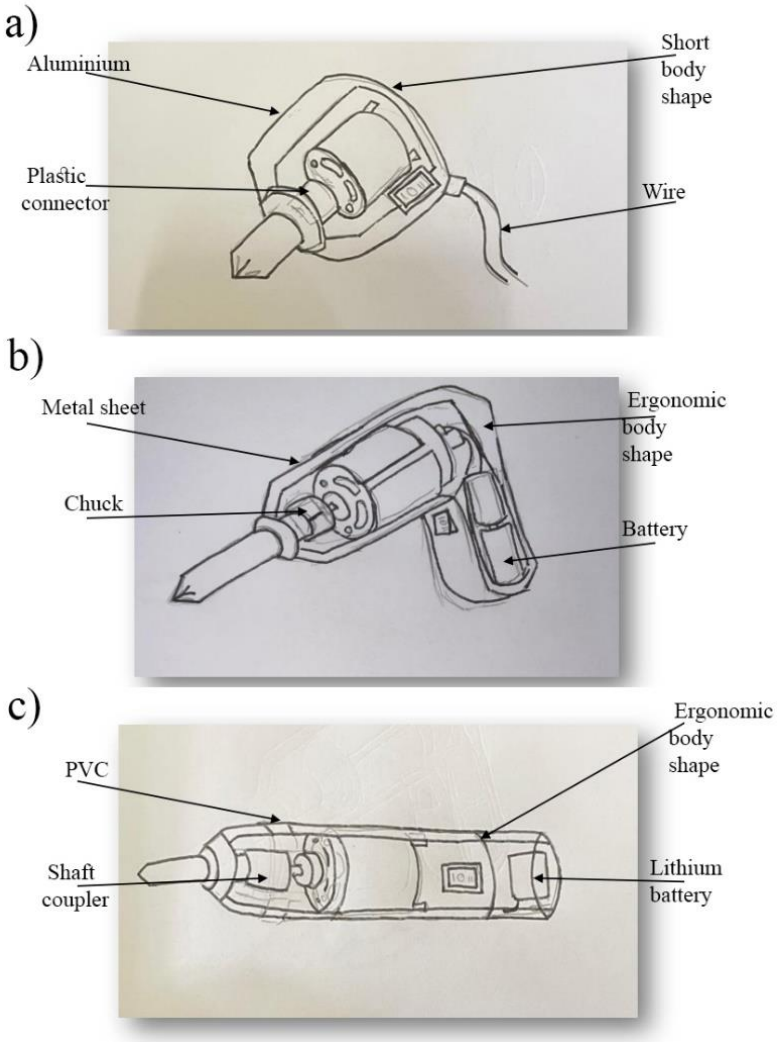

Figure 2: Concept design sketches a) First design 2) Second design 3) Third design

2.2 Pugh Chart and Final Model

In the early design process, the Pugh chart is a simple tool for comparing design ideas against the design criteria. This step is crucial as it helps to reduce emotion and bias from the decision-making process, provides a consistent approach for selecting among several concepts, and provides a tool to define a hybrid design or solution based on the best characteristics from several options [9].

Assigning weightage to each criterion in the Pugh chart involves evaluating each criterion's relative importance or priority in achieving the project's objectives. Weightage is usually determined on a scale of 1 to 5, with higher values indicating more significant importance. Experts' insights, stakeholder input, and the project's specific needs and context guide the assignment of weightage. Table 1 shows the Pugh chart evaluation with a suggested weightage allocation for six criteria. Due to its importance, performance, energy, and force distribution have more weight than others. The performance and force distribution have a value of 4, showing it is much more important than the others. Energy with a value of 3 is essential but not as important as performance and force distribution [10].

Table 1: Puch chart for design concept evaluation

Description					
Criteria	**Weight**	**Datum** 	**Design 1**	**Design 2**	**Design 3**
Performance	4	0	+	+	++
Cost	1	0	-	--	--
Vibration	1	0	++	+	+++
Energy	3	0	+	+	++
Mass production	1	0	+	+	+
Force distributes	4	0	++	+	+++
+			6	5	11
0			0	0	0
-			1	2	2
Net score			5	3	9

Referring to Table 1, necessary measures must be considered in detail to study each concept design's score. The consideration was to help get a systematic design alternative with each pro and cons considered relative to the design criteria. When using the product, the criteria considered are performance, cost, vibration, maintenance, mass production, and force distribution, which are priorities of most users [11].

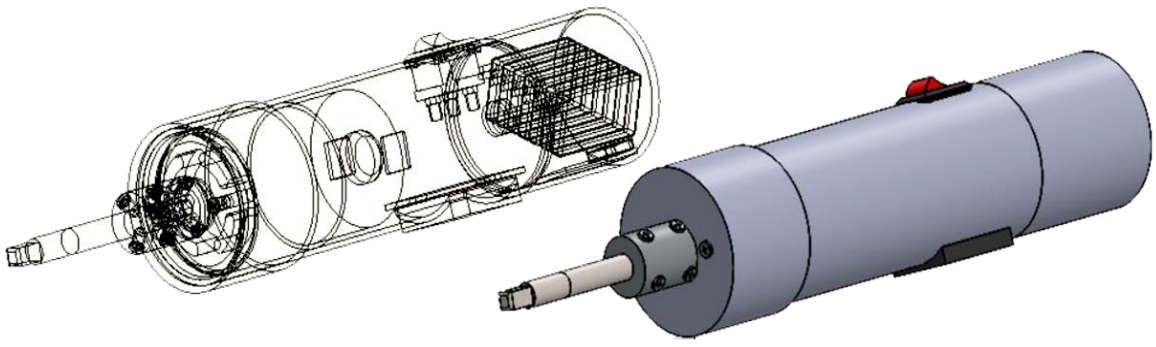

Figure 3: CAD model of the screwdriver based on the Pugh chart evaluation

The detailed CAD model in Figure 3 shows the fully assembled model of the screwdriver. The machine was designed to secure the DC motor and prevent rotation during operation. Three holes are required for this component: two M4 screws to hold the DC motor and a bigger central hole to accommodate the screwdriver shaft.

Besides, the body frame was necessary for completing the product. This component houses all the electrical elements securely, preventing any accidental dislodging. It features two square holes for drilling, designated for the battery indicator and the 3-toggle switch responsible for driving the DC motor.
For the bottom part of the product, an oval-shaped hole was indicated, tailored to fit a Type-C charger for recharging the lithium battery. This section serves as the enclosure for the rechargeable battery.

2.3 Fabrication

The fabrication process for the screwdriver involves several critical steps, each requiring attention to detail and safety considerations. Initially, the PVC pipe was cut to the specified length of 250 mm. This step ensures that the screwdriver body is in the correct size. Following this, the surface of the PVC pipe is sanded to ensure smoothness, facilitating seamless assembly and preventing difficulties in joining components later on. Holes are then drilled to accommodate the switch and battery indicator. Safety precautions were considered by wearing gloves, goggles, and safety shoes, which are strictly adhered to during this drilling process to prevent accidents.

The shaft undergoes sawing to shorten its length, optimizing force transfer from the DC motor and ensuring compatibility with the shaft coupler. Gears initially installed on the DC motor were removed to enable the motor tip to fit smoothly into the shaft coupler, facilitating effective force transfer. End PVC was used for the screwdriver tip, and careful measurements were taken to ensure compatibility with the screwdriver body. Three holes were drilled in the tip: two for screws and one for the shaft. The drilling process involved using both 4mm and 17mm boreholes, with the latter requiring a widening process using a boring tool due to the unavailability of a suitable drill bit.

Like the tip, the battery holder was assembled with an oval-shaped hole drilled to accommodate a Type-C charger. Boring processes are employed to ensure a proper fit. Wiring is essential for functionality. A three-toggle six-pin switch was used to control both the DC motor and battery indicator. Wiring must be carefully executed to ensure proper operation. Finally, all parts are assembled according to specifications, ensuring neatness and proper alignment. However, issues may arise post-assembly, requiring troubleshooting and potential rewiring. In case of malfunctioning electrical components, rewiring processes are undertaken, including soldering and using heat string. A switch from steel to copper wire is also made to improve electrical conductivity. The screwdriver fabrication process can be completed effectively by following these steps precisely, as shown in Figure 4, resulting in a functional and safe product.

Figure 4: Final prototype

3.0 RESULTS AND DISCUSSION

Selecting the appropriate screwdriver for a specific task is essential to avoid damaging screws or surfaces. Incorrect type or size usage can result in stripped screws or potential injury, underscoring the necessity of matching the screwdriver to the screw head for both efficient and safe utilisation. Thus, maintaining a diverse selection of screwdrivers equips individuals to address various maintenance, repair, and construction tasks effectively.

The product of this project is an electrical screwdriver with distinct functionality that integrates electric energy. Electric screwdrivers operate similarly to their manual counterparts but with the added convenience of power. These tools utilise an electric motor to tighten or loosen screws, eliminating the manual twisting or turning requirement. Electric screwdrivers offer flexibility in application in both corded and cordless variations. They expedite tasks by automatically applying torque to drive screws into surfaces or remove them, which is particularly advantageous for projects necessitating repetitive or extensive screwing. Additionally, the screwdriver often features speed control and adjustable torque settings to ensure precision and prevent over-tightening or stripping of screws. Electric screwdrivers find widespread use in assembly lines, construction, woodworking, and various DIY projects, significantly reducing manual effort while maintaining accuracy and efficiency.

In this project's final product, multiple tips were incorporated to accommodate various screw types. Interestingly, despite the assortment of tips, users only require one tool for all their tool needs. The key lies in interchangeable tips that seamlessly attach to the main part of the tool. These tips come in different shapes and sizes, such as flathead, Phillips, Torx, and more, catering to different screw heads. Once users identify the screw type, they can easily swap the tip to match, enhancing versatility without the need for multiple tools cluttering the toolbox. With just one product, users can efficiently handle a wide array of screws, simplifying their tasks and increasing overall efficiency.

The benefits provided by a product are tailored to meet the user's needs, desires, and preferences. Accordingly, the automatic screwdriver machine offers distinct advantages by facilitating the tightening and loosening of screws of various sizes and shapes. Users can easily attach one of the different screwdriver tips to the screwdriver shaft, providing them with the flexibility to utilise the machine with different screw types. This versatility extends to assembling or disassembling a wide range of items, including machines, tables, chairs, cupboards, and other objects, enhancing the tool's usability across diverse applications.

Moreover, operating the automatic screwdriver requires minimal effort, streamlining the process and reducing fatigue during prolonged use. Users need to follow simple steps to activate the machine, which involves flipping a switch and directing the tip towards the targeted screws for tightening or loosening. Additionally, the product is characterised by durability and robustness, offering heavy-duty performance that ensures longevity. Although it may have a substantial weight, this attribute contributes to its efficient operation.

4.0 CONCLUSION AND RECOMMENDATION

The process of making the screwdriver involves careful and safe steps. It starts by cutting and smoothing a PVC pipe, then drilling holes and cutting the shaft. Ensuring the screwdriver tip and battery holder fit well is also essential. Wiring is done neatly, and any problems after assembling are fixed by rewiring. The wire material is changed for better electricity flow. Choosing the right screwdriver is important to avoid problems. An electric screwdriver is handy for many tasks and comes with different tips for different screws. It is easy to use and lasts a long time. Overall, the screwdriver is safe, easy to use, and lasts long. It helps get jobs done faster and better.

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