Prototype Design and Research Collection

Series 1

Universiti Teknologi MARA
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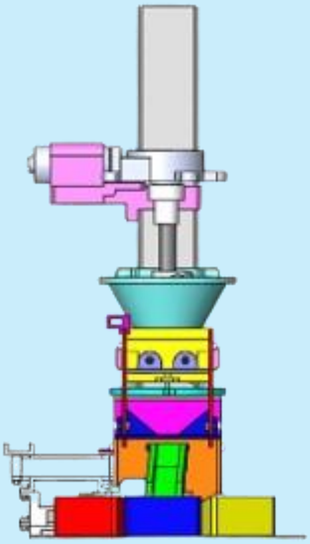

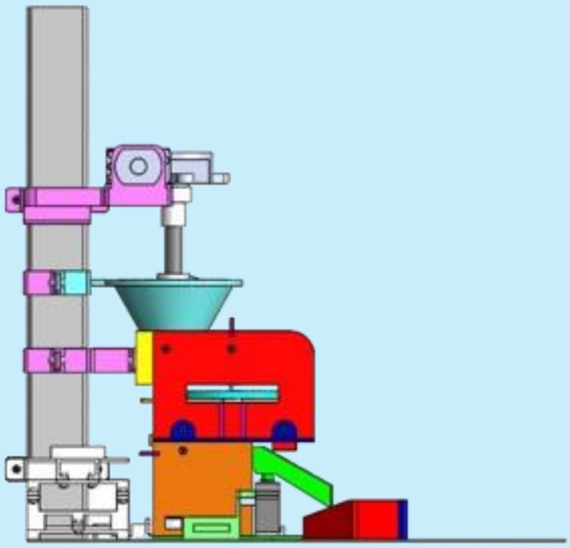

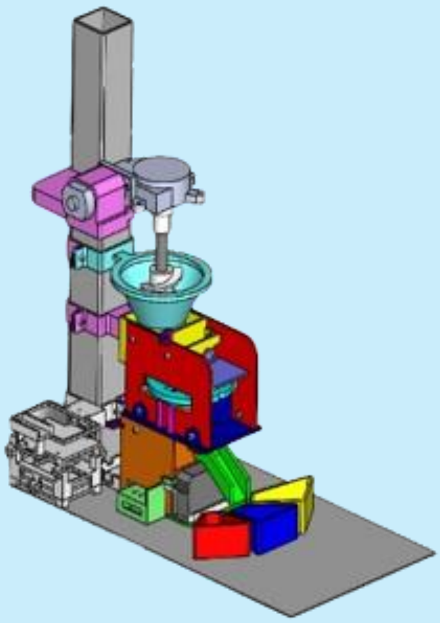

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FOREWORD

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 1

Development of a Motorized Skateboard Prototype

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ABSTRACT

According to findings, many individuals in the community are concerned about the safety of skateboards, which may reach high speeds and are sometimes difficult to manage. To address these issues, a novel motorized skateboard was proposed so that it can be more closely controlled, if not outright outlawed, to safeguard the safety of riders and pedestrians. Hence, this project aims to design and fabricate a motorized skateboard. The prototype of the motorized skateboard consists of a motor, battery, wheels, deck, and speed control. The axle has two wheels at the front and back that will connect to a deck but one of the axles has a motor and timing pulley that connect to it so that the wheels can rotate automatically by the motor. Other than that, to move the motor and speed control, a 12V 1.3AH battery that generated as a power source to the motor so that it can move the skateboard.

Keywords: Motorized skateboard, Remote control

1 INTRODUCTION

A motorized skateboard is a device that has a motor and can be moved by humans without the need for any force. This invention was made for those who enjoy skating, but in a unique fashion in which the skateboard can move on its own and the user simply needs to put their feet on the deck and move about with it. Furthermore, the skateboard is often controlled by a wireless hand-held throttle remote or by the rider changing body weight between the front of the board for forward speed and the back for braking. This autonomous skateboard comes with cruise control and a motor that allows the skateboard to go from one location to another. Cruise control is a useful function seen in many automobiles, and it is easy to put it on a motorized skateboard to make the experience even more comfortable. This will allow individuals to drive at a consistent speed in their little vehicles [1].

Motorized skateboards are fresh to those who have never heard of them, and they are something that people should try. Motorized skateboards have grown in popularity in recent years, and with good reason. They have several advantages over traditional skateboards, making them a more practical mode of transportation for many people. Riders on a motorized skateboard can travel longer distances more quickly and with less physical effort, allowing them to cover more ground in less time. This makes them an excellent choice to work or school, running errands, or simply exploring the city.

This project aims to develop a motorized skateboard that can converts motor power to mechanical power. The process of development of the prototype starts with the design of the prototype using SolidWorks. Then, the prototype were fabricated using cutting, grinding, drilling, turning and assembly.

2 LITERATURE REVIEW

A skateboard is a type of sports equipment used for skateboarding. It typically consists of a wooden board or deck, with four wheels attached to the underside [2]. The deck is usually made of high-quality wood and the most commonly used is maple wood due to its slow growth under impact and possess high stability [2]. The wheels are usually made of urethane or other durable materials. Skateboards come in a variety of shapes and sizes, with different designs and features depending on the intended use. Some skateboards are designed for street skating, while others are designed for downhill racing or cruising. Skateboarding can be a fun and exciting way to get exercise and explore the outdoors.

There are several motorized skateboards that are already patented. One of it is as shown in Fig. 1, a skateboard patented by Aaron M. King from United States (Pattern number: US20200391098A1). In this patent, it is explained that the motorized skateboards allow users to utilize a power supply, such as a rechargeable battery pack, that is remote with respect to the skateboard. The skateboards can also have the battery mounted on, under, partially or wholly enclosed within, and/or integral with the skateboard deck. The drive wheel adaptor allows the user to modify standard skateboard wheels to use as drive wheels for the electric skateboard. Because of the strength of the link between the drive hub and the wheel, the skateboard can use higher torque without failing [3].

Another example of patented electric skateboards is an invention by Peter Treadway and Janelle Wang from United States (Pattern number: US20220023746A1)[4]. They indicated that their electric skateboard has a frame assembly that includes a deck with an opening of the deck to house a battery case mounted to the bottom of the deck. The first and second wheels are powered by one motor with a differential and a shaft coupled to the first and second wheel. The motor is then coupled to the shaft to rotate the first and second wheels. The motor is electrically connected to the battery pack through a rear channel. The motor rotates the first and second wheels in the same direction and propels the electric skateboard forward and backward [4].

(a) (b)

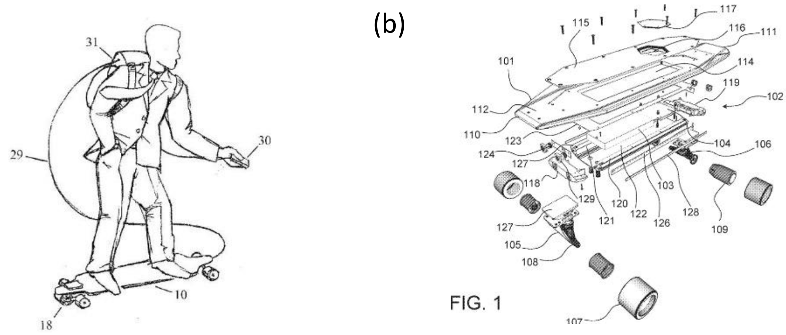

Fig. 1: Motorized skateboards patented by (a) Aaron M. King [2] and (b) Peter Treadway and Janelle Wang [3].

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3 METHODOLOGY

3.1 Design Process

The 3D model parts were designed using Solidworks. An assembly document was created by joining all parts through regular and mechanical mates. Finally, a technical drawing was generated from the assembly document with all dimensions and a list of material necessary to build the prototype [5].

3.2 Fabrication Process

The fabrication process was conducted using the design completed in Solidworks. The fabrication process done were as shown in Table 1.

Table 1: Fabrication process of a motorized skateboard.

Process	Picture
Marking the board The deck of the motorized skateboard will go through a marking process first. The dimension was 200 mm wide and 750 mm length.	
Cutting process using vertical saw machine The cutting process were conducted using a vertical saw machine with the help of assistant engineer to make sure that no accidents happen during this process.	
Grind the board using sanding belt machine The board was grinded to get a smooth surface at every corner of the board to make sure there is no wood fragments each vertex.	
Cutting the plate using vertical saw machine The plate was cut with the applied dimension to put it under the deck so that it can support the weight of the rider that uses the skateboard.	

Drilling process Drilling were used to make holes in the deck. Safety precautions were taken by wearing a glove when use the machine.	
Turning process The process proceeds with turning process to make wheels with nylon by using a lathe machine. This process needs to be done to get the wheel with inner diameter that has been applied through turning process.	
Plate Drilling Process Plates were placed under the board to make sure the board has more strength to support the load. Holes on the plate were also conducted using drilling process. This is done so that the board will not easily bend or break because it has the strong support.	
Assembly Process Assembly processes were conducted using screws to connect the parts. Motor was placed and connected to the motor holder and timing pulley that was already connected to the wheels.	 

4 RESULTS AND DISCUSSION

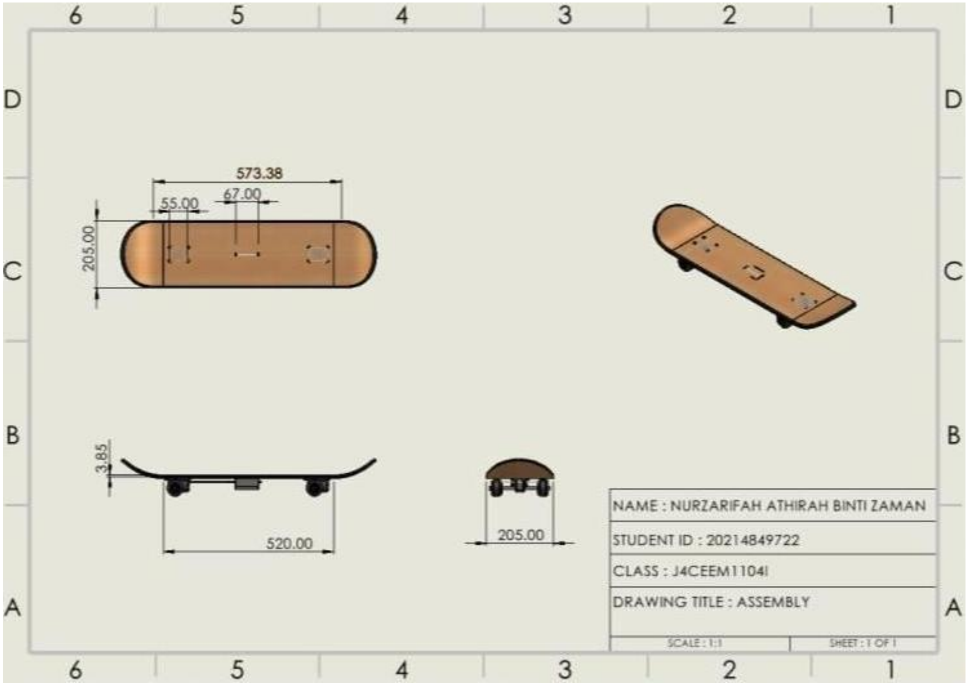

Figure 3.1 Assembly Drawing

An assembly shows the final assembly on the drawing board with a dimension and final design of motorized skateboard. The whole dimension is 573.38 mm and 3.85mm in thickness.

4.1 Final Fabricated Prototype

The prototype of the motorized skateboard consists of motor, battery, wheels, deck and speed control (Figure 4.1 ~ Figure 4.3). The axle has two wheels at the front and back that will connect to a deck but one of the axles has motor and timing pulley that connect to it so that the wheels can rotate automatically by the motor. Also, the motor will connect to the speed control to control the speed whether the rider wants it to be slow or faster. Other than that, to move the motor and speed control, two of these will connect to the battery 12V 1.3AH that generate as a power source to the motor so that it can move the skateboard.

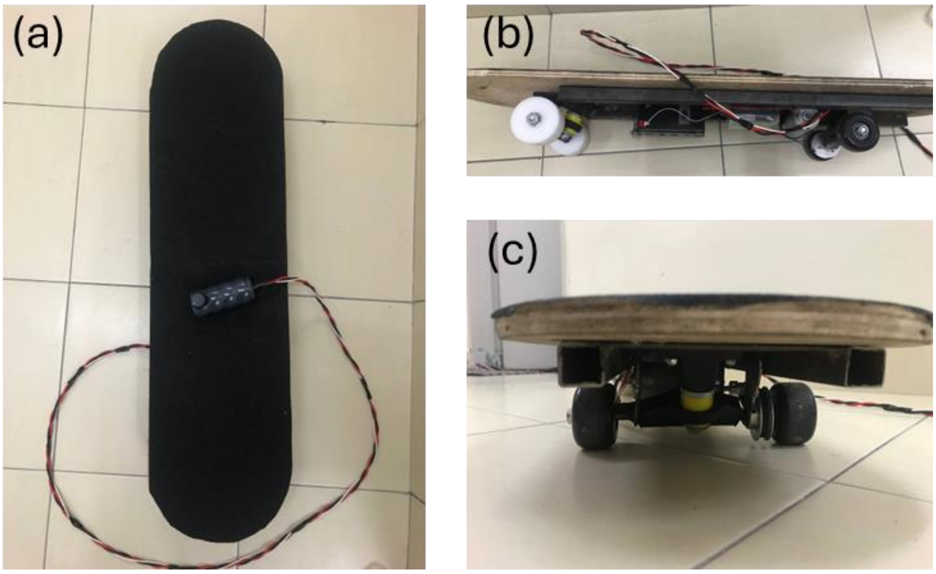

Figure 4.1 (a) top view, (b) side view, and (c) front view of the motorized skateboard.

5 CONCLUSIONS

In conclusion, designing a motorized skateboard requires careful consideration of the power source, control system, construction and adherence to local regulations. By taking these factors into account, it can create a motorized skateboard that offers a thrilling and safe riding experience.

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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.

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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.

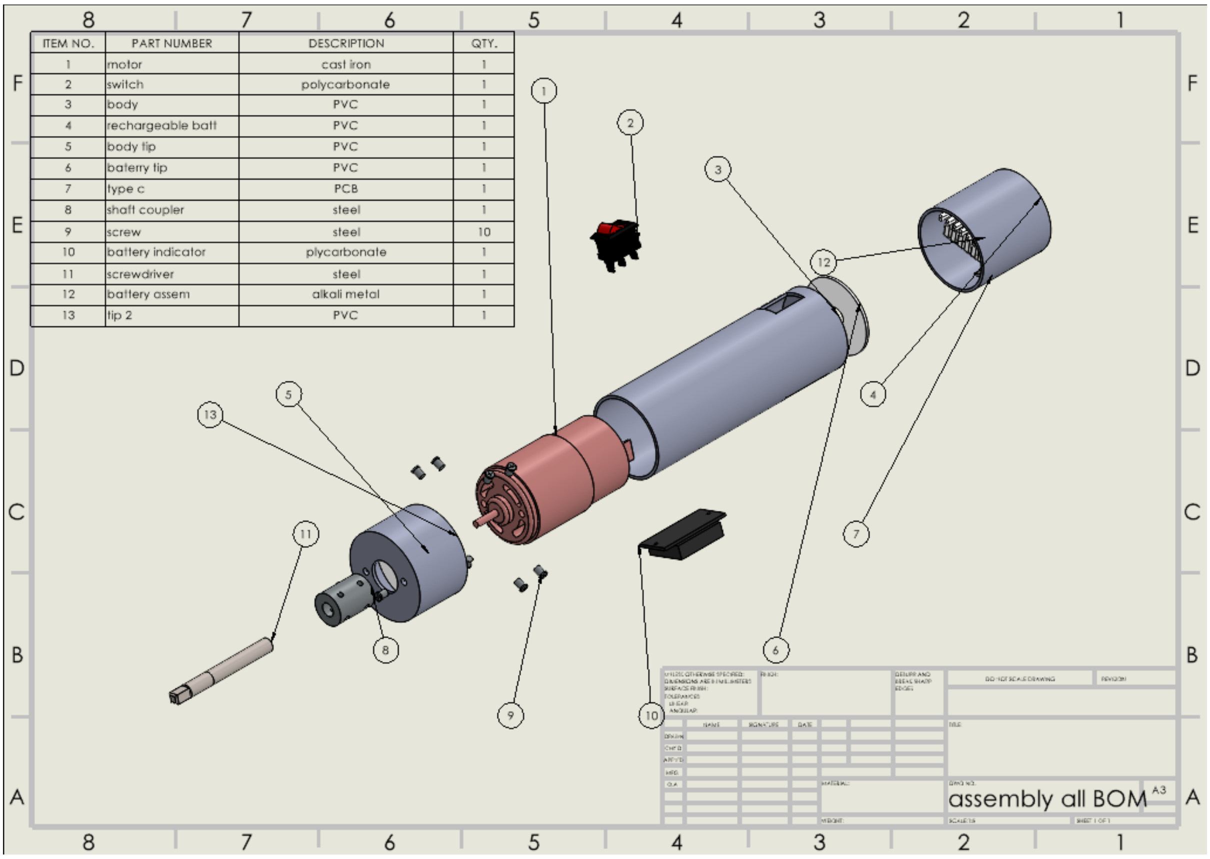

Fig.1: Design of the screwdriver

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 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.

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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CHAPTER 3

Conceptual Design of a Multifunctional Barbeque Set

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ABSTRACT

Addressing the limitations of conventional BBQ sets, which often lack user-friendly features and are limited to basic grilling functions, this project focuses on developing a conceptual design that integrates a griller and a skewer attachment. The design process involves utilizing SolidWorks software for modeling and analyzing the BBQ set design, with careful consideration given to material selection to ensure durability and safety. By combining innovative design elements with a focus on functionality and material quality, this conceptual BBQ set seeks to establish a new standard in the market, providing consumers with a versatile option that meets a variety of needs. This project represents a significant advancement in improving the BBQ experience and aligning with the changing preferences of consumers.

Keywords: Multifunction barbeque, Griller, Skewer

1 INTRODUCTION

Barbecue culture, deeply ingrained in social gatherings and culinary traditions worldwide, continues to evolve alongside modern lifestyle preferences. In Malaysia, where outdoor barbecues are a cherished pastime, the demand for efficient and versatile barbecue sets is on the rise. According to recent market research, the barbecue equipment market in Malaysia is witnessing steady growth, with an annual increase in demand of approximately 5%.

However, despite the popularity of barbecuing, users often encounter significant challenges with existing barbecue sets, which primarily offer limited functionality and pose safety and health concerns. The prevalent issues include the lack of adjustability in grillers, non-ergonomic design, cumbersome charcoal replenishment processes, and compromised food quality due to inadequate design features.

Recognizing these challenges, the objective of this study is to propose a conceptual design for a multifunctional barbecue set (BBQ) that addresses the aforementioned shortcomings while enhancing user experience, safety, and productivity. Through meticulous analysis of user requirements and innovative design strategies, this research aims to offer practical solutions to improve the overall barbecue experience for both consumers and vendors in Malaysia.

2 LITERATURE REVIEW

Barbecuing typically serves as a social gathering and is generally considered a safe recreational activity. In Malaysia, under Environmental Quality Act 1974 [Act 127] Environmental Quality (Prescribed Activities) (Open Burning) Order 2000 stated that open burning from outdoor grills, barbeques or fireplaces for the preparation of food which is not carried out at any peat soil area is allowed (Environmental Quality Act 1974 (Act 127), Regulations, Rules & Orders, 2015) [1]. In traditional grilling, charcoal serves as the primary heat source, and the food is cooked by rotating it frequently. Unlike alternative cooking techniques such as frying, steaming, or smoking, grilling involves higher temperatures, with ingredients directly exposed to flames. Consequently, this direct flame contact generates a greater amount of harmful substances during the grilling process, potentially emitting pollutants into the environment or posing a risk of burns to individuals operating or in the vicinity of the barbecue [2]. Conventional large BBQ sets typically only offer grilling functionality and are often bulky and stationary, making it difficult to relocate them to a more convenient location when needed [3]. Besides, it is widely acknowledged that extended periods of grilling can strain the neck and back. An ergonomic expert recommends that individuals operating a BBQ should ensure that their elbows are at the same level as the grill surface when standing [4].

Furthermore, a user-friendly and portable BBQ set is preferable due to its convenience, versatility, and ease of use. Portable BBQ sets offer unparalleled convenience, allowing users to grill anywhere and anytime, whether it's at a park, camping trip, or tailgate party [5] ,[6]. In addition, the advantages of using a multifunction BBQ set over a traditional BBQ set offer the ability to switch between different cooking styles, such as gas and charcoal grilling, providing a wider range of culinary options for users [7]. These sets often come equipped with advanced features like precise temperature control and even heat distribution, ensuring consistent and delicious cooking results. Additionally, multifunction BBQ sets are designed for durability, making them a long-lasting investment compared to traditional BBQ sets that may deteriorate over time.

3 METHODOLOGY

The concept design of this multifunction BBQ set is divided into 7 steps outlined as follows:

a) Define design requirements

Based from the literatures and competitive benchmarking products, the functional requirements of the multifunction BBQ set are indentified, considering factors like cooking methods, size, portability, materials, and user interface.

b) Generation of schematic diagrams

The schematic diagrams are created to illustratre the overall layout and components of the multifunction BBQ set as shown in Figure 1. This diagram helps visualize the design concept and understand the integration of different functions available in the multifunction set. Based from Figure 1, it was shown that the proposed BBQ set consists of main and subfunction and further illustatrates the cooking and support components in the set.

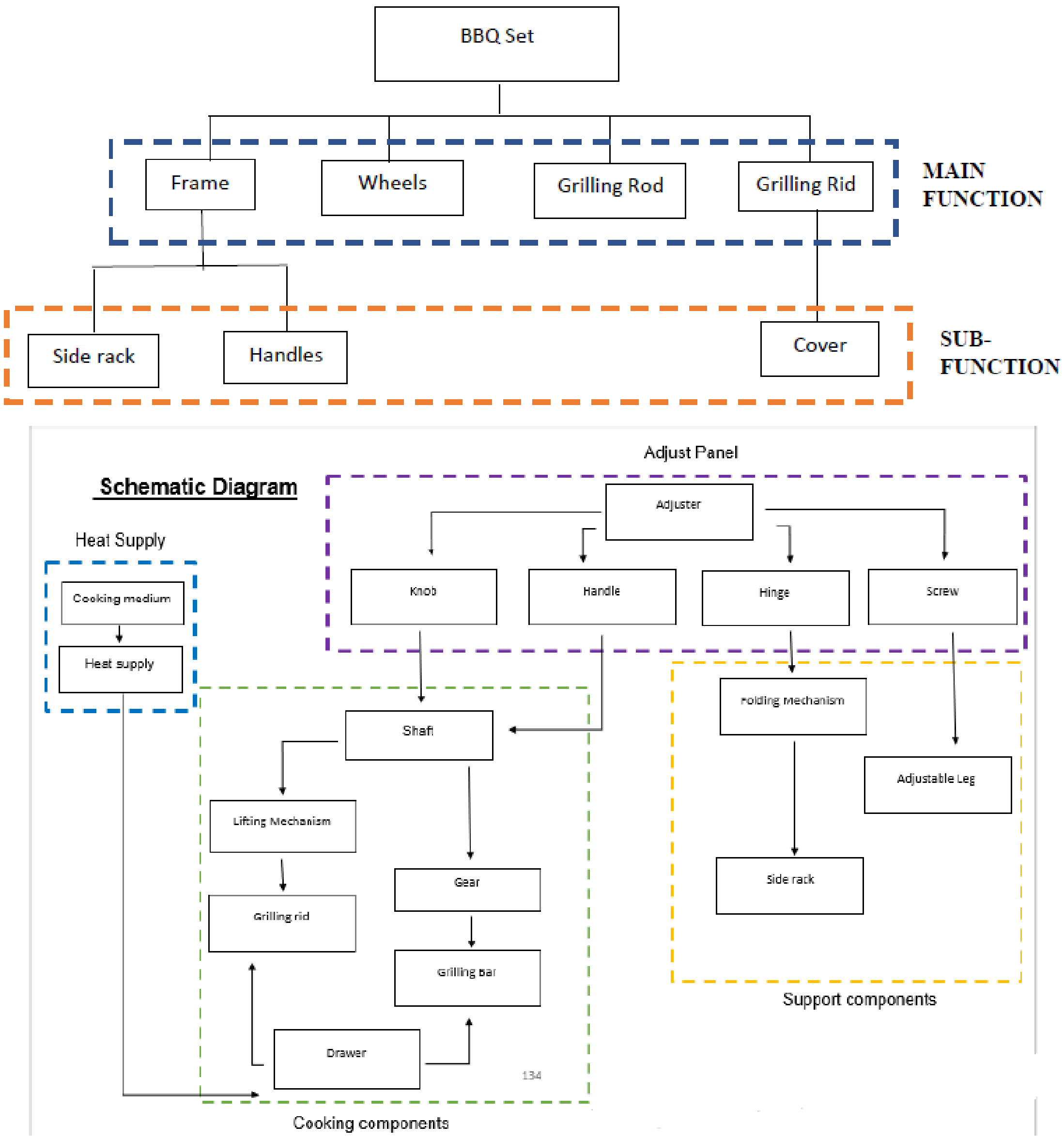


Fig. 1: The schematic diagrams of the multifunction BBQ set

c) *Morphological analysis*

A morphological analysis is conducted to break down the multifunction BBQ set into subsystems or modules based from Figure 1. Various design options is analysed for each subsystem to explore different configurations and functionalities as shown in Figure 2.

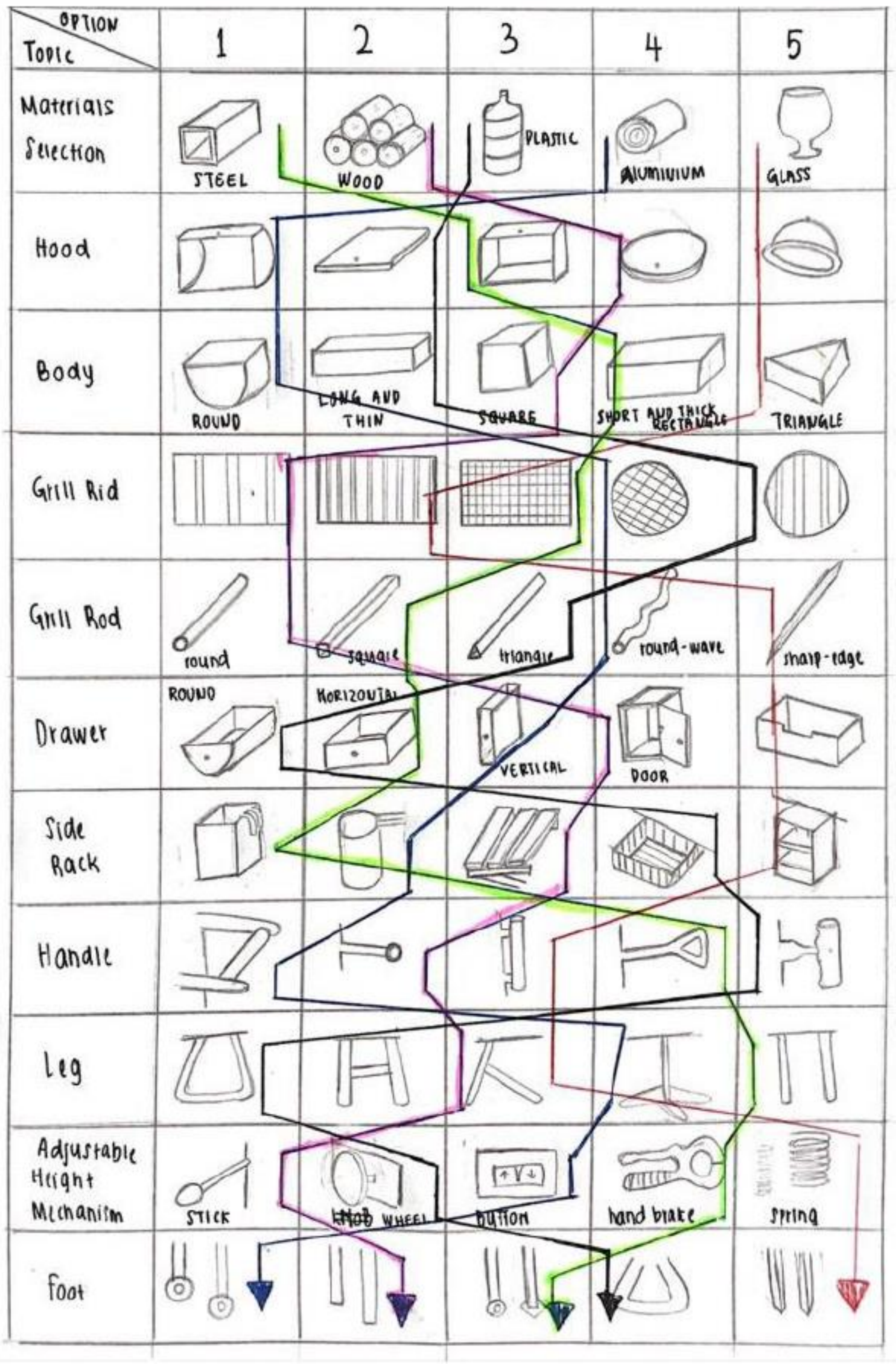


Fig. 2: Morphological chart

d) Generation of design concept and development of Pugh Chart

Based from the morphological chart shown in Figure 2, 5 design concepts considering different combinations of subsystem options where each concept will address specific aspects of the design requirements. The designs concepts then were evaluated using a Pugh chart to compare their performance against a datum concept (Figure 3). Criteria such as durability, portability, cost, ease of use, and cooking are assessed to determine the most suitable design.

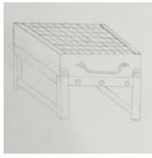
SKETCH							
CRITERIA	**WEIGHT**	**Datum**	**Design 1**	**Design 2**	**Design 3**	**Design 4**	**Design 5**
Durable	2	0	+	0	0	-	0
Portable	2	0	+	0	+	+	+
Affordable	2	0	-	0	+	+	+
Easy to use	3	0	0	--	++	0	0
Cooking area	3	0	0	-	+	--	0
+		0	4	0	13	4	4
0		12	6	6	2	3	8
-		0	2	9	0	8	0
Net Score		0	2	-9	13	-4	12

Fig.3: Pugh chart generated to select the optimal design concept of multifunction BBQ set

Based from the Pugh chart in Figure 3, it was concluded that Design 3 stands out for ease of use, being very handy, and boasts the widest cooking area while Design 2 is the most inconvenient due to its size and complexity. With a net score of 13, Design 3 is selected as the final product due to its overall performance meeting most requirements effectively.

e) Selection of optimal design concept

Based on the Pugh chart analysis, the most promising design concept was chosen that best meets the established criteria and aligns with the design requirements. The chosen design concept is further refined and iterated based on feedback and further analysis to enhance its functionality, usability, and overall performance.

f) Finalize conceptual design of multifunction BBQ set

Detailed drawings including materials, dimensions and specifictaions were developed using Solidwork software for the finalized conceptual design of the multifunction BBQ set. As part of engineering knowledge, a mechanical part for the BBQ set is also analysed to evaluate its strength and deformation.

4 RESULTS AND DISCUSSION

The final design of the BBQ set was first outlined in PowerPoint (Figure 4) mirroring the schematic diagram in Figure 1. Subsequently, the design was accurately rendered using Solidworks software to capture its dimensions, materials, and specifications, as shown in

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Figure 5. It was observed that the BBQ set was designed to reduce burn risks and harmful smoke for the user by incorporating a cover lid, while enhancing user convenience through features like a side rack, a coal drawer, and adjustable legs

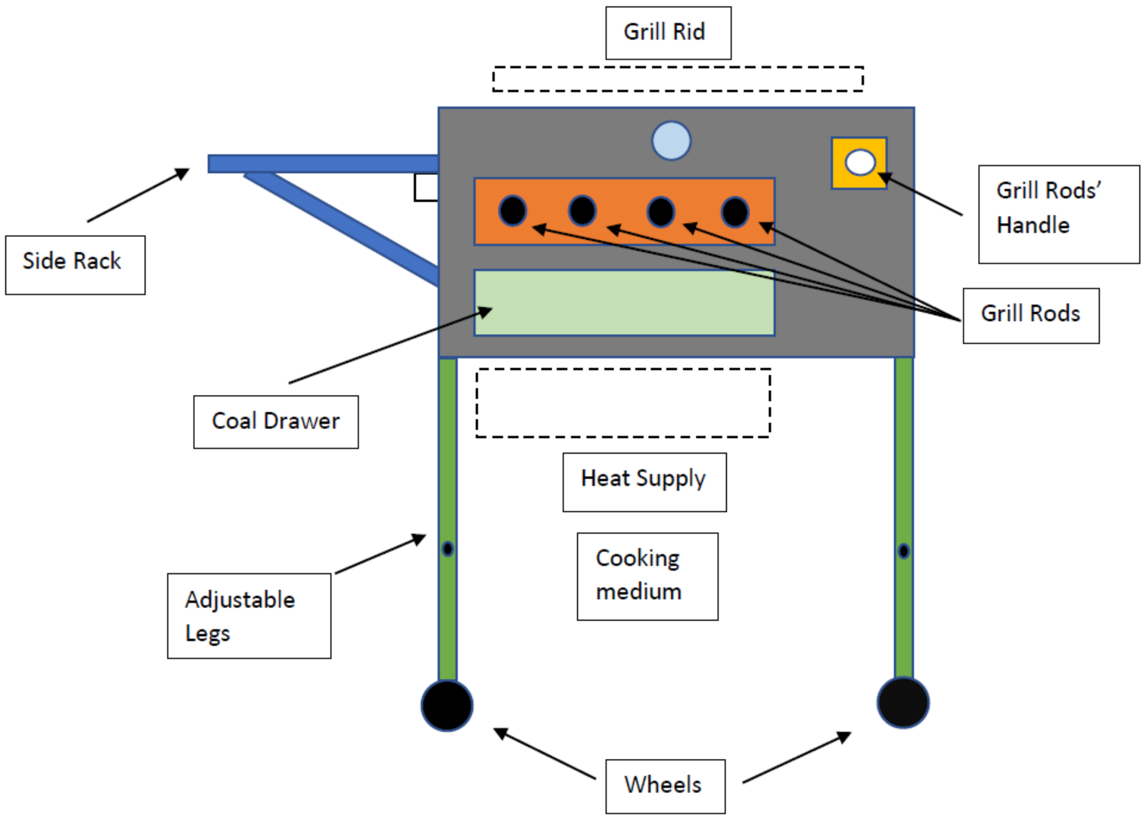

Fig.4: The front viewed sketch of final concept design of multifunction BBQ set

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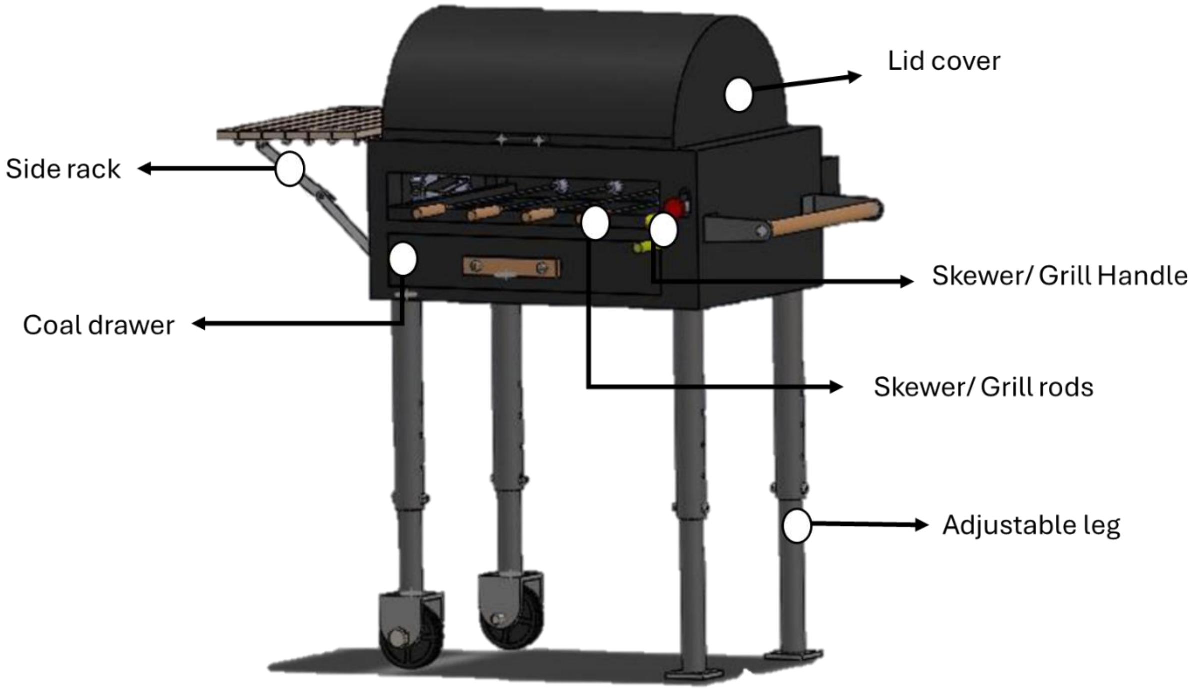

Fig 5: The front viewed Solidwork illustration of final concept design of multifunction BBQ set with its respective labels.

The design innovation involves integrating skewer rods into the BBQ set, comprising four rotating skewer rods connected to individual gears controlled by a main gear at the handle knob as depicted in Figure 6. This integration enables users to grill on the surface while simultaneously cooking skewers. To reduce the risk of burn injuries, users must rotate the handle to turn all four skewers simultaneously.

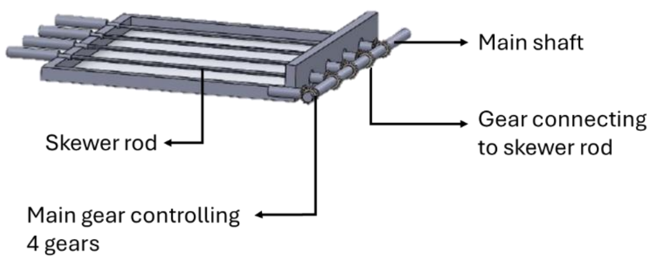

Fig. 6: The Solidworks illustration depicts an assembly of four steel rods connected to individual gears, controlled by a main gear, forming a mechanism for the four-skewer setup.

As a crucial functional component of the BBQ set, the strength analysis of the main shaft of diameter 25 mm supporting the gears and skewers was conducted. It was shown in Figure 7, upon applying an estimated uniform load of 20 kg (factoring in the weight of the skewers), the main shaft, constructed from Gray Cast Iron, demonstrated resistance to deformation indicated by the presence of the blue-colored structure along its entire length. Notably, sources indicate that gray cast iron exhibits high ductility and can withstand high temperatures without deforming [8].

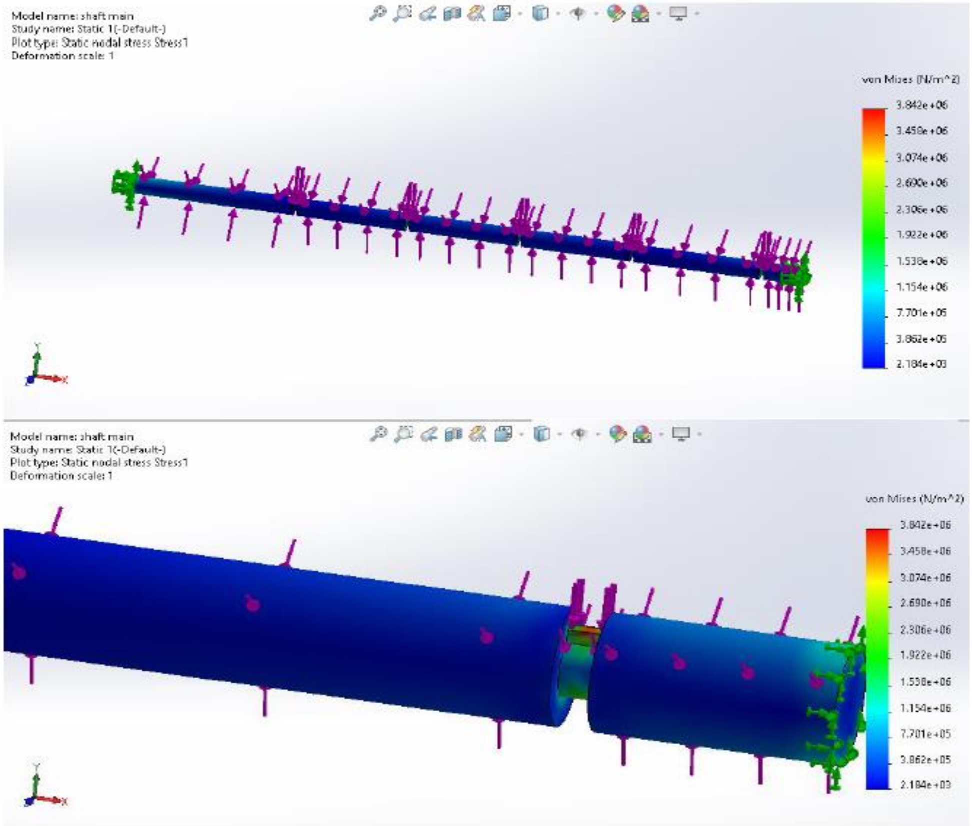

Fig.7: The strength analysis of the main shaft of diameter 25 mm subjected to a uniform load of 20 kg

5 CONCLUSIONS

In conclusion, the conceptual design of the multifunction BBQ set has been successfully realized through a meticulous process that involve series of analysis, sketches and detailed drawings using SolidWorks software. The strength analysis of the crucial main shaft, demonstrated resilience under a uniform load of 20 kg, ensuring structural integrity.

Furthermore, the innovative incorporation of skewer rods into the set enhances its functionality, allowing users to simultaneously grilling and cooking skewers. The inclusion of features such as a lid cover, adjustable legs, a coal drawer, and a side rack not only maximizes user convenience but also minimizes burn risks and harmful smoke exposure during use.

This comprehensive design approach ensures a multifunction BBQ set that not only meets user needs but also prioritizes safety, efficiency, and versatility in outdoor cooking experiences.

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CHAPTER 4

Stress and Strain Analysis of Egg Yolk Separator

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ABSTRACT

The design and fabrication of an egg yolk separator represent a significant advancement in kitchen utensils, aiming to streamline the process of separating egg yolks and whites efficiently. This project employs SolidWorks software for the design phase and subsequently fabricates and tests the designed egg yolk separator. The primary objectives include designing and fabricating a product capable of autonomously separating egg yolks and whites, thereby reducing the effort required by users during food preparation. The proposed egg yolk separator utilizes an ingenious design methodology. As the egg is broken directly over the starting point of the upper plane, it initiates a seamless process where the egg slides down. Gravitational force then comes into play, orchestrating the natural separation of the white egg from the yolk as they traverse through a strategically designed gap. This innovative approach ensures a simple yet effective means of egg yolk separation, enhancing the usability and efficiency of the proposed egg yolk separator. Additionally, this study will involve stress-strain analysis using SolidWorks to evaluate the structural integrity and performance of the egg yolk separator under different loading conditions. Integrating this analysis into the project will provide valuable insights into the performance and reliability of the product. By incorporating this methodology, the project aims to offer a promising solution to the challenges associated with traditional egg yolk separation methods, providing a user-friendly approach to streamline kitchen processes and improve overall productivity. As for conclusion, the egg yolk separator has been successfully designed and fabricated, hence mark a significant achievement in addressing the objectives of the project. The seamless operation and effectiveness of the separator underscore its potential to revolutionise egg yolk separation practices, contributing to enhanced efficiency and productivity in culinary environments.

Keywords: Egg yolk separator, Stress strain analysis

1 INTRODUCTION

Egg yolk separators serve as indispensable tools in various industries, particularly in food processing, where the separation of egg yolks from egg whites is a common requirement. The efficient operation of these separators' hinges upon their structural integrity and mechanical performance under diverse stress conditions. The study focused into the intricate mechanics governing egg yolk separators, focusing on elucidating the stress and strain distribution within these devices to enhance their design, efficiency, and longevity. The

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primary objective of this study is to design and fabricate an egg yolk separator. Specific objectives include the stress and strain analysis of to conduct a meticulous analysis of the stress and strain distribution within egg yolk separators under varying loading conditions

The findings of this study hold significant implications for the design and operation of egg yolk separators especially for small industries. By gaining a deeper understanding of the stress and strain behaviour within this devices, all the decisions regarding material selection, structural design, and operational parameters, can be made thus ultimately leading to improved performance, reduced maintenance costs, and enhanced sustainability.

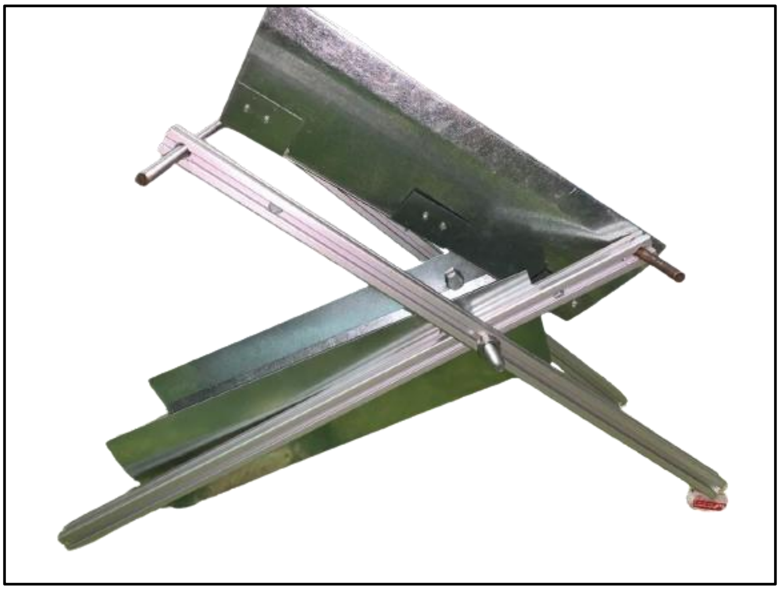

Fig. 1: Final Product of Egg Yolk Separator

2 LITERATURE REVIEW

Eggs are a vital component of the human diet, serving as a cost-effective source of essential nutrients such as easily digestible proteins, lipids, minerals, and vitamins [1]. An egg product separating machine (egg breaking and separating machine), is a processing equipment that break eggs and separate their contents [2].The study conducted by [3] introduced an egg yolk separator comprising a strainer equipped with a segment designed to retain the egg yolk and an aperture for filtering the egg white. Additionally, the separator features a pair of arms extending in opposite directions from the strainer, intended for positioning on opposite sides of an opening vessel to secure the separator in place.

Egg yolk separators undergo a spectrum of mechanical forces during their operational lifecycle, including bending, torsion, and compression. Understanding the stress and strain dynamics within these separators is pivotal for ensuring their reliability and optimal performance. While previous research has explored various aspects of egg yolk separator design and functionality, a comprehensive analysis of the stress and strain behavior remains largely unexplored.

3 METHODOLOGY

The methodology employed in this study aims to design, analyse and fabricate an egg yolk separator. This study includes the analysis of stress and strain distribution within the egg yolk separator to enhance its design and functionality. The study starts with the design selection method, then the selected design was developed using SolidWorks CAD software. This software facilitated the creation of part drawings, assembly drawings, and 2D representations of the product.The design incorporated a strainer (upper plane) with a section dedicated to retaining the egg yolk and an aperture (lower plane) for straining the egg white. Additionally, a pair of legs extending from the strainer were designed to facilitate secure placement on opposite sides of an opening vessel. The stress and strain analysis was conducted by using SolidWorks Simulation, which allowed for the virtual testing of the separator under various loading conditions.

Following the design and analysis phases, the egg yolk separator has been successfully fabricated using appropriate materials and manufacturing techniques. The product is using galvanised sheet metal, a commonly used material known for its durability and corrosion resistance, through precision machining techniques. The pair of legs extending from the strainer were meticulously attached using nut and bolt, providing sturdy support for secure placement on the both upper and lower plane.

4 RESULTS AND DISCUSSION

The following section presents the results and discussion of our study on the stress and strain analysis of an egg yolk separator. Figure 1 and 2 show the stress and strain analysis for the leg for egg yolk separator. This analysis shows that the leg can support 100kN. Most of the parts remain blue. Generally, the overall stress does not exceed the yield stress of the leg which means the design will be able to withstand the load and it is safe to be used.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	6.390e+02N/m^2 Node: 58	1.506e+07N/m^2 Node: 142

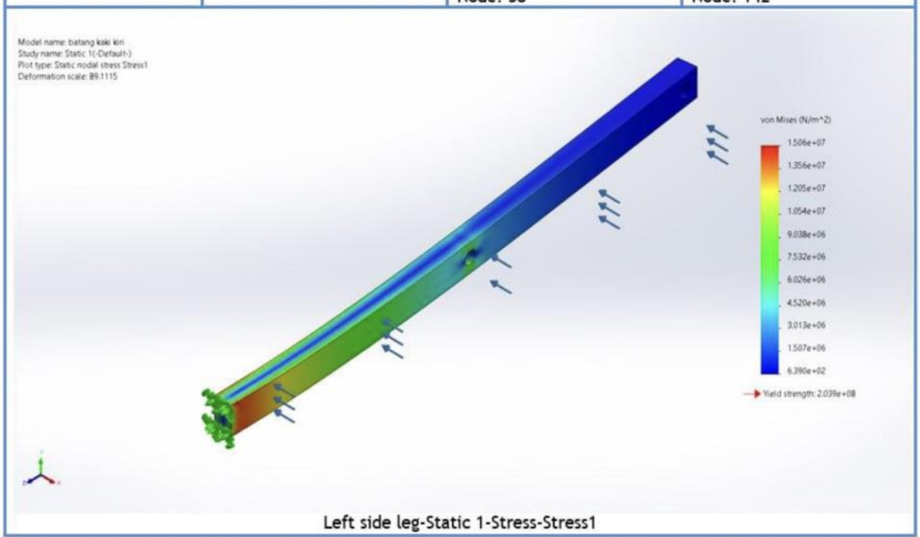

Fig. 1: Stress Analysis of Left Leg of the Egg Yolk Separator

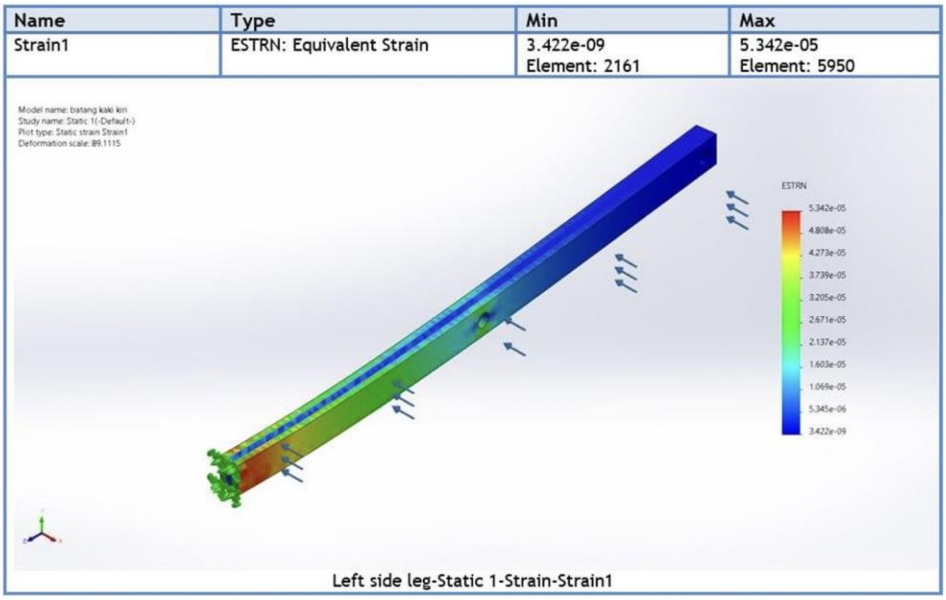

Fig. 1: Strain Analysis of Left Leg of the Egg Yolk Separator

5 CONCLUSIONS

In conclusion, the stress and strain analysis conducted using SolidWorks simulation tools provided valuable insights into the mechanical performance of the egg yolk separator. The results of this analysis have confirmed the design iterations, enabling researchers to fabricate the separator for enhanced efficiency and longevity in egg processing applications. The final results shows that the separator has been successfully fabricated and functioning well.

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CHAPTER 5

Innovative Design and Construction of a Mini Coin Sorter Device

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ABSTRACT

A mini coin sorter machine is a device designed to sort coins into different categories. Often, coins are stored together without being sorted, leading to disorganization in daily life. This project aims to address this issue within our community. The project includes several objectives, such as designing a prototype and fabricating the machine. Additionally, the project explored the concept and mechanism of the mini coin sorter machine, the fabrication process, and how the machine operates. This involves considering the materials used for fabrication, determining the necessary components and engineering requirements. Furthermore, the project provide instructions for manual operation and safety precautions. Issues such as using low-quality materials and limitations in workplace utilities may affect the final product, prompting recommendations for improvement. Through this discussion, the project aims to identify areas for enhancement and contribute to the development of more efficient mini coin sorter machines in the future.

Keywords: Mini Coin Sorter Device, Mini Machine, Design and Fabrication process

1 INTRODUCTION

Throughout childhood, individuals are taught the importance of managing finances, often through the traditional method of the "Piggy bank." In this system, children are encouraged to save money received from parents for daily expenses. Alternatively, money can be deposited in banks equipped with sorting technology for efficient storage. The concept of automated counting devices for coins and banknotes was introduced in the 1950s by companies like Kokei (Glory) in Japan, aiming to streamline banking operations. However, the challenge remains: how do we effectively manage loose change?

Often, the coins received daily are haphazardly stored in a single container, leading to disorganization, particularly in financial matters. A significant issue highlighted in project proposals is the challenge of locating or losing coins stored in such a manner when needed. Furthermore, in Malaysia, coins are still widely used in various establishments like laundry machines and vending machines. However, sorting and transporting numerous coins from home to these locations can be time-consuming, discouraging individuals from carrying excess coins due to concerns about weight and bulkiness in their handbags or wallets.

Coins collected daily are often stored in a single container without organization. This lack of order can lead to confusion, especially in managing finances. One common problem is the difficulty in locating needed coins when required. Furthermore, in Malaysia, certain establishments still rely on coins for transactions, like laundry machines and vending machines. However, it can be inconvenient to sort and transport coins from home to these locations. Many individuals prefer not to carry excessive coins to avoid adding weight to their bags or wallets.

2 LITERATURE REVIEW

Sorting is a crucial method in manufacturing industries to organize things neatly. Many coin sorter machines have been invented, but most are large and not portable.

One invention, the US7971699B2 coin counter/sorter and coupon/voucher dispensing machine by Vae E. Sun, automatically gives out cash vouchers based on coin values and coupons. Coins are sorted, counted, and dropped into a holding area, then approved or rejected for the transaction. This invention is mainly used in big companies like banks [1].

Another invention, the US10049521B1 coin processing system by John R. Blake and others, manages rejected coins during processing. It sorts coins into genuine and reject categories, with high durability and a professional appearance, suitable for professional settings [2].

The US4531531A coin handling machine by Victor Gory Ristvedt and Roy Black Johnson sorts coins of various values using rotating discs. It effectively sorts coins based on their dimensions, offering a simple and space-saving solution [3].

In simple words each of the innovation have their own specification related to the purposed of the design such as 1) Automatically distributes cash vouchers based on the value of the collected coins, manufacturer coupons, and retailer coupons 2) Handling processed coins, coin-processing equipment, computer-readable storage media, and related information are described 3) The coin sorter is made up of a stationary disc with a first surface positioned close to the resilient surface of the rotatable disc, and a rotatable disc

3 METHODOLOGY

The design and fabrication undergo several steps. The first step was concept design. The concept design serves as the project's initial step, providing a foundational vision for the product. It incorporates considerations such as materials and product shape, influencing the ultimate design decisions. Utilizing tools like morphological charts aids in exploring various design options and clarifying distinctions between them.

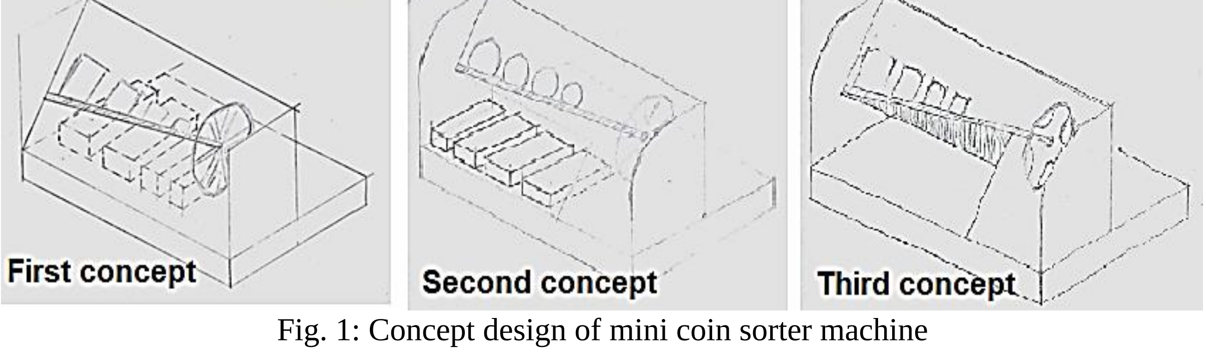

Fig. 1: Concept design of mini coin sorter machine

Figure 1 shows the concept design of the mini coin sorter. The after the consideration the first concept lack certain safety features, posing risks such as sharp edges that could potentially cause injury. Additionally, constraints like inadequate space for container movement and the complexity of generating circular plates can hinder efficiency and effectiveness.

To address these shortcomings of first concept, iterative improvements are made to the second design concept. Safety concerns are addressed by adding protective features, such as smoothing out sharp edges and ensuring secure placement of components. Enhancements are also made to optimize functionality, such as expanding the space available for container movement and simplifying the design of circular plates to improve efficiency.

Despite these enhancements, challenges persist. For instance, ensuring the optimal placement of components like the motor and power supply remains a concern, as does refining the design to accommodate the sorting system effectively while minimizing the risk of coins becoming stuck.

Ultimately, the selection of the final design is based on a holistic assessment, considering factors such as safety, ergonomics, and functionality. By integrating the best elements from each iteration of the design process, the final design aims to strike a balance between efficiency and usability. Furthermore, additional features like a rocker switch button are incorporated to enhance the product's overall aesthetic and user experience.

NO.	PART
1	BASE
2	PILLAR
3	SORTING SECTION
4	COIN TRACK
5	MOTOR BLADE
6	DC MOTOR
7	ENTRANCE WALL
8	SPEED REGULATOR
9	ROCKER WHITCH
10	CONTAINER
11	HEIGHT EXTENDER
12	SCREW / RIVET

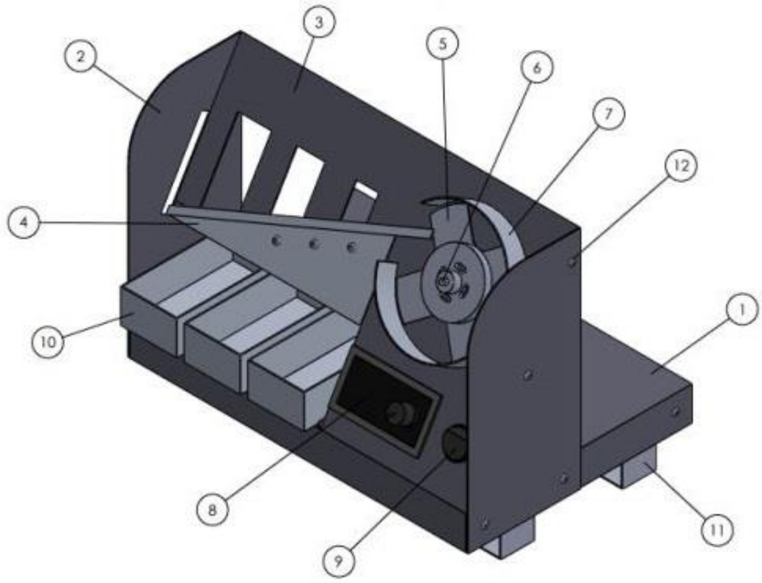

Fig. 2: Model of the mini coin sorter machine

Based on the consideration the final design shows in Figure 2 was preliminary designed and expressly along with the preparation of final construction plans using SolidWorks software that be compiled as a final design for the product that was fabricated. The full dimensions of the final project design were depicted in Figure 3, which showed measurements of 300mm (length) x 200mm (width) x 221mm (height). The main structure was use of aluminum plates as the primary material, which were bent accordingly. All the parts were joined using a combination of rivets and screws for assembly.

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4 RESULTS AND DISCUSSION

Figure 3 shows the final prototype of the machine. The manual operation instructions for users of the mini coin sorter machine are outlined in this section, aiming to facilitate safe and effective use while minimizing the risk of incidents. Additionally, this manual operation guide serves as maintenance guidelines to ensure the long-term functionality of the machine.

To operate the machine, first, connect the micro-USB cable to the micro-USB charging board port. Use a plug adapter with a voltage of 33V or higher to supply sufficient power to the DC motor and ensure the adapter has a current rating of 5A or below to prevent short circuits. Verify that the LED on the micro-USB charging board flashes red, indicating that the circuit is connected, and then gently connect the cable to the port to avoid damage.

Next, insert the coins vertically into the entrance of the machine. Turn on the rocker switch until the red LED on the voltage regulator appears. Adjust the speed regulator to set the suitable speed of the DC motor, typically between 40 to 60. The motor blade will lift the coins to the sorting section, where they will be sorted based on their dimensions into respective categories. Finally, the sorted coins will fall through the hole into the container for storage, which can be easily pulled out as needed by the user.

It is important to carefully follow the product manual operation to ensure the safe operation of the mini coin sorter machine. Avoid increasing the voltage regulator beyond the recommended levels to prevent potential incidents such as overheating or electrical malfunctions. Refrain from touching the circuit wires to prevent damage or breakage, which could lead to electrical hazards. Be cautious of sharp edges on the machine, as they pose a risk of scratching or injuring hands during operation. It is essential to use an appropriate current adapter to prevent short circuits, ensuring the machine operates safely and efficiently. Additionally, utilize the ON/OFF rocker switch as a safety feature to immediately cut off power to the circuit in case of emergencies or to prevent unauthorized use, enhancing overall safety during operation. By adhering to these safety precautions, users can minimize risks and ensure a safe experience when using the mini coin sorter machine.

Fig. 3: Final prototype of mini coin sorter

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5 CONCLUSIONS

In conclusion, the mini coin sorter machine offers a convenient and efficient solution for sorting and organizing coins. Its compact design and user-friendly operation make it suitable for various settings, from households to small businesses. By following the provided manual operation instructions and safety precautions, users can ensure the machine's proper function and longevity. Additionally, the machine's ability to sort coins accurately and quickly enhances productivity and streamlines coin handling processes.

However, ongoing maintenance and adherence to safety guidelines are crucial to prevent incidents and ensure safe operation. Overall, the mini coin sorter machine serves as a valuable tool for simplifying coin management tasks while promoting efficiency and organization.

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CHAPTER 6

Mini Electric Sander Belt Machine: Design, Development, and Testing

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ABSTRACT

Machines are designed to make tasks easier. They come in various sizes and price ranges, but smaller ones are often expensive and difficult to find. This project aims to address this issue by creating an affordable and compact electric sander belt. The process begins with designing the machine using software called SOLIDWORKS. Following the design phase, fabrication involved using tools like drills, cutters, and grinders, with aluminium as the primary material. The objective is to develop a small electric sander belt that activates with a switch. It was suitable for grinding small items such as shaping knives or reshaping drill bits. This mini machine particularly useful for small-scale projects and accessible to a wide range of users due to its affordability.

Keywords: Sander belt machine, Mini machine, Fabrication process

1 INTRODUCTION

Sanders are machines used in various industries such as carpentry, metal fabrication, and automotive repair to achieve smooth surfaces. One popular sander is the belt sander. It has a motor that moves a sanding belt continuously over a flat table. The workpiece is moved against the belt to sand it. The size and roughness of the belt can be changed to match needs [1].

The main goal of a belt sander is to remove material quickly while making the surface smooth. They are used for tasks like smoothing surfaces, removing paint, and shaping wood or metal.

Belt sanders have improved over time. Now they have features like speed control, dust collection, and user-friendly designs. Different types of sandpaper are also available for them [2]. However, belt sanders have some problems. Sometimes they don't make surfaces smooth even. This could happen because the belt isn't tight enough, the pressure isn't right, or the material being sanded is different. They also create a lot of dust, which can be bad for air quality and health if not managed properly. This dust can also make the sander less effective and need more maintenance

The durability and performance of abrasive belts in belt sanders significantly impact efficiency and cost-effectiveness. Issues like premature wear, clogging, and reduced cutting ability affect material removal rates and productivity. Optimizing belt performance is crucial for enhancing reliability. Prolonged use may cause operator fatigue due to vibration and weight.

Improving ergonomic design, including handle grip and vibration reduction, is essential to enhance operator comfort and reduce musculoskeletal issues. Addressing these challenges is vital for developing more efficient belt sander machines, ultimately improving productivity, surface quality, and operator well-being.

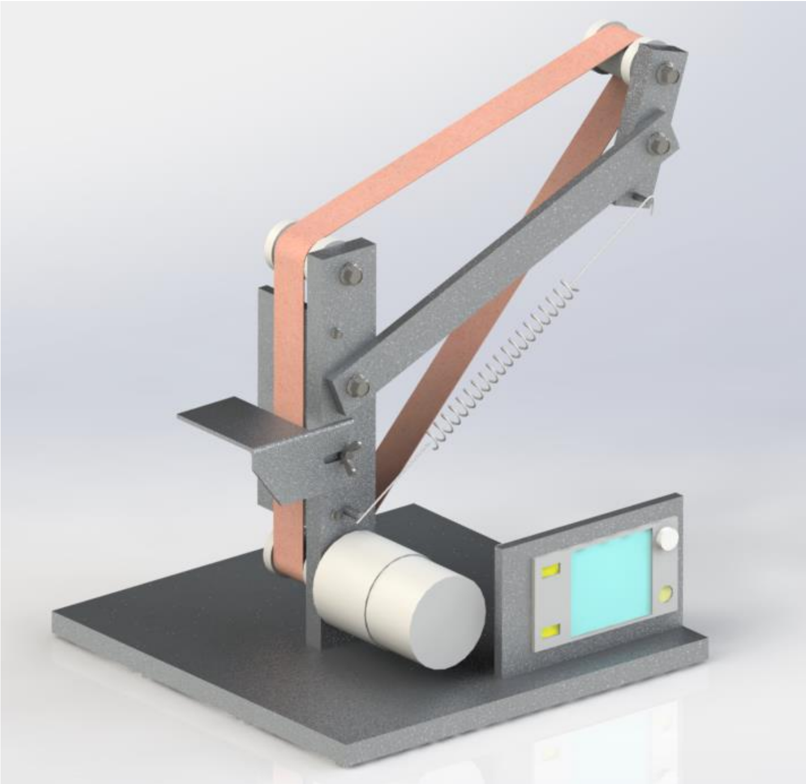

Fig. 1: Render model of the belt sander machine

2 LITERATURE REVIEW

When comparing belt sander machines, essential factors include power, speed, belt size, construction quality, and price. In a recent benchmarking and comparison analysis, three notable models—Model 1, Model 2, and Model 3—were assessed based on these criteria.

Model 1, engineered by Herman S Newton (US2416493A), boasts a robust motor with high power output, making it suitable for demanding sanding tasks. Its variable speed control ensures precision, and its durable construction suits heavy-duty industrial use [3].

Model 2, designed by Georg Weber (US20050136813A1), offers a compact, lightweight design ideal for portability. Although slightly lower in power, its variable belt speeds accommodate diverse finishes, appealing to DIY enthusiasts [4].

Model 3, developed by John Schnell and Daniel Wall (US20060264161A1), strikes a balance between power and affordability. Its moderate power rating and adjustable belt speed make it versatile for various sanding applications [5].

This benchmarking and comparison studies drawn on product specifications, manufacturer details, and user feedback from reputable sources and industry publications. Its objective is to offer users a thorough analysis of each model's strengths and weaknesses, aiding them in making well-informed decisions.

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3 METHODOLOGY

The final design of the sander machine is shown in Figure 1. All the design process was based on this design, and it was used to make the final construction plans. The design of this project was made using a software called SOLIDWORKS, which helps to make 3D parts and drawings. Designing this project involved a few steps: making each part of the product with the right size and putting them together like pieces of a puzzle. After that, each part was drawn from different angles, like from the front, top, side, and an angle called isometric view, to show all the details.

Fabrication means making or creating something by putting together different parts using various methods. Cutting and drilling are common techniques used in fabrication to shape materials into a finished product. The machine was made using aluminium plates and sheet metal, as shown in Figure 2. First, ten-millimetre-thick aluminium plates were used based on certain considerations. These plates were measured and cut using tools like a band saw machine and angle grinder. Holes were drilled in them. The sheet metal was also measured, cut using a shearing machine, and holes were drilled in it too. Then, the sheet metal was bent at a 90-degree angle using a bending machine. After that, it was attached to the aluminium plates using bolts and nuts.

The bearing holder, which holds a ball bearing, was made from PLA plastic. It was created using a 3D printing machine, which took about 14 hours to make three bearing holders. After the bearing was put into the holder, it was attached to the main part of the mini sander belt machine using bolts and nuts.

4 RESULTS AND DISCUSSION

One of the key features of the mini sander belt machine is its ability to remove material and smooth surfaces. Its main job is to take away material from a workpiece and make its surface smooth. This is done using a continuous loop of sandpaper or abrasive belts that rotate over the bearing holder to do the sanding.

Using the mini sander belt machine as in Figure 2 requires manual operation. It is crucial to follow the steps carefully to prevent accidents and ensure the machine lasts longer.

- Put the sander belt around the bearing holder and attach the spring to give it tension.
- Adjust the angle of the part by loosening the wing to the desired angle.
- Plug in the power supply.
- Turn the voltage clockwise according to the LED indicator until the sander belt starts rotating. Make sure the voltage regulator is off before plugging in the power supply.

The advantage of this mini sander belt machine is its low production cost. Making one costs around RM90, which is considered inexpensive. This makes the machine appealing for small businesses, hobbyists, or individuals on a budget who still need efficient sanding capabilities. It's a smart choice for the sanding process.

Fig. 2: Fabricated prototype of the sander belt machine

5 CONCLUSIONS

In conclusion, the mini sander belt machine, designed and manufactured for sanding tasks, demonstrates reliability and effectiveness. Recommendations to enhance its utility include adding a dust barrier, utilizing a higher-voltage motor and grit belt, and employing more durable materials. These measures aim to maximize its potential applications, catering to diverse sanding needs across different materials while ensuring longevity and efficiency.

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CHAPTER 7

Stress Analysis of Mini Compact Manually Operated Crane Design

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ABSTRACT

This project aims on designing a mini compact manually operated crane. This crane is designed to be easily maneuverable and can fit into tight spaces, making it ideal for tasks such as lifting tools, materials, or equipment in confined work areas. The design of mini compact crane is incorporating with features such as articulating arms and lever-operated model. A stress analysis is performed on the articulating arm to ensure that this manually operated crane can withstand the expected loads and forces it will experience during its extended use.

Keywords: Mini crane

1 INTRODUCTION

Cranes are lifting tools found in various industries and applications, including construction, shipping, logistics and manufacturing [1]. They often come in different types and sizes to accommodate different needs, ranging from small-scale operations to large construction projects. Mini compact designs of cranes are particularly useful in situations where space is limited or where smaller loads need to be lifted. The mini compact cranes are particularly designed to be easily maneuvered, fit into confined spaces but able for general tasks such as lifting tools, materials or equipment in confined work areas. Manually operated cranes, such as hand-cranked or lever operated models, can be suitable for lighter loads or situations where power sources are limited or unavailable. They are typically more affordable and easier to maintain than powered cranes [2]. This project aims to design a mini compact, manually operated crane ideal for such purposes. A stress analysis is performed on the articulating arm to optimize the design, improve its long-term performance, and reduce the risk of failure or mechanical problems in real-world applications.

2 LITERATURE REVIEW

A patent of mini crane has been reported, capable of moving a weight in the up and down direction or right and left directions after being fixed on the inner wall of a building. The load of the weight is supported using a jack [3]. This project adopts the working concept of the arm pulley in [3], while transmuting the jack with solid base. The Mini Compact Manually Operated Crane is a versatile and efficient lifting device designed for use in small-scale industrial and construction applications. Its compact size allows it to be used in areas with space constraints while still providing reliable lifting capabilities. The manually operated mechanism ensures ease of use without relying on electricity or fuel, making it both cost-effective and environmentally friendly. This crane is ideal for transporting light to medium loads across short distances. By integrating a user-friendly design with durability, the Mini Compact Crane serves as an indispensable tool for workshops, warehouses, and small construction projects.

3 METHODOLOGY

The mini compact design of the manually operated crane is design using SolidWorks 2020 as shown in Fig. 1. The engineering calculation for buckling was performed on the hollow bar pole of the crane as to ensure it will not be buckling as it performs. Most of the body frame is made from mild steel due to its strength and durability. Stress analysis is then performed using SolidWorks to simulate and visualize how a part or assembly behaves under different types of mechanical stresses, such as tension, compression, shear, and bending (Fig. 2). [4].

Fig. 1: Isometric view of manually operated mini crane design using SolidWorks 2020

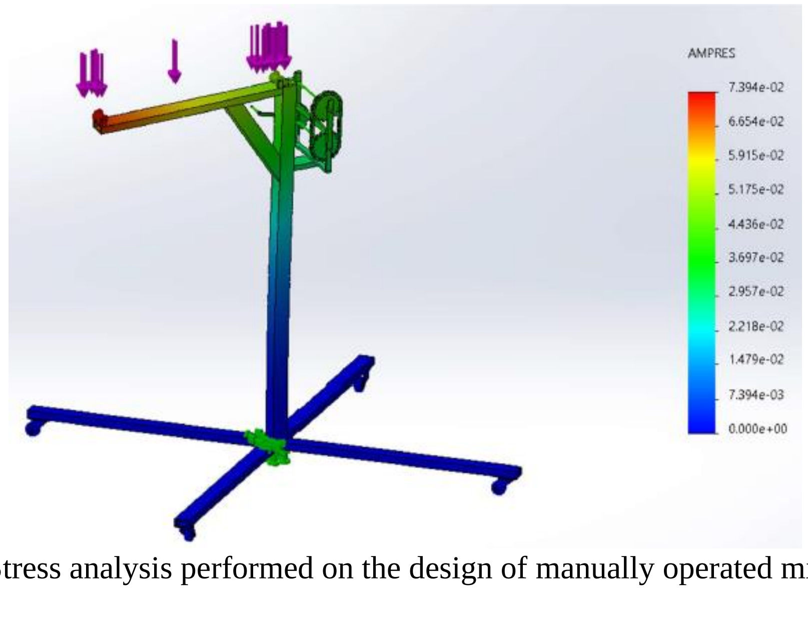

Fig. 2: Stress analysis performed on the design of manually operated mini crane

4 RESULTS AND DISCUSSION

Fig. 1 shows the stress analysis performed using SolidWorks on the mini crane. The edge of the arm displays a region of high stress concentration where failure is more likely to occur. This area may require design modifications or additional reinforcement to improve the structural integrity of the component. By analysing the stress distribution at this area and making design modifications, this can iteratively optimize the design to reduce stress concentrations, improve structural performance, and enhance product reliability.

5 CONCLUSIONS

The project has been successfully designed and analysed. The manually operated crane can carry around 20kg, with mini compacted design that can easily manoeuvred, and should have no problem delivering its general tasks.

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CHAPTER 8

Development of a Prototype Spray Paint Hut

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ABSTRACT

Recognizing the limitations of traditional painting methods in achieving precision and efficiency, this paper presents the development of the Spray Paint Hut, a pioneer solution designed to address the challenge of painting small parts in various industries. The prototype of the spray paint hut offers a compact, user-friendly solution. Through a hut which includes a rotating platform, a pump to generate pressure for the paint, and a battery for portable usage, this spray paint hut enables users to achieve intricate detailing with ease, enhancing productivity and minimizing the mess as well as the duration of the painting process. This prototype development process starts with problem identification, concept generation using Morphological Chart, design selection by Pugh Chart, design development using Solidwork, and lastly fabrication and testing process. This prototype of a spray paint hut is limited to a certain size of product so that it will be easier to fabricate. Nevertheless, this innovation unlocked the possibilities in design and production of diverse applications across industries such as automotive, electronics, and toys manufacturers. In summary, the prototype of the spray paint hut represents a significant advancement in painting, offering a transformative solution to the challenge of painting small parts. Its precision, efficiency, versatility, accessibility, and innovation have the potential to enable users to minimizing time and energy and ensure a clean environment during the painting process.

Keywords: Paint hut, Spray painting

1 INTRODUCTION

Spray painting methods involve the application of paint using pressurized air or gas to atomize and propel the paint particles onto a surface. This method offers several advantages, including fast application, smooth finish, and even coverage. There are various spray-painting techniques, each suited to different applications and desired outcomes [1].

Currently, painting small parts typically involves manual methods that can be time-consuming, labour-intensive, and prone to inconsistencies. Some common techniques include aerosol spray can, airbrushing, and spray guns [1]. Therefore, there is a need for innovative solutions that can overcome these limitations and provide users with greater control, consistency, and productivity in painting small parts.

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2 LITERATURE REVIEW

Spray painting is a technique for applying paint to a surface using a device that sprays the paint in a fine mist or aerosol. This method is widely used in various industries, artistic pursuits, due to its efficiency, versatility, and ability to achieve smooth, uniform coverage [1]. Aerosol spray cans are convenient and portable, making it possible for DIY projects and outdoor use, however, they may lack the precision required for intricate detailing [2]. Airbrushing involves using a small, handheld airbrush gun connected to an air compressor. It allows for precise control over the flow of paint and air pressure, making it suitable for detailed work. But they may cause an unhealthy environment as the paint is sprayed to the parts, the paint particles are spread away [3]. While for spray guns, it is commonly used in professional painting applications such as automotive refinishing, furniture finishing, and industrial coatings. These guns operate at lower air pressure resulting in reduced overspray and offer greater control over paint flow, enabling users to have finer finishes with less waste [4].

(a) Aerosol spray cans (b) Airbrushing (c) Spray guns

Fig. 1: Existing Spray-Painting Tools

3 METHODOLOGY

This prototype development process starts with problem identification, concept generation using Morphological Chart, design selection by Pugh Chart, design development using Solidwork, and lastly fabrication and testing process as shown in Fig. 2 below.

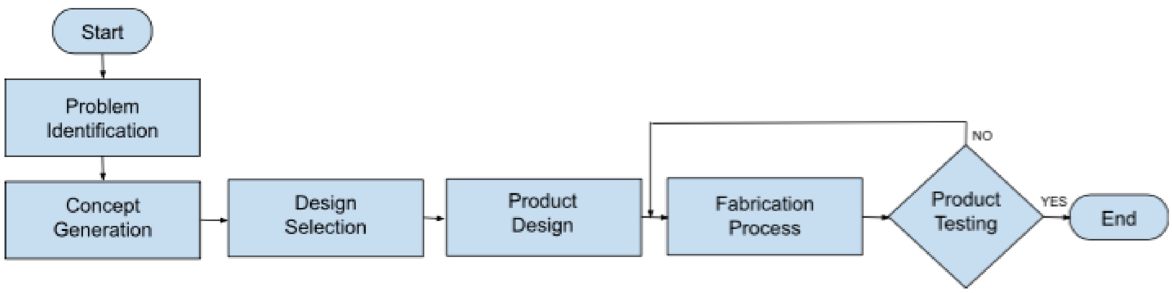

Fig. 2: Product Flowchart

Fig. 3 shows an assembly drawing of the Prototype of Spray Paint Hut. Based on the drawing, it will then proceed with the next process which is the fabrication process. In this process, it involves selecting the raw materials, cutting, shaping, machining, grinding, and assembling the product.

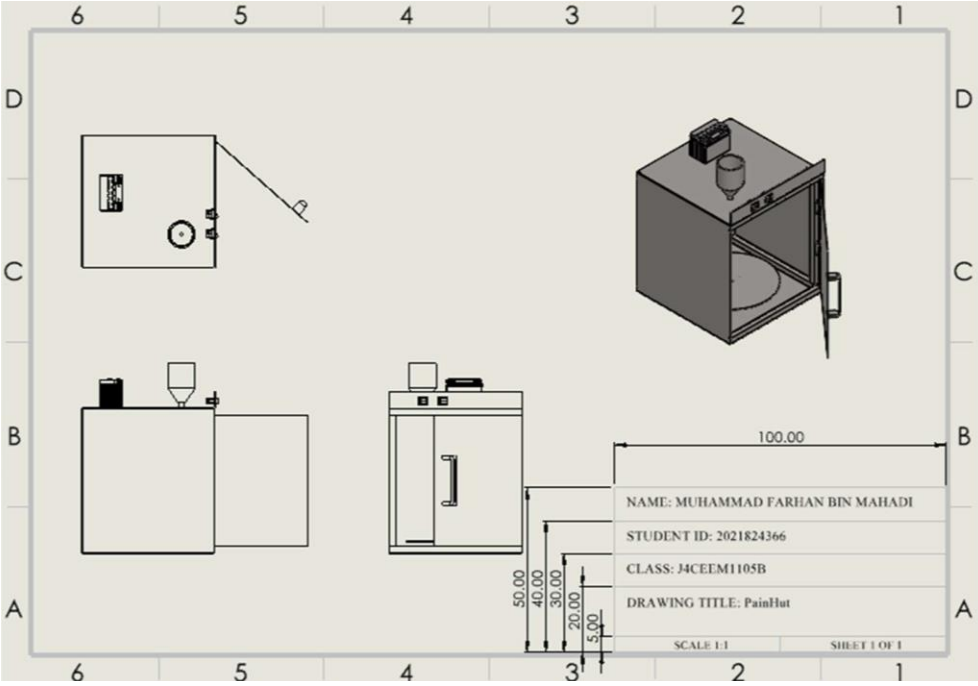

Fig. 3: Assembly Drawing

4 RESULTS AND DISCUSSION

The fabrication process of the Spray Paint Hut prototype is a critical stage in development of the product, bridging the gap between design and functionality. In conjunction to ensure the product is successful, engineering analysis also has been conducted. It simulates the behaviour and performance of the design during force application. Based on Fig. 4, it shows that the frame is strong enough to handle the max load applied. The selection of material is also suitable as it is able to support the load. The final product has successfully fabricated as shown in Fig. 5.

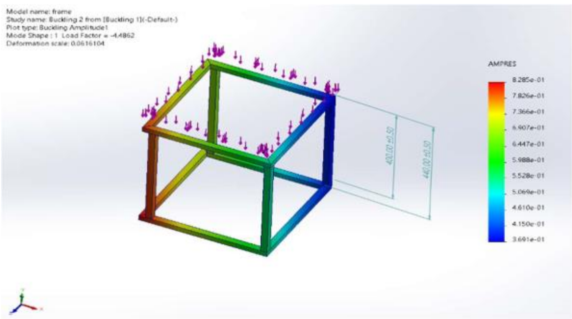
Fig. 4: Assembly Drawing

Fig. 5: Final Product

5 CONCLUSIONS

In conclusion, the innovation of the Spray Paint Hut prototype offers valuable insights into the future of painting technology, highlighting the importance of precision and intricate detailing on small parts, overcoming the limitations of traditional painting methods. Besides that, this prototype also enhances efficiency and productivity. It reduces the time and effort required for painting tasks, allowing users to complete projects more quickly and effectively. Lastly, the Spray Paint Hut prototype represents a significant advancement in painting technology, with the potential to drive further innovation and development in the field. It opens up new possibilities for customization, product design, and sparking creativity.

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CHAPTER 9

Development of An Automatic Barbeque Grill: A Prototype

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ABSTRACT

Nowadays, the use of grills has become widespread. Therefore, it is not surprising that many types of barbeque grills that have their qualities can be found on the market. However, the high cost is a barrier to ownership as its large size often contributes to high prices. This will also make it difficult to store after use. This project aims to create a barbeque grill that enhances user-friendliness, and durability also emphasizes ease of maintenance. The primary objective is to design a grill that employs the rotisserie method, utilizing a wiper motor to achieve uniform cooking. The advantage of using a wiper motor is that it requires a lower-voltage power supply. Studies have indicated that the environmental impact of barbecue grills is significant, primarily attributed to their extensive charcoal consumption required for uniform cooking. Additionally, the rotisserie technique is less commonly utilized in budget-friendly barbecue grills. The study found that this technique can reduce grilling time and minimize the use of excessive charcoal. The choice of materials significantly influences the product's longevity. As a result, the decision was made to predominantly utilize mild steel in this project, along with a rust-preventing finishing spray. Furthermore, product safety is a crucial factor in ensuring a product's sustainability and reducing pollution can lead to a higher-quality product. A grill that uses less fuel while still maintaining optimal cooking temperatures would be more environmentally friendly and save users money. The use of high-quality and durable materials, such as mild steel, can prevent rusting and increase the grill's resilience. Ultimately, incorporating these improvements can lead to the creation of a better BBQ grill machine that offers a safer, more efficient, and versatile cooking experience, with the added potential for commercial value.

Keywords: Automatic barbeque grill, Prototype development,

1 INTRODUCTION

Barbeques, or BBQs, have always been trendy. Generally, people consider it a summertime activity [1]. However, in recent years, there has been a surge in the popularity of outdoor cooking. Thus, BBQ grills have become increasingly popular. These days, barbecue has been elevated to a glam and gourmet level [1]. This trend is also seen in the increase in demand for outdoor kitchens and built-in grills. One common problem that people might face when owning their BBQ grill is budget constraints. In Malaysia, the average Malaysian spends upwards of RM1,000 on barbecue sets, most of the gas or charcoal variety for people who live in landed properties [2]. Buying a BBQ grill also involves considering factors like storage space. Some individuals have limited space, making the buying process more challenging.

The use of modern materials such as cast iron, stainless steel, and aluminium for constructing grills has made it possible to produce products that are durable, lightweight, and corrosion-resistant at an affordable price range. They have different properties that affect heat conductivity, and as a result, it influences the method and speed of grilling [3]. Functionality should be a top priority, ensuring the grill has ample space to cook multiple items simultaneously. Proper ventilation is also crucial for preventing flare-ups and ensuring safety while cooking. With careful research on consumer preferences and market trends, products made could bring unique features that enhance user experience. Hence, the project also focuses on the selection of high-quality materials that are durable and heat-resistant at reasonable prices.

The key issue in the production of a BBQ grill revolves around finding the right size. Most BBQ grills are large which is difficult to use and maintain. Most people choose a built-in grill between 34 and 40 inches [4]. BBQ grills require regular maintenance and cleaning to ensure their longevity and optimal performance. The increased size of a BBQ grill reduces its portability. Having a portable grill, whether it's a miniature tabletop model that's easy to carry or something a little bigger to cook for a crowd, gives you the freedom to grill whenever you want [5].

Considering the above issues and problem statements the main objectives of this study are:

1. To design a new barbeque grill with a simple design while incorporating distinctive and unique features.
2. To fabricate the barbecue grill it has become easier to clean and maintain.

The scope of this study covers below statements:

1. This BBQ grill will use electric power to operate the motor.
2. This project is focused on the rotisserie cooking style.
3. This purpose is to reduce cooking time and make uniform cooking during grilling.
4. This barbeque grill does not require more space for storage.

The significance of this study from this project is to be overcome by undertaking a customization approach to creating a BBQ grill. This process allows the design of the BBQ grill to be adapted to the desired needs while maintaining a low cost compared to commercialized options. Conducting an initial project assessment can aid in customizing the design to align with specific desired requirements. The grill's design, size, and unique advantages can compete with available products in the market. On the other hand, this project will bring many benefits to the community. It serves as a gathering medium between family and friends and provides a great opportunity to bond to socialize while enjoying delicious food in an open environment.

2 LITERATURE REVIEW

In this section, a concise and comprehensive literature review regarding the development of an automatic barbeque grill will be presented. The literature review will cover four main elements which are benchmarking or comparison with available products, review of related manufacturing processes, and patent or intellectual properties regarding the proposed prototype design. For benchmarking purposes, there are three previous or in-the-market products have been selected. There are 1) Weber Genesis E-435 (Gas grill), 2) Electric Barbeque Grill Korean Pan, and 3) Charcoal Grill. Details regarding the benchmarking are presented in Table 2.1.

Table 2.1: Automatic barbeque grill benchmarking

Name	**Advantages**	**Disadvantages**
Weber Genesis E-435 (Gas Grill)	1. The luxurious design includes wheels for mobility and storage choices, making this BBQ grill a coveted item for all. 2. Gas grills have an uninterrupted fuel supply. 3. Has a stable gas emitting [6] and offers easy with fast heating, allowing precise temperature control.	1. Higher in price.
Electric Barbeque Grill Korean Pan	1. Versatility in terms of they can be used both indoors and outdoors, making them suitable for various settings such as balconies or countertops. 2. The adjustable temperature controls allow for precise cooking and consistent results.	1. The device consumes a lot of electricity to heat and maintain the desired temperature, it is usually very expensive for owners of powerful devices [7].
Charcoal Grill	1. The use of different types of charcoal and wood can result in a wide range of flavors. 2. Charcoal grills tend to be more affordable overall, especially smaller and portable models that commonly utilize charcoal as their fuel source [8]	1. Produce a lot of smoke and less precise temperature control.

For the related manufacturing process literature review, six main processes are required to develop an automatic barbeque grill. First, it begins with designing the grill, considering the desired size, shape, and features. Second is the selection of the material which majority of materials to be used in this BBQ grill are expected to exhibit properties such as heat resistance and rust resistance and for that reason mild steel is a prime selection. The adoption of the rotisserie method in this project allows the use of wiper motors. This addition enhances the versatility of this BBQ grill, allowing it to serve multiple functions. The fourth stage is the final assembly involves bringing together all the components, including the grill body, cooking grates, charcoal tray with the motor, and additional features like handles and vents. Then thorough testing is conducted to ensure safety and functionality, checking the motor's rotation and adjustability, as well as heat distribution and ventilation. Defects are inspected, and necessary adjustments or improvements are made. The last manufacturing process will be a heat-resistant coating or finish applied to protect the grill from corrosion and enhance its appearance, with a focus on food safety and suitability for high temperature.

Intellectual property and patents are legal rights that protect inventions, innovations, and creative works. This promotes innovation, creativity, and healthy competition among creators. It also enables creators to benefit financially from their work while safeguarding it from unauthorized use by others. A few patent applications offer an intriguing look into the future of backyard grilling, including methods of reducing unwanted smoke and making grilling safer [9]. Table 2.2 portrays a summary of the detail’s specifications of the reviewed patterns.

Table 2.2: Details specifications of the reviewed patterns

Patent	**EP3677156B1**	**US8084719B2**	**US8201550B2**
Material	Aluminium	Plastic Aluminium	Aluminium
Machining Process	Forming Machining Joining	Joining	Forming Machining Joining
Machine Name	SMAW CNC Milling Machining	Welding	SMAW CNC Milling Machining
Size	Too Large	Small	Large

3 METHODOLOGY

The prototype development begins with the first step which is a concept design, wherein ideas are transformed into structured plans. Conceptual design is an early phase of the design process, in which the broad outlines of the function and form of something are articulated [10]. This part keeps going from the earlier research and evolves into the fundamental framework essential for bringing the project to fruition.

Following that, three preliminary sketches were crafted during the concept design phase. Each design shows its unique features. The emphasized standards include versatility, effectiveness, and additional expertise in each design. Next, SolidWorks software was utilized to construct a 3D model, providing a more detailed insight into the project. SolidWorks software also offers clearer visualization and a more detailed understanding of the project's structure and functionality. This process involves precisely aligning and connecting the various parts according to the design specifications. Virtual prototyping helps you make key design decisions earlier in the process [11]. Fig. 3.1 shows the final solid work prototype drawing.

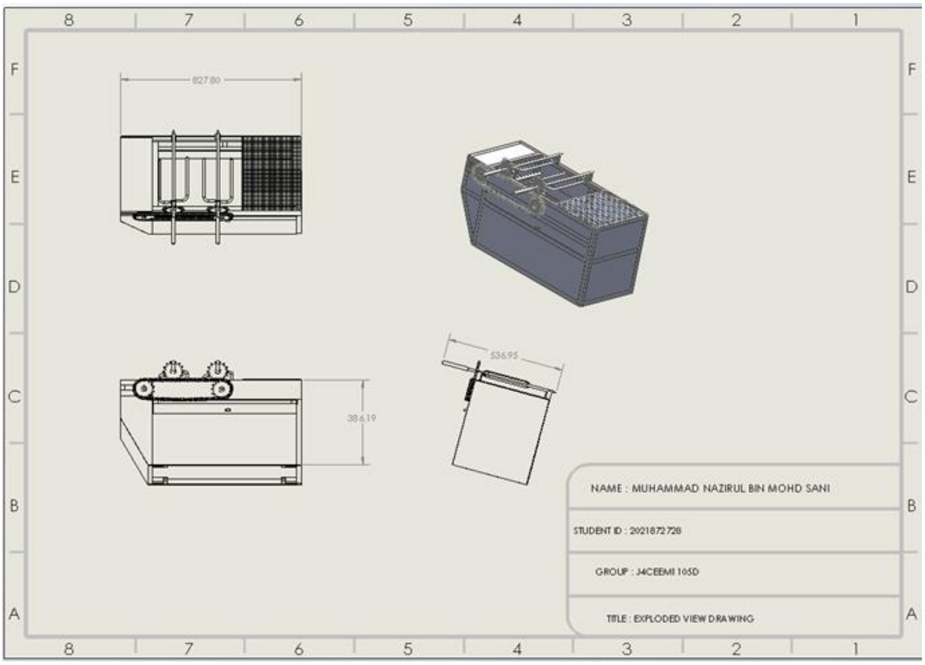

Fig.3.1: Final solid work prototype drawing

Once the design of the product has been finalized, the next critical stage involves selecting the materials and a fabrication process plan. When choosing materials, mild steel stands out as the optimal choice for constructing a BBQ grill. Due to its favorable characteristics such as durability, heat resistance, and suitability for grilling purposes. This high melting temperature means that mild steel is more ductile when heated, making it particularly suitable for forging, cutting, drilling, and welding, and is easy to fabricate [12].

To fabricate the product, various processes are required, such as measuring, cutting, grinding, and welding. These processes are crucial for shaping and assembling the components, ultimately leading to the creation of a functional. The next step involves engaging in parameter calculation, which entails analyzing and computing various factors essential to the project's specifications and requirements. For this project, the calculable aspects of the rotisserie BBQ grill involve determining the necessary torque for a single revolution and establishing the minimum power essential for system movement.

Following the previous stages, the subsequent phase involves design detail. This phase includes specifying precise dimensions and material specifications for the final product's construction and functionality. For example, list all the stuff used in manufacturing, such as the main material (mild steel), the project's moving parts like sprocket and chain, and the material that covers it, such as galvanized iron sheets, along with their sizes. The next stage involves preparing the item for its intended purpose by undertaking necessary actions such as assembling, testing, and ensuring its functionality and readiness for deployment according to the design from SolidWorks. It helps to predict the threats and develop proper steps to recover [13]. Fig. 3.2 portrays the assembling drawing of the proposed prototype.

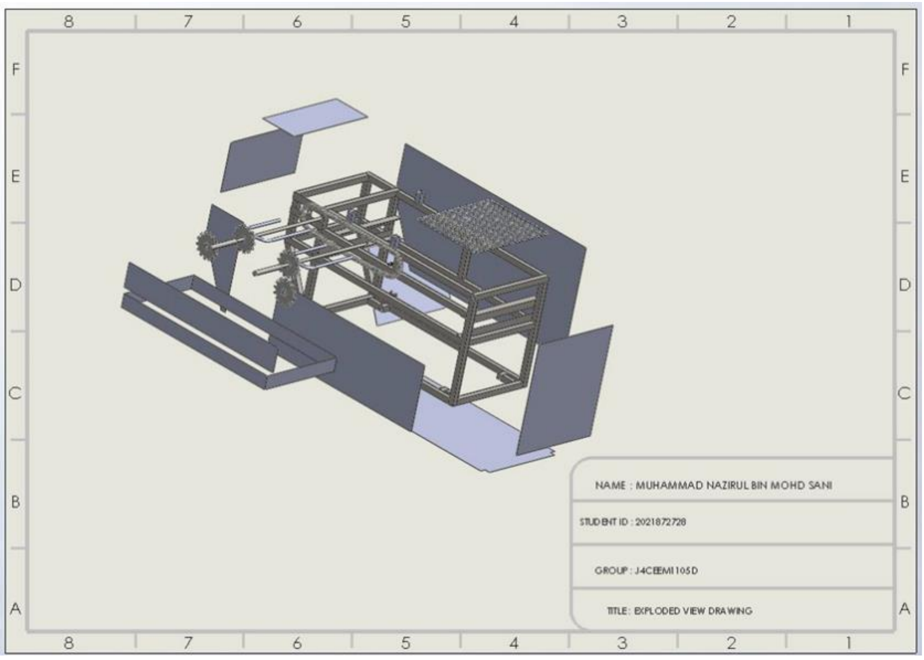

Fig. 3.2: The assembling drawing of the proposed prototype

Next, the fabrication process adapts to the project's specific needs. The fabrication process adjusts according to the exact requirements of the project. For example, the technique of riveting galvanized iron sheets demands accurate sizing to avoid any surplus material when fastening onto the mild steel, thereby preventing potential injuries or mishaps.

Finally, after undergoing the fabrication process, the rotisserie BBQ grill undergoes testing to thoroughly evaluate its performance in alignment with the predetermined goals. This evaluation aims to ensure that the grill functions optimally and establishes criteria for efficiency and effectiveness in its operation. Upon successful completion of these assessments, any necessary adjustments are made to ensure the rotisserie BBQ grill meets the required standards, concluding in a well-functioning and reliable final product.

4 RESULTS AND DISCUSSION

The final output is a crucial component in evaluating a project's success. This is often regarded as a tangible measure of the project's completion and alignment with the initially set objectives. The result holds significance since it serves as an evaluation of both the project's overall quality and the achievement of its objectives. The most important factors are functions and advantages since they can indicate how well a product would satisfy users' demands with special features. Fig. 4.1 shows the result of the prototype after its effectiveness has been tested.

Fig. 4.1: The final result of the prototype

This prototype works when the sprocket can be moved by the chain perfectly. The rotating shaft is unable to move. It is possible to lower the shaft's potential for slipping out the retainer. After adding cooking ingredients, such as chicken, the shaft's rotation stays at the optimal level. The direction of movement of the wiper motor, which is anticlockwise, influences the direction of the shaft's rotation. The direction of this movement can be determined according to the wire connection on the power supply, which is the motor battery.

The pros and cons of a product can be influenced by a variety of situations. Among the factors that can affect the project's result are shifting requirements, resource constraints, shifting environmental conditions, and the availability of technology at various points in time. Without a doubt, the original intention behind this project's creation was to solve problems that already existed. But shortages are unavoidable. Therefore, the product produced is at least capable of being an answer to the lack of existing products. Coupled with new advantages at the same time able to make this product almost perfect. Table 4.1 portrays the advantages and disadvantages of the prototype.

Table 4.1: Advantages and disadvantages of the prototype

Advantages	Disadvantages
1. Creating a multifunctional setup	1. Not intended for use beyond the confines of a home environment
2. Easily portable and user-friendly	2. Inappropriate for utilization in rocky terrains
3. Capable of achieving uniform grilling of food	
4. Provides a spacious and safe storage area	

The rotisserie BBQ grill prototype's sustainability adds value for customers by having a beneficial environmental impact, which makes the product look better. Table 4.2 displays all the sustainability points that have been considered during the development of this prototype.

Table 4.2 Sustainability consideration during the development of the prototype

Sustainability considerations
1. The use of long-lasting materials like mild steel and galvanized sheet iron.
2. The design of this prototype which can distribute heat evenly allows food to be cooked uniformly and consistently, speeding up the overall cooking process.
3. The use of recycled materials such as the caster roller wheel found in the foundry workshop as a result of leftovers from the previous semester's project.

The last important element is prototype maintenance. Every product needs a maintenance interval to guarantee optimal performance and effortless use. The product's materials and parts are what define how long this maintenance period should survive. Components with more complexity are more likely to be damaged. Therefore, frequent and comprehensive maintenance schedules are necessary for intensive use. This is to avoid undesirable flaws from happening. To guarantee that the product can function correctly and has a long lifespan, this prototype is also given the right maintenance schedule.

5 CONCLUSIONS

In conclusion, by combining innovative characteristics with uniform cooking capabilities, this project effectively reached its aim by creating a new design for a BBQ grill. This grill's focus on a simpler design allows it to cook food evenly while retaining special characteristics that raise the product's potential, able to last longer due to the project's easily maintainable design. Thus, this project achieved success in fulfilling its objective to create a grill that is efficient, easy to use, and has unique features that differentiate it from existing products. On top of that, a BBQ grill prototype with components that can move automatically with the use of motor wipers has been successfully created. The study also involves testing the efficiency of using wiper motors such as ensuring uniform rotation for even heat distribution. The research also details the wiper motor's ability to withstand heat or environmental conditions that may be different during grill operation.

For the future undertakes, several recommendations have been made to improve the prototype quality, including:

1. Automatic function - One potential enhancement involves integrating an automatic function allowing users to set temperature, time, or specialized cooking modes for greater ease.

2. Safety - Using durable high-quality materials as well as integrating safety elements such as additional locks, more efficient fire control, or compliance with certain safety standards will increase the appeal of the product and consumer confidence in the safety of its use.

3. Design of body - Installing a roof on the BBQ grill is an additional element that has the potential to provide several advantages to the product.

All these features and improvements allow the product to compete better in the market. By being able to fulfill the needs and wants of modern consumers, and provide the competitive edge needed in this competitive industry.

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CHAPTER 10

Development of Adjustable Table Lifter Transport Using Hydraulic Jack

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ABSTRACT

This project is presenting a piece of equipment or a system that uses hydraulic jacks to lift and transport heavy objects or materials, and the adjustable aspect allows you to control the height or position of the lifted load. It is expected to simply move the furniture and heavy appliances from one location to another, allowing to rearrange the furniture. After that, the design of this project also included additional features using hydraulic jacks, it can precisely adjust the height or position of the lifted load. This project discusses about the expected to be easy to maneuver easily, comfortable to use and safer and more secure. In conclusion based on the developed system, authors discussed the advantages and points need to be considered when working on the system.

Keywords: Transport heavy objects, Hydraulic jacks

1 INTRODUCTION

Nowadays, a heavy object is an item or an entity that is notably heavier than what can be easily lifted, moved, or manipulated by human strength alone. Roughly 21% of workplace injuries are directly linked to manual handling tasks, such as the lifting, carrying, or movement of objects [1] .These incidents are frequently exacerbated by improper lifting methods and insufficient ergonomic practices. It's imperative for consumers to make the safety of manual handling procedures a top priority and to prevent injuries resulting from manual handling.

Next, many claims that the difficulty of carrying heavy object, even with two people, is due to its weight. People's laziness in moving this bulky object for cleaning and interior design will be well-spent. Regarding this issue, it is challenging to carry that heavy furniture to a specific place. To help get along with people with their moving problems, we need a mechanism that can move a heavy object to the place where I need it by myself.

So, our current solution is to create a mechanism that can move the bulky goods quickly and is simple to use without using an effective tool or even needing manpower. However, when moving any load, there is always chance of problem such as the risk of loads slipping on smooth surfaces, suitability only for flat terrain, challenges with maneuvering around corners, limited load capacity, instability in heavy-duty tasks, and a requirement for substantial force to push or pull the trolley [2].

This project aims to fabricate the designed adjustable lifter transport as a proof of concept that could be replaced or function as an alternative for lifter transport by using hydraulic jacks to lift and transport heavy objects or materials, and the adjustable aspect allows you to control the height or position of the lifted load. This model's main benefit is that it makes carrying heavier furniture less difficult for people using it.

Moving on to the next point which is the significance of this study from this project that it helps make the process of moving heavy objects easier and more efficient, especially for individuals who may need access to professional movers or sufficient physical strength to lift heavy items on their own. After that, the versatile design makes the heavy objects lifter transport can easily move such as household items, bookshelves, and so on. This quality can also significantly reduce physical strain and make the process more manageable for individuals[4].

2 LITERATURE REVIEW

Fig. 1: Handling Trolley Hydraulic Table Truck

Figure 1 shows a typical handling trolley heavy duty lift hydraulic table truck. These widely used nowadays cause this transport strong enough to deal with items up to 150 kg. It's important to check the weight capacity of the furniture transport and ensure that it is suitable for the specific furniture. This product contains a wheeled lifter and 4 wheels corner movers that can help move any piece of furniture in their own home. Another factor to consider is the product designed with hydraulic scissor lift jack that can be easy to control cargo and table and can get as far as the desired platform height. The market price is also high and not suitable appropriate for everyone to purchase one.

Fig. 2: Metal Lift Table

Figure 2 shows a well-known that combining special handling systems and ergonomic design allows this tool to lift heavy objects effortlessly. The lift table is constructed with knob which it can be adjusted the height of objects by knob. The high-grade material from stainless steel is high hardness and resistant to rust or even corrosion, while it also capable of withstanding heavy use and loads. The products generally require less maintenance compared to lifts made from other materials.

Fig. 3 Furniture Lifter kit Lifting Moving Slider

Figure 3 shows this furniture lifter tool incorporates an ergonomic and labor-saving design, allowing them to move their furniture effortlessly using their physical strength[5]. The ergonomic design ensures it can lift and transport heavy furniture and appliances without straining back. Effortlessly lift furniture with just one hand. The four roller pads are in the four corners of the furniture. It can bear a weight of up to 100 KG, enabling it to move furniture or heavy objects easily.

3 METHODOLOGY

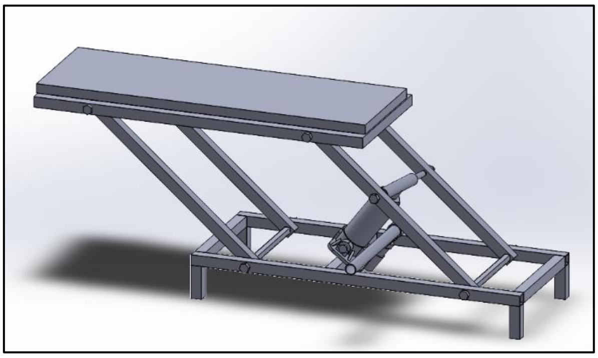

Fig. 4.1: Design model

Fig. 4.2: Final prototype

The design seen in Figure 4.1 was created using the SolidWorks, whereas Figure 4.2 represents the completed prototype. The final prototype predominantly used two types of steel, namely mild steel, and stainless steel. The stainless-steel material is utilized for components that require exceptional resistance to substantial forces.

Table 1: Prototype Final Specification

Types	**Specification**
Frame	Mild Steel Square Hollow
Power Source	Hydraulic Jack
Material	1. Mild Steel (frame) 2. Stainless steel (bolt) 3. Pine wood (base)
Market price	RM250
Basic Function	Lifting the heavy items
Dimension	600 mm x 200 mm x 400 mm

4 RESULTS AND DISCUSSION

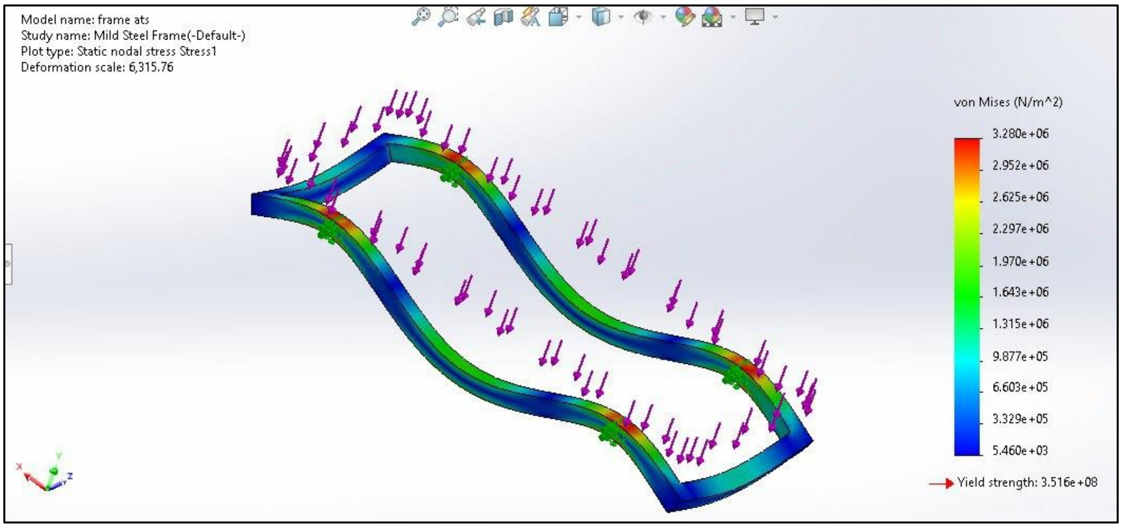

Fig. 5: Von Mises Stress Diagram

Based on the project's calculations, the applied force is about 500N on the frame when lifting the load. The maximum stress which 3.280+06 Nm/m² is lower than the yield strength 3.516+e08 Nm/m². Consequently, this design is deemed safe for consumer usage, however its weight capacity is restricted and varies according to different applications and situations.

5 CONCLUSIONS

The objective aim of the project was to create the prototype. The assigned assignment was challenging to complete due to insufficient feedback on the desired design. The design process was hindered by a lack of proficiency in utilising the SolidWorks programme. In addition, it is necessary to cross-reference the study conducted on the machine with the product that is now accessible. Primarily, the inspiration was derived from conventional tables. The prototype underwent many iterations to get its ultimate design. The ultimate design successfully rectifies the shortcomings of the first concept. They have features such as adjustable height, high load-bearing capacity, and stability, which make them suited for a diverse array of jobs. Nevertheless, it is crucial to contemplate the benefits and drawbacks of hydraulic tables, together with their sustainability and upkeep prerequisites.

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CHAPTER 11

Introducing the PrecisionFlex Grinder: A Revolutionary Adjustable Cutting Solution

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ABSTRACT

This study develops the PrecisionFlex Grinder as an innovative solution to meet the modern manufacturing demand for adaptable cutting tools by overcoming traditional grinders' limitations. Traditional cutting tools struggle with varying material thicknesses, hardness levels, and cutting angles, resulting in operational inefficiencies and higher costs because of the need for multiple specialized tools. The research tackled these problems using a systematic process that combined design conceptualisation with SolidWorks simulation and iterative testing to achieve performance optimisation. Stress tests on the grinder holder confirmed material suitability, as the maximum stress remained below the yield strength limit. Performance tests revealed traditional tools were outperformed as cutting times dropped by up to 50% across aluminum and mild steel sheets of different thicknesses. The PrecisionFlex Grinder demonstrates enhanced workflow efficiency while minimising costs and improving precision and adaptability. The next development phase will incorporate intelligent systems while minimizing noise and vibration levels and testing new eco-friendly materials to boost performance attributes. The study demonstrates that merging theoretical design principles with practical manufacturing techniques leads to the development of advanced tools that address industries' changing requirements.

Keywords: SolidWorks Simulation, Adaptability

1 INTRODUCTION

In modern manufacturing and fabrication, precision tools are key to productivity, accuracy and meeting industry demands. Among these tools, cutting grinders are essential for shaping, refining and processing materials from metals to composites. Traditional cutting grinders lack adaptability and are limited to specific tasks or material types. This necessitates the use of multiple tools for different applications, increasing costs and inefficiencies [1-3]. To fill this gap, we have developed the PrecisionFlex Grinder, a game changing solution that combines precision engineering with unlimited adjustability. Designed to cover a wide range of cutting needs this tool will redefine industry standards with one tool for all complex fabrication challenges. As industries demand tools that can handle multiple materials and geometries the introduction of an adjustable cutting grinder is a major step forward in machining [3].

One of the biggest challenges in modern cutting and grinding is the lack of versatility in existing tools to accommodate varying material thickness, hardness and cutting angles. This inflexibility leads to suboptimal performance, equipment wear and tear and higher operational costs due to the need for multiple specialized tools [4]. Industries like aerospace, automotive and construction which demand high precision and adaptability, are particularly affected by the shortcomings of conventional grinders.

Fig. 1: Normal hand grinder

For example, in aerospace manufacturing, where tight tolerances and materials like titanium and carbon fiber are common the lack of adaptable cutting solutions results in material waste and production delays [5,6]. This limitation hampers operational efficiency and stifles innovation in material processing. To address these challenges the PrecisionFlex Grinder has been designed with a dynamic system that allows users to change cutting parameters. The objectives of this project are to design, analyse and build a tool that improves workflow, reduces costs and enables industries to achieve better outcomes.

2 LITERATURE REVIEW

Research in manufacturing and material science has focused mostly on the evolution of cutting tools since their crucial influence on the quality and efficiency of fabrication techniques. Although they are useful for use, traditional cutting grinders have been limited by their incapacity to change in geometries and material properties. Kumar et al. [6] found that the lack of adaptability in traditional grinding tools often leads to suboptimal performance when processing materials with varying hardness or thickness. This restriction has made one more dependent on several specialised tools, which raises running expenses and causes workflow inefficiencies. Moreover, Brown and Martinez [7] underline that developments in material science, including the creation of sophisticated composites and alloys, have outpaced the capabilities of traditional cutting tools, creating a growing demand for more versatile solutions. These studies highlight the urgent need for tool design developments that can overcome rigidity constraints and improve adaptability in cutting operations.

By including adjustable mechanisms in cutting tools, recent developments in machining technology have started to solve certain difficulties. Zhang and Chen [8] for example carefully examined adaptive cutting systems, stressing the need of dynamic parameter changes in enhancing tool performance and lifetime. Their results imply that tools with changeable characteristics help lower material waste and improve consistency and accuracy in many different uses. Roberts and Thompson [9] also investigated how cutting tools might incorporate smart technologies such as sensors and real-time feedback systems into their design, so increasing their adaptability and accuracy. These developments closely relate to the idea behind the PrecisionFlex Grinder, which uses changeable cutting settings to satisfy the changing needs of contemporary sectors. But even with these developments, there is still a lack of affordable, approachable tools that blend durability, accuracy, and adaptability. By providing a workable solution that tackles both technical and financial difficulties in material processing, the PrecisionFlex Grinder aims to close this gap.

3 METHODOLOGY

The process of designing and fabricating the PrecisionFlex Grinder begins with identifying the problem statement, which highlights the limitations of existing cutting tools, such as their inability to adapt to varying material thicknesses, hardness levels, and cutting angles. Once the problem is defined, a conceptual design is developed, and a suitable design and materials are selected. Precise measurements are then taken to finalize the design specifications, after which the design is subjected to SolidWorks simulation to evaluate its performance under real-world conditions. If the simulation reveals shortcomings, iterative adjustments are made until the desired functionality is achieved. This iterative process ensures that potential issues are addressed before fabrication.

Once the design passes the simulation phase, the fabrication process begins, where the physical components of the grinder are manufactured using advanced techniques like CNC machining or 3D printing. After fabrication, the grinder undergoes rigorous testing to verify its performance in practical scenarios, including cutting precision, adaptability, and durability assessments. Any issues identified during testing are resolved through further refinements. The process concludes when the final product meets all performance criteria, ensuring that the PrecisionFlex Grinder is a reliable, cost-effective, and adaptable solution for modern manufacturing challenges. This systematic approach ensures the development of a high-quality tool tailored to meet industrial demands.

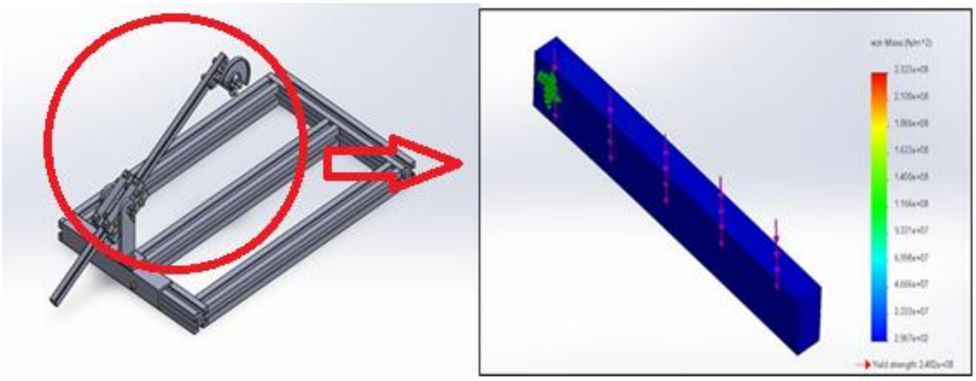

Fig. 2: SolidWorks simulation to evaluate

4 RESULTS AND DISCUSSION

During the design and fabrication of the PrecisionFlex Grinder, a critical focus was placed on analyzing the structural integrity of its key components, particularly on the holder grinding, which plays an essential role in the tool's performance. The holder underwent stress analysis to assess its ability to withstand operational forces without bending or breaking. A force of 10N was applied to assess the load-bearing capacity and the results revealed a maximum stress value of 2.333×10^{8} N/m ^{2}, which is below the material's yield strength of 2.482×10^{8} N/m^{2}. This indicates that the material size used is highly suitable for holding the grinder, as it can resist deformation under the expected operational loads. Stress, defined as resistance to deformation per unit area ($P = F/A$), was mathematically validated to ensure durability and reliability. These findings confirm that the selected material meets the necessary performance criteria, ensuring the grinder's robustness and longevity.

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Table 1: Data of performance analysis

Adjustable cutting grinder				**Angle grinder (using hand)**	
Aluminium		**Mild steel**		**Mild steel**	
Thickness	**Time**	**Thickness**	**Time**	**Thickness**	**Time**
1mm	7 sec	1mm	15 sec	1mm	30sec
2mm	14 sec	2mm	30 sec	2mm	64sec
3mm	21 sec	3mm	45 sec	3mm	90 sec

To further validate the effectiveness of the PrecisionFlex Grinder, performance tests were conducted using materials such as aluminium and mild steel with varying thicknesses (1mm, 2mm, and 3mm). As shown in Table 1, the PrecisionFlex Grinder demonstrated superior efficiency compared to traditional tools like angle grinders operated manually. For instance, cutting aluminium sheets of 1mm, 2mm, and 3mm thickness required only 7 seconds, 14 seconds, and 21 seconds, respectively, whereas an angle grinder took 15 seconds, 30 seconds, and 45 seconds for the same task. Similarly, cutting mild steel sheets of identical thicknesses was significantly faster with the PrecisionFlex Grinder (30 seconds, 64 seconds, and 90 seconds) compared to manual grinding methods. These results highlight the grinder's ability to deliver consistent and efficient performance across different materials and thicknesses. The stress analysis and performance testing demonstrate that the PrecisionFlex Grinder successfully fulfills its design objectives, offering a versatile, precise, and time-efficient solution for modern cutting applications.

Fig. 3: Final appearance PrecisionFlex Grinder

5 CONCLUSIONS

The PrecisionFlex Grinder's design and construction effectively illustrate how theoretical ideas and real-world manufacturing procedures can be integrated. The development process used SolidWorks to balance manufacturability, utility, and simplicity while tackling important issues like minimizing vibration, optimizing power consumption, and simplifying blade replacement. The proof-of-concept prototype confirmed the design's feasibility, and its functionality was further improved through iterative testing modifications. This interdisciplinary approach emphasises how crucial it is to match creative design with reliable fabrication methods to produce an effective and user-friendly tool.

The PrecisionFlex Grinder has significant potential for future growth. The grinder can improve usability and simple control by integrating smart technologies like sensors and real-time monitoring. Its appeal will be further enhanced by initiatives to lessen noise, vibration, and environmental impact using eco-friendly materials and energy-efficient motors. Refinements will be guided by testing feedback and scalability evaluations, opening the door for mass production and wider market acceptance. Ultimately, this project establishes a strong foundation for continuous innovation, ensuring the PrecisionFlex Grinder evolves into a cutting-edge solution that meets and exceeds user expectations in precision and adaptability.

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CHAPTER 12

Design and Development of Mechanical Linkage Steering System for Go-Kart

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ABSTRACT

This project focuses on the design and development of a Go-Kart Direct Mechanical Linkage Steering System. Three initial design concepts were sketched, and the final design was modeled using SolidWorks software. After modifications, the system was fabricated over a 13-week period. The fabrication process included cutting, turning, grinding, welding, and assembly, ensuring the system's structural integrity and functionality. The fabricated steering system was tested at its maximum steering angle to evaluate performance, demonstrating reliability and precision in maneuvering the go-kart. The system offers simplicity, cost-effectiveness, and a direct mechanical connection, providing quick and responsive steering. However, it requires manual effort and regular maintenance. By analyzing the system's design, fabrication, and performance, this study contributes to optimizing mechanical linkage steering for go-karts, enhancing safety, durability, and efficiency. The findings provide insights into improving future steering systems for recreational and competitive applications.

Keywords: Design, Fabrication, Mechanical linkage system

1 INTRODUCTION

The evolution of go-kart steering systems has progressed significantly from their early designs, with mechanical linkage steering systems still in use today. Over time, advancements in design and technology have led to the development of more efficient and responsive steering mechanisms. Systems such as rack, pinion, and hydraulic steering have been introduced to enhance go-kart performance and control [1]. The steering system is crucial to the rider's safety and comfort. It ensures directional stability and controls the go-kart, even during sharp turns. The system achieves the angular motion of the front wheels through a series of linkages and steering gears, which convert the steering wheel's rotational movement into precise angular adjustments of the wheels. The rack and pinion system is widely preferred among various steering mechanisms due to its simplicity and efficiency. This system directly translates the steering wheel's rotation into linear motion, allowing for a smaller turning radius, which is essential for manoeuvrability and safety in specific driving conditions.

Key components of a go-kart steering system include the steering column, tie rods, steering knuckles, steering wheel, and the linkage mechanism, such as the rack and pinion. Each component contributes to the system's smooth operation by accurately transmitting the driver's input into precise wheel movements. This study explores go-kart steering systems' performance characteristics and applications by analyzing factors such as movement dynamics, directional control, material selection, and the forces acting on the linkage. Additionally, it seeks to identify the most suitable components for an efficient steering system and evaluate the effectiveness of different steering mechanisms. The findings from this research will enhance the understanding and optimization of go-kart steering systems for improved performance and safety.

2 LITERATURE REVIEW

The go-kart mechanical linkage steering system is crucial in determining handling, performance, and overall driving experience. Different types of steering systems have been developed over the years, each offering unique advantages and limitations [2]. Understanding these systems is essential for optimizing steering responsiveness, precision, and ease of use [3]. This study explores the three main types of go-kart steering systems: direct steering, rack and pinion, and recirculating ball steering. The direct steering system, also known as the tie rod steering system, is the most straightforward mechanism, where the steering wheel is directly connected to the front wheels via tie rods. This system offers immediate response, making it highly effective for precise control. Its simple design, with fewer moving parts, ensures low maintenance and reduced repair costs. However, it requires more space for installation and is more prone to wear and tear, reducing durability over time. Despite these limitations, the direct steering system remains a cost-effective and widely used option in go-kart applications [4].

The rack and pinion steering system provides greater precision by translating the rotational motion of the steering wheel into linear motion. This system consists of a pinion gear that moves a rack gear, enabling smooth and responsive steering [5]. Compared to direct steering, rack and pinion systems offer better feedback and control, making them ideal for performance-focused go-karts. However, the added complexity of this system requires more maintenance, and its repair costs are higher. Despite these challenges, its compact design makes it suitable for go-karts with limited space.

The recirculating ball steering system is a more advanced mechanical linkage system commonly found in vehicles requiring high mechanical advantage. It uses a worm gear and sector gear mechanism to convert steering input into lateral wheel movement. The recirculating balls reduce friction and wear, ensuring smoother operation and increased durability. However, this system is mechanically complex, leading to higher maintenance and costs than the other two systems. While not as commonly used in go-karts, it remains a viable option for applications requiring greater steering force and longevity.

3 METHODOLOGY

Fabrication is a crucial aspect of this final-year project, ensuring the successful construction of the go-kart mechanical linkage steering system. It involves the process of manufacturing and assembling various components using multiple fabrication techniques as in Figure 1. The most common fabrication techniques are cutting and drilling, which shape raw materials into the necessary parts. The fabrication process differentiates itself from other manufacturing methods by combining multiple processes to create a functional and reliable system. Each step in this process is vital to achieving precision, durability, and overall performance.

The first stage involves measuring and cutting the required materials, primarily steel, to form the base components of the steering system. Steel bars are used as structural support, requiring manual cutting for precise dimensions. Next, the turning process is performed on mild steel rods using a lathe machine to fabricate the steering column and shafts. This step ensures that each component has the required dimensions and functionality. The polishing and grinding phase smooths out the steel components, removing imperfections and ensuring a refined finish for better performance and aesthetics.

Fig. 1: Fabrication process of the steering

Once individual components are fabricated, the next step is spray painting to enhance durability and protect against corrosion. All parts are disassembled, sprayed, and left to dry thoroughly. After drying, the components are assembled, ensuring all parts fit together with the correct dimensions. This process is followed by welding, where mild steel rods are permanently joined at precise angles to provide structural support. Welding ensures a secure and stable connection between components, reinforcing the steering system for long-term use.

Finally, the testing phase is conducted to verify the functionality and reliability of the go-kart mechanical linkage steering system. This step ensures that all fabricated components work together seamlessly, allowing smooth steering and control. Any necessary adjustments are made to optimize performance before finalizing the project. Following this structured fabrication process, the steering system is developed to meet the required specifications, ensuring safety, efficiency, and durability in go-kart applications.

4 RESULTS AND DISCUSSION

Figure 2 shows the final fabricated prototype of the Go-Kart Mechanical Linkage Steering System that has been finished and manufactured. The Go-Kart Mechanical Linkage Steering System requires proper handling and maintenance to ensure safety and longevity. The first step involves checking and securing all bolts, nuts, and fasteners in the steering assembly to prevent any loose components that could lead to steering failure. The second step focuses on inspecting for wear or damage in key components such as tie rods, steering column bearings, and universal joints, ensuring that no critical part is compromised.

The third step is applying grease or lubricant to all moving components to reduce friction and minimize wear over time. Proper lubrication extends the lifespan of the steering system and enhances smooth operation. The fourth step involves manually turning the steering wheel in the desired direction, ensuring the mechanical linkage responds accurately and smoothly to driver input. These operational steps will help maintain optimal steering performance and prevent accidents.

Fig. 2: Final prototype

The Go-Kart Mechanical Linkage Steering System offers various advantages and disadvantage. One of the primary benefits is its straightforward design, which makes it easy to maintain and repair. It is also cost-effective and more affordable than hydraulic or electronic steering systems. The direct mechanical connection ensures a quick and precise steering response, making it highly reliable. Additionally, the system's lightweight construction enhances the go-kart's overall efficiency.

However, there are notable disadvantages. The system requires more physical effort, especially at low speeds or tight corners. It also demands frequent maintenance to prevent excessive wear and tear. Another drawback is the lack of self-centring capabilities, meaning the driver must manually return the steering wheel to the centre position after turning. Lastly, while the system works well for standard go-karts, it is unsuitable for high-speed vehicles, requiring greater precision.

By understanding these advantages and disadvantages, users can make informed decisions about the suitability of the mechanical linkage steering system and take the necessary steps to ensure its proper function and durability.

5 CONCLUSIONS

A Go-Kart Direct Mechanical Linkage Steering System was designed and developed in this project. Three initial design concepts were sketched, and the final design was created using SolidWorks software. The system was fabricated after incorporating the necessary modifications, which took approximately 13 weeks to complete. The fabricated steering system demonstrated reliability and efficiency in manoeuvring the go-kart. It was tested at its maximum steering angle and performed well, ensuring smooth and precise control during turns.

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CHAPTER 13

Structural Design and Fabrication of a Go-Kart Front Suspension

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ABSTRACT

The suspension system is an essential component of an automotive vehicle, ensuring proper functionality and performance. It absorbs shocks from rough terrains while maintaining handling stability by keeping all tyres in contact with the road. This project focuses on developing a functional front suspension for a go-kart. The most suitable suspension type will be selected and integrated into the go-kart's frame. An informed decision will be made through mock-ups and testing of different suspension types. Ultimately, this research and development process will enhance the go-kart's overall performance.

Keywords: Design, Fabrication, Front Suspension

1 INTRODUCTION

The suspension is a mechanical system that connects the wheels to the vehicle's frame, allowing relative motion between them. It is designed to support the weight of the vehicle and its passengers by evenly distributing it across all wheels. Additionally, it absorbs and dampens shocks and vibrations caused by uneven road surfaces, maintains tyre contact with the road, and controls body roll, pitch, and yaw to enhance stability and handling. The suspension system also improves ride comfort by isolating the cabin from road noise and disturbances as in Figure 1.

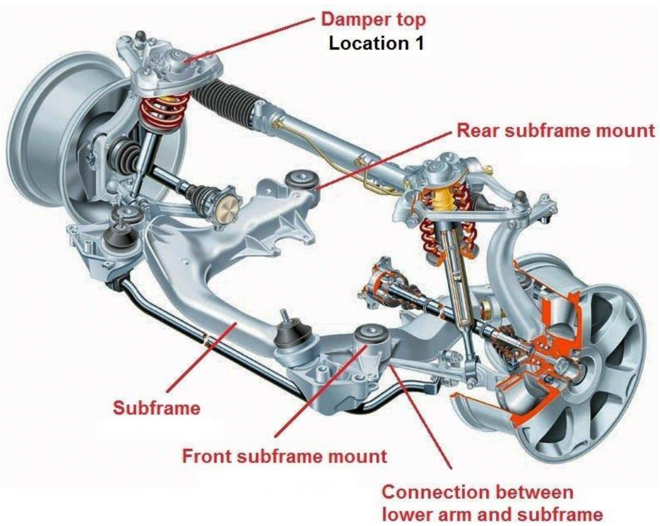

Fig. 1: Multilink Suspension

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A suspension system consists of multiple components working together to fulfil its function. For example, springs store and release energy when compressed or extended while supporting the vehicle's weight. Dampers, also known as shock absorbers, dissipate the energy stored in the springs to minimize excessive oscillations and bouncing. Control arms or wishbones connect the wheels and the frame, enabling controlled vertical and horizontal movement.

Over the years, various suspension innovations have been developed, ranging from rigid axle to active suspension. Rigid axle suspension consists of a solid beam connecting the wheels on the same axle. While it offers high durability and load capacity, it compromises comfort and handling—for example, leaf springs. On the other hand, independent suspension allows each wheel to move independently, providing better comfort and handling at the cost of reduced durability and load capacity, such as the double wishbone suspension.

A hybrid system known as semi-independent suspension allows some degree of movement between wheels on the same axle, such as the twist beam suspension. Lastly, active suspension utilizes sensors, actuators, and controllers to adjust suspension parameters for optimal comfort and dynamic handling. However, this system comes with higher costs and increased complexity.

2 LITERATURE REVIEW

Manufacturing is the process of transforming raw materials into finished products through the use of tools, labour, machining, and chemical processing [1]. Every manufacturing process begins with design, which is carried out using advanced CAD software to create 2D or 3D models of the product intended for production.

Material selection is a critical step in manufacturing, directly impacting the final product's strength, stiffness, and weight [2]. Choosing an unsuitable material can lead to product failure. For this reason, steel is commonly used in large-scale manufacturing due to its desirable mechanical properties.

Cutting involves shaping a workpiece such as metal by moving it about a cutting tool [3]. Techniques such as shaving, drilling, and milling are used to achieve the desired shape. Cutting also includes separating or dividing materials into smaller parts for further processing.

Metal joining is a controlled process used to fuse metals, either temporarily or permanently, with or without applying heat or pressure [4]. Various joining techniques include welding, brazing, soldering, bolting, and riveting. This process is essential because many products cannot be fabricated as a single piece; individual components are manufactured separately and later assembled. The strength and durability of the final product depend on the joining method used.

After joining, the finishing process is applied to remove imperfections and achieve precise dimensional accuracy. Finishing also enhances the product's appearance and extends its lifespan by adding corrosion resistance. Standard finishing techniques include powder coating, plating, and painting, which create a protective layer on the product's surface.

eISBN: 978-967-0033-63-1

3 METHODOLOGY

A flowchart is a crucial tool in the improvement process, providing a clear and structured representation of workflow and decision-making steps. Figure 3.1 presents the flowchart for FYP 1 to FYP 2 in a graphical format, outlining the key stages of the project. This flowchart serves as a guide to help identify critical steps and maintain focus during the fabrication process, ensuring a systematic and efficient approach.

The fabrication process involves several steps, each requiring specific tools and equipment to ensure accuracy and quality. It begins with measuring and marking, where a measuring tape is used to determine and mark the desired length of the metal beams before cutting. Once marked, the beams are cut using a cut-off machine to achieve the required dimensions.

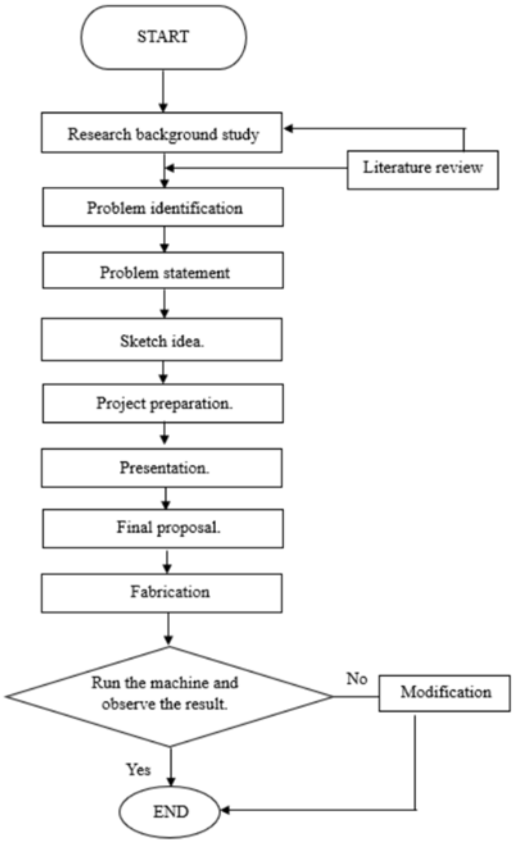

Fig. 2: Flow chart

After cutting, grinding is performed with a stone grinder to smooth out any sharp edges, ensuring safety and precision. Next, the drilling process is carried out using a bench drill, which creates holes in the metal beams to serve as mounting points for nuts and bolts.

eISBN: 978-967-0033-63-1

Fig. 3: Fabrication process

The joining stage follows, where a MIG welding machine is used to securely weld the metal beams together, ensuring a strong and stable structure. Finally, the finishing process is applied using a hand grinder to refine the surface, allowing the spray paint to adhere effectively. This step enhances the final product's appearance while providing a protective layer to prevent corrosion. This structured approach ensures that the fabricated components are precise, durable, and visually appealing.

4 RESULTS AND DISCUSSION

As shown in Figure 3.14, the complete go-kart prototype is designed with front suspensions securely attached to the frame using welded brackets. This reinforcement enhances the connection's strength, ensuring the control arm remains stable and does not fail under load. In Figure 3.15, the demonstration showcases the functionality of the prototype. Initially, the front suspension remains static in its original state. However, when weight is applied, the system moves upward to absorb and dampen the force. This demonstration confirms that the prototype is fully operational and performs as intended.

Fig. 4: Final prototype

The front suspension prototype consists of several key components, each playing a crucial role in ensuring stability and performance. The upper and lower control arms manage the wheel's lateral movement, allowing controlled side-to-side motion. These arms are connected to the frame through control arm bushings, which enable vertical movement and absorb road impacts and vibrations. Shock absorbers regulate the spring action, preventing excessive bouncing when driving on uneven surfaces. Additionally, coil springs help maintain the proper ride height and control suspension travel during various driving manoeuvres. Before testing the prototype, users should read the user manual to understand the system's functionality and learn how to replace broken parts if necessary.

The front suspension operates by absorbing and damping road vibrations. When the wheel encounters an obstacle, the spring compresses to absorb the impact energy. The shock absorber dampens this motion, preventing excessive vibrations and ensuring a smooth ride. This suspension system also contributes to distributing weight evenly, maintaining balance, and enhancing overall handling. During cornering, the suspension adjusts dynamically to keep the go-kart stable and responsive, providing better control for the driver.

5 CONCLUSIONS

In this project, the front suspension of a go-kart was successfully designed by first developing three design concepts. After careful evaluation, the final design was selected and modelled using SolidWorks. Once the design phase was completed, necessary calculations and analyses were conducted to ensure structural integrity and performance. The front suspension was fabricated according to the finalized design specifications. The fabrication and testing process took approximately 10 weeks to complete. The prototype demonstrated excellent reliability in absorbing shocks and maintaining stability under load. During intense testing, which included applying a 50 kg weight by stepping on the suspension, the system effectively dampened the force, proving its durability and functionality.

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CHAPTER 14

Design and Fabricate Back Suspension System for Go-Kart

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ABSTRACT

The design and development of a go-kart rear suspension system play a crucial role in enhancing stability, traction, and ride comfort. This project aimed to create a functional and durable suspension system by integrating key components such as shock absorbers, coil springs, brackets, and a backframe. Three existing designs were benchmarked to evaluate their strengths and weaknesses, leading to an optimized system that could handle various terrains and driving conditions. The fabrication process involved material selection, cutting, sanding, drilling, welding, and assembly, ensuring structural integrity and precision. Shielded Metal Arc Welding (SMAW) was initially used but later replaced with Tungsten Inert Gas (TIG) welding for better material compatibility. Rigorous testing confirmed that the suspension system provided improved handling, reduced vibrations, and enhanced ride quality. The results demonstrated that the developed suspension system met performance, durability, and safety standards. The final prototype ensured smooth driving dynamics, better weight distribution, and optimal shock absorption. This study provides valuable insights for further adjustability, maintenance, and customization improvements to enhance go-kart performance. The successful implementation of this project highlights the practicality and effectiveness of a well-designed rear suspension system in go-kart engineering.

Keywords: Design, Fabrication, Back suspension system

1 INTRODUCTION

A go-kart's rear suspension system is a crucial component that absorbs shocks, maintains tyre contact with the ground, and enhances traction and stability during driving. It consists of mechanical parts such as springs, dampers, and sway bars, designed to evenly distribute weight, control body roll, and adjust handling characteristics. Standard configurations include live axles for simplicity, independent suspension for improved performance, and swing axles for high-performance applications. Ultimately, the rear suspension system plays a key role in ride quality, handling, and overall driving experience.

However, several challenges can affect a go-kart's rear suspension system, including traction loss, handling instability, bottoming out on bumps, component wear and failure, adjustment complexity, and cost. Poor suspension setup or alignment may result in traction issues, making control difficult, particularly on turns or uneven surfaces. Additionally, worn-out or poorly maintained components can cause discomfort and compromise safety. Simplifying adjustments and ensuring easy access to replacement parts can help users address these issues efficiently. Regular inspection and maintenance ensure optimal performance and a smooth driving experience.

Modern go-kart rear suspension systems emphasize adjustability, durability, and ease of use. Manufacturers improve reliability and reduce maintenance needs by utilizing high-quality materials and innovative designs. Adjustable components allow users to customize settings for different tracks and driving preferences, while modular systems enable easy installation and upgrades. These advancements significantly enhance performance, comfort, and user satisfaction.

2 LITERATURE REVIEW

The evaluation and comparison of go-kart rear suspension systems were conducted based on the project title, identifying key design features for implementation. Instead of designing a suspension system from scratch, a commercially available suspension was acquired, requiring modifications to fit the go-kart design. This benchmarking and comparison study assessed three selected designs, Design 1, Design 2, and Design 3 which to determine their suitability for the final year project.

Design 1, invented by Rip Uphaus (US6749039B1), features a modular go-kart assembly with a central body, front and rear drive assemblies, and a protective cage, allowing easy construction and disassembly. The system includes a motor with multiple power take-off shafts, simplifying connections to the acceleration and braking systems controlled by a single pedal for enhanced safety. Additionally, the go-kart incorporates a rear suspension system, improving ride comfort, stability, and control, particularly for drifting. Design 2, patented by Peter R. J. Derviller (US5199526A), integrates rear caster wheels that rotate and swivel for dynamic drifting, controlled by a hand lever. The inclusion of a rear suspension system enhances comfort, stability, and control, enabling precise drift management and improved overall safety.

Design 3, developed by Edwin L. Etnyre and John O. Heimbecher (US5823552A), features a vehicle suspension system with a cross-frame member, upper spring seat, spindle knuckle for wheel attachment, and a suspension strut with a coil spring. The strut consists of a housing with a movable piston and a fixed lower spring seat, supporting the coil spring concentrically around the strut. This design ensures a compact and well-aligned suspension system within the cylindrical plane of the tyre tread, optimizing efficiency and performance. Based on product specifications, manufacturer information, and user reviews, the benchmarking and comparison study provided valuable insights to refine the go-kart suspension system. Additionally, the analysis of each design's strengths and weaknesses assists in making informed decisions regarding fabrication and implementation.

3 METHODOLOGY

The structural design of a go-kart rear suspension is essential for ensuring stability, traction, and ride comfort. Based on the detailed drawings as in Figure 1, the design focuses on precision, durability, and efficient load distribution. The drawing illustrates the individual components and their assembly, clearly understanding how the suspension integrates with the go-kart's frame.

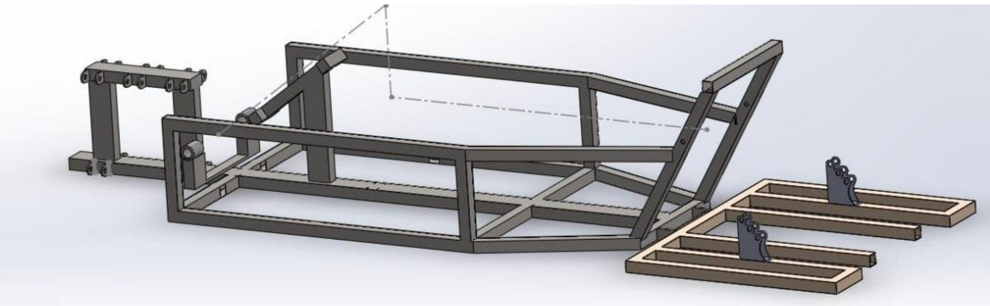

Fig. 1: Structural design of a go-kart rear suspension

Key components in the structural design include bolts and nuts, which serve as essential fasteners to hold the system securely. The shock absorber is critical in reducing vibrations and maintaining tyre contact with the ground, ensuring a smoother ride and better handling. The back suspension bracket is a mounting structure for the absorber, while the backframe provides structural support to the entire system, reinforcing the chassis for strength and rigidity.

Fig. 2: Fabrication process

The material selection process plays a crucial role in developing the go-kart rear suspension system. It involves assessing materials based on durability, strength, and compatibility with design specifications to ensure optimal performance. Although no specific safety precautions were required during this phase, selecting the right materials is essential for maintaining structural integrity and longevity in the suspension system.

The fabrication process as in Figure 2 show the cutting process, where a cutting machine is used to ensure precision and efficiency. Safety measures were strictly followed, including wearing protective attire such as jackets, pants, boots, gloves, and safety glasses. After cutting, the sanding process is performed to refine the material's edges, ensuring accurate measurements and eliminating sharp edges. A sanding machine was used, and gloves and safety glasses were worn for protection. The next step, drilling, was carried out using a standing drill machine to enhance accuracy. Materials were securely clamped to the platform to prevent movement, and workers adhered to safety protocols by wearing appropriate attire, gloves, and glasses.

The welding process initially used Shielded Metal Arc Welding (SMAW) but was later switched to Tungsten Inert Gas (TIG) welding due to material compatibility issues. Welding was conducted at 80–90V to ensure strong and reliable joints for the suspension base. Safety precautions included using welding gloves, masks, and protective clothing. Lastly, in the assembly process, all fabricated components were assembled according to the design, ensuring proper ride height, damping, and alignment for optimal handling stability. No specific safety precautions were required during assembly, but careful attention was given to achieving a smooth and functional suspension system

4 RESULTS AND DISCUSSION

Figure 2 shows prototype viewed from the front, featuring a chain-driven axle connected to a central electric motor. The system is designed for stability on uneven terrain, supported by red spring shock absorbers and two wheels on each side, which help absorb shocks and maintain traction.

At the rear, a black panel is likely a structural component or enclosure for electronic systems such as the battery, motor controller, or wiring. This configuration suggests the prototype is built for load-bearing or mobility applications, potentially for off-road use, industrial transport, or autonomous vehicle testing. The combination of electric power and a chain-drive system ensures efficient torque transmission, while the suspension system enhances ride comfort and control over rough surfaces.

Fig. 3: Final prorotype

This guide provides detailed instructions on operating, assembling, and maintaining the rear suspension system in an electric go-kart. The system comprises key components, including shock absorbers, the backframe, brackets, and coil springs, all of which contribute to the go-kart's stability, handling, and ride comfort. Understanding the role of each component ensures that users can operate the system effectively and safely, maximizing both functionality and lifespan.

The shock absorbers play a crucial role in the rear suspension system, utilizing dual coil-over springs to absorb impacts and minimize vibrations. This helps improve ride comfort and control, particularly on rough or uneven surfaces. Meanwhile, the back frame is responsible for evenly distributing weight across the rear section of the go-kart, enhancing handling performance and structural support. A well-designed back frame ensures better stability and maneuverability, especially when navigating tight turns or varying terrain.

The brackets serve as essential mounting components, securing the upper and lower ends of the shock absorbers to ensure they remain in place during operation. Properly installed brackets help maintain the effectiveness of the suspension system, allowing it to absorb shocks efficiently. Additionally, coil springs provide further shock absorption, reducing the impact of bumps and vibrations to deliver a smoother, more controlled ride for the driver.

Proper installation, maintenance, and periodic inspection of these components are necessary to maintain the optimal performance and durability of the rear suspension system. By following the guidelines in this manual, users can ensure safety, longevity, and improved ride quality, making the electric go-kart more efficient and comfortable

5 CONCLUSIONS

In conclusion, the design and fabrication of a go-kart rear suspension system were successfully implemented, effectively meeting the project's objectives. The primary goal of developing a functional prototype was achieved by analysing key factors such as performance, comfort, and durability. The design incorporated essential elements, including spring rate, damping characteristics, and structural integrity, ensuring that the suspension system could withstand various terrains and driving conditions while maintaining stability and control.

The second objective, which focused on manufacturing the suspension system based on the design prototype, was also accomplished. The fabrication process involved sourcing appropriate materials, precise assembly, and rigorous testing to validate the system's performance. Testing results confirmed that the constructed suspension system met the required standards, providing a smooth and stable driving experience while ensuring safety and durability. The successful completion of this project highlights the effectiveness of the design and its practical application in go-kart engineering

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CHAPTER 15

Development and Manufacturing Fixing Holder and Gearing Mechanism for a Electrical Go-Kart

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ABSTRACT

This project focuses on designing and fabricating a go-kart motor fixing holder and gearing system to enhance stability and efficiency in electric go-karts. The development process involved conceptualizing three initial designs and refining and finalizing the most suitable concept using SolidWorks software. The fabrication phase, which spanned approximately 12 weeks, incorporated essential manufacturing processes such as cutting, drilling, welding, and bending to construct the motor fixing holder and gearing system.The motor fixing holder was fabricated using 2mm thick recycled steel plates, while the gearing system was assembled with a 3mm steel driven gear welded onto the motor shaft. A relay-based starter circuit was integrated to ensure a safe and controlled power transfer, preventing accidental motor engagement. The final prototype was successfully manufactured and assembled, demonstrating practical functionality in securing the motor and transmitting power efficiently to the wheels. The results confirm that the fabricated system meets the intended design objectives, providing a secure mounting solution and reliable gearing mechanism for the go-kart. Future improvements can be made by optimizing material selection, enhancing structural reinforcement, and refining the gearing system to improve performance, durability, and overall efficiency.

Keywords: Fixing Holder, Gearing System, Go-Kart

1 INTRODUCTION

A go-kart is a small, four-wheeled vehicle classified as a sports car, closed-wheeled car, open-wheeled car, or quadricycle. Go-karts come in various designs, ranging from non-motorized models to high-performance racing karts. Karting is a form of racing that utilizes these compact vehicles, with the first go-kart invented by Art Ingels in Los Angeles in 1956 [1]. An electric go-kart is a lightweight, single-seater racing vehicle powered by an electric motor instead of a traditional petrol engine. Electric motors convert electrical energy into mechanical energy, delivering power efficiently.

The safety and performance of an electric go-kart depend significantly on the type of motor and battery system used. As of 2022, electric go-karts are primarily used for recreational rental, while professional kart racing favours 2-stroke petrol engines. However, advancements in high-performance electric karts are ongoing, and competitive races using electric models are already being held. This study aims to design and fabricate a go-kart motor fixing holder and gearing system. Specifically, the research aims to develop a motor holder that securely attaches the motor to the go-kart frame and to engineer a gearing system based on the designed prototype.

2 LITERATURE REVIEW

When selecting an engine for a go-kart, several key factors must be considered, including power output, torque characteristics, weight, fuel consumption, noise levels, emissions, and regulatory requirements. The ideal engine choice depends on the user's needs, whether for recreational driving, competitive racing, or commercial rental operations. Different gear and clutch systems also play a crucial role in optimizing performance, control, and efficiency.

The gear and clutch system selection should be based on factors such as the engine model, track layout, driver weight, and desired top speed. High-performance racing karts often require precisely tuned gearing and clutch systems to enhance acceleration and maintain speed on varying track conditions. In contrast, rental and recreational karts prioritize durability, ease of use, and safety over raw performance. Understanding these factors ensures that the go-kart operates efficiently while meeting the needs of its intended application [2].

Electric go-karts have gained significant popularity recently due to their instant torque, quiet operation, and low maintenance requirements. They are especially favoured in indoor racing facilities and environments where noise and emissions are a concern. Electric motors have fewer moving parts than traditional petrol engines, eliminating the need for oil changes, spark plug replacements, and fuel system cleaning. This results in lower maintenance costs and reduced downtime, making them a more cost-effective option in the long run [3].

Electric go-karts are more energy-efficient than their petrol-powered counterparts, as they convert a higher percentage of battery energy into motion. This improved efficiency can lower operational costs, particularly in areas with affordable electricity rates. However, one limitation of electric engines is their battery capacity, which may result in shorter runtimes. This can be a drawback for long endurance races or extended activities that require continuous operation without recharging.

3 METHODOLOGY

Fabrication is manufacturing or assembling components by combining standardized parts through various techniques such as cutting, drilling, and welding. Unlike other manufacturing methods, fabrication involves shaping raw materials into functional components through mechanical or thermal processes. This project's fabrication focuses on constructing the go-kart motor fixing holder and gearing system, as shown in Figure 1.

The fabrication of the motor fixing holder involves using 2mm thick recycled steel plates, which are measured and cut with an angle grinder. Several holes are drilled into the plates to secure the motor using bolts, nuts, and washers. Sheet metal is also measured, cut using a shearing machine, and drilled for mounting purposes. It is then bent at a 90-degree angle with a bending machine and attached to the holder. Finally, the motor's shaft is welded to the driven gear to complete the assembly (Figure 1).

Fig. 1: Fabrication process

A 3mm steel driven gear (sprocket) is welded onto the motor shaft for the gearing system. The driving gear is pre-mounted onto the tyre shaft and secured by a team member. The shaft is then drilled to allow screws to fasten the driving gear in place, ensuring a firm and stable connection. These fabrication steps ensure the durability and functionality of the go-kart's mechanical components.

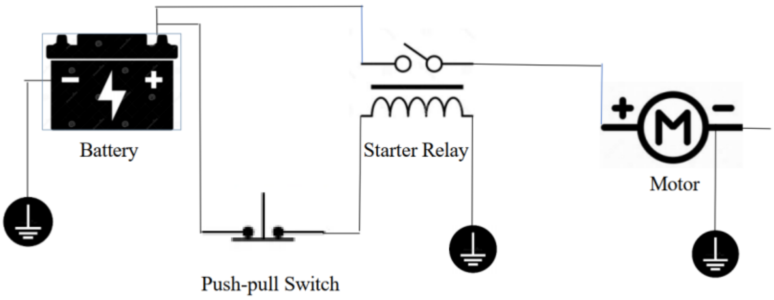

Fig. 2: Electrical circuit for the motor

A starter circuit as in Figure 2 used to initiate engine operation in this go-kart motor fixing holder and gearing system. The motor provides the initial torque required to crank the engine, after which the engine takes over. A relay system is incorporated to ensure safe operation, allowing the starter motor to function only when the push-pull switch is engaged, preventing accidental activation.

When the push-pull switch is activated, current from the battery is permitted to flow through the relay's coil. This energizes the coil, generating a magnetic field that closes the relay contacts. As a result, a direct high-current path is established between the battery and the motor, supplying the necessary power to start the motor.

Once the push-pull switch is released, the circuit is broken, de-energizing the relay and cutting off power to the motor. This ensures that the starter motor operates only when needed, enhancing safety and efficiency in the go-kart's starting mechanism.

4 RESULTS AND DISCUSSION

Figure 3 presents the final prototype of the go-kart motor fixing holder and gearing system, which has been successfully manufactured. The fabrication process took 12 weeks, during which several challenges had to be addressed and resolved.

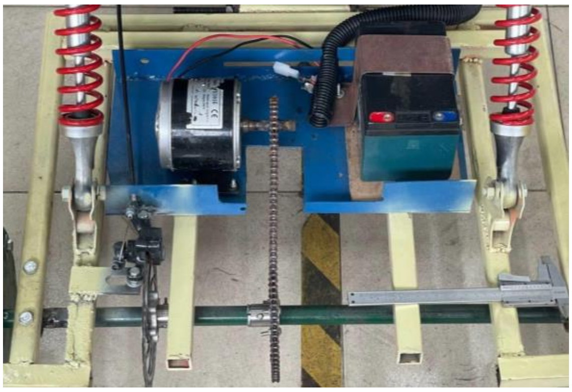

Fig. 3: Final prototype

After overcoming these issues, all components were carefully assembled, ensuring the system functions as intended. The final prototype operates effectively, meeting the design objectives and performance requirements of the go-kart's motor fixing holder and gearing system. Table 4.1 outlines the manual operation required to use the go-kart motor fixing holder and gearing system, emphasizing the importance of following these steps to prevent accidents. The process begins with switching on the power lock using a key. Once the power is activated, all necessary switches must be turned on to ensure the system is ready for operation.

Next, the pedal, which contains a push-pull button switch, is pressed to control the speed of the go-kart. As the pedal is engaged, the motor begins to rotate with the driven gear welded to it. This movement transfers power through the chain to the driving gear, which drives the tyres. As a result, the go-kart moves forward smoothly. By carefully following these steps, users can operate the go-kart efficiently, ensuring safety and optimal performance.

5 CONCLUSIONS

In this project, a go-kart motor fixing holder and gearing system was designed by initially developing three design concepts, which were then evaluated to select the most suitable one. The final design was created using SolidWorks software and underwent several modifications before fabrication. The entire fabrication process took approximately 12 weeks to complete. The primary objective of this research was to fabricate a go-kart motor fixing holder and gearing system based on the design and analysis conducted during Final Year Project 1. This involved ensuring that the system met the required performance and functionality standards. Several recommendations should be considered to further enhance the effectiveness and usability of the go-kart motor fixing holder and gearing system. Material selection, structural reinforcement, and system efficiency improvements can help maximize its potential and ensure better durability and performance.

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CHAPTER 16

Designing and Fabricating Mini Lathe Machine for Low Volume Production

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ABSTRACT

This research focuses on developing a compact and cost-effective mini lathe machine capable of producing small and precise components. The bench lathe was chosen for its versatility, ease of use, and suitability for woodworking applications. The design process involved using SolidWorks for modelling, and Finite Element Analysis (FEA) was conducted to assess structural integrity. 1345 Aluminium Alloy was selected for its strength-to-weight ratio and durability. The analysis revealed that the spindle experienced a maximum stress of 7.6 MPa, well below its yield strength of 27.57 MPa, with a Factor of Safety (FoS) of 3.4, ensuring safe operation. The prototype successfully performed cutting, grinding, and turning with minimal difficulties. While it is limited to wood due to motor constraints, it meets all design and fabrication objectives. Regular maintenance is required for long-term functionality. Overall, the mini lathe machine demonstrates efficiency, reliability, and practicality for small-scale applications.

Keywords: Mini Lathe Machine, Design, Fabrication

1 INTRODUCTION

Lathe machines are essential tools commonly found in workshops. They rotate a workpiece along a central axis to perform various operations, including cutting, grinding, knurling, drilling, facing, and turning [1]. One particularly popular type of lathe is the bench lathe, valued for its compact size, versatility, and ease of use. Due to its user-friendly design, it is widely employed for educational and training purposes.

Lathe machines generally serve two primary purposes: industrial and artisanal applications. In industrial settings, they are used to manufacture small components for vehicles or large-scale construction parts. Conversely, artisans utilize lathes to shape metal, wood, and plastic, crafting furniture such as tables and chairs [2].

A lathe machine has three main components: the headstock, tailstock, and bed. The headstock is crucial, housing the main spindle, gears, and motor while also holding and rotating the workpiece. Positioned at the opposite end, the tailstock supports the workpiece and can hold taper taps for threading operations. The bed is the machine's foundation, securing both the headstock and tailstock to ensure stability and prevent movement during operation [1, 3].

2 LITERATURE REVIEW

Lathe machines are essential tools in workshops, enabling various machining operations such as cutting, grinding, knurling, drilling, facing, and turning. These machines rotate a workpiece along an axis to achieve precision shaping and finishing. Among the many types available, the bench lathe is particularly popular due to its compact size, versatility, and ease of use, making it an ideal choice for both professional and educational applications.

Lathe machines are generally categorized into industrial and artisanal uses. In industrial settings, they are employed to manufacture small components for vehicles and construction. At the same time, artisans use them to shape metal, wood, and plastic to create furniture and other handcrafted items. The bench lathe, in particular, is a preferred option for small-scale projects due to its user-friendly nature and adaptability.

A standard lathe machine comprises three main components: the headstock, tailstock, and bed. The headstock is critical as it houses the main spindle, gears, and motor while also holding and rotating the workpiece. The tailstock at the opposite end serves as a support mechanism and can also accommodate taper taps for threading. The bed provides structural stability, securing both the headstock and tailstock to prevent movement during operation.

The compact nature of bench lathes makes them an excellent choice for individuals or small workshops that require precision machining on a smaller scale. Their affordability and ease of maintenance further enhance their appeal, making them an indispensable tool for professionals and hobbyists.

3 METHODOLOGY

The figure 1 illustrates the chosen concept sketch for this prototype, specifically depicting the tailstock assembly of the mini lathe machine. The motor will be housed within the motor base, secured by two screws with a diameter of three millimetres. To minimize vibrations, the motor base will be firmly attached to the bed using four screws. Additionally, the motor base will feature an 18.80-millimetre hole through which the spindle will pass.

To protect the motor from wood chips and dust, the motor base will enclose the exposed parts while being securely fastened to the bed with two screws on each side. The two holes at each end will tightly clamp down on the protruding parts of the motor and chuck. As the motor rotates, the coupler will transfer motion to the chuck, ensuring smooth and efficient operation.

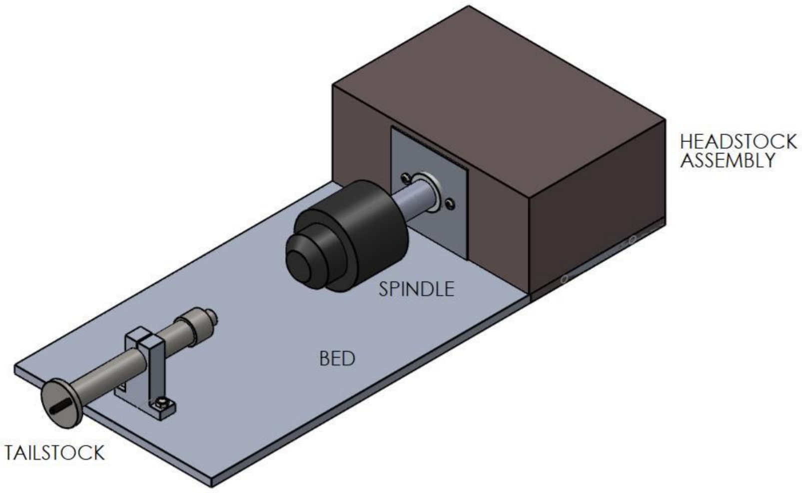

Fig 1: Solidwork design of the machine

The methodology used in this analysis involves Finite Element Analysis (FEA) to assess the mechanical behaviour of the mini lathe machine's components under applied forces. The first step is material selection, where 1345 Aluminum Alloy was chosen due to its high strength-to-weight ratio, corrosion resistance, and ease of machining. The yield strength of the material is 27.57 MPa, while the tensile strength is 82.72 MPa, making it suitable for sustaining mechanical loads.

A linear elastic, isotropic model was applied, and the failure criterion was set using Von Mises Stress Theory, which determines if the component will yield under loading conditions. The spindle was meshed into finite elements, and a 70N force was applied at the tailstock to simulate actual operating conditions.

4 RESULTS AND DISCUSSION

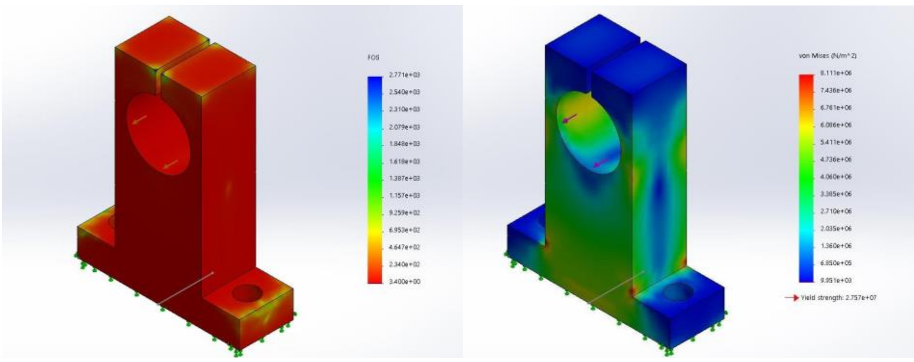

Fig 2.: Stress analysis and Factor of safety analysis of tailstock

The analysis results as in Figure 2 reveal that stress concentration occurs at specific points on the spindle, highlighted in red in the stress distribution plot. The maximum stress recorded was 7.6 MPa, well below the yield strength of 27.57 MPa, ensuring safe operation. Additionally, the Factor of Safety (FoS) was calculated as 3.4, indicating that the spindle can withstand 3.4 times the applied load before failure, equating to 238N. These results confirm that the design is structurally sound and capable of handling the intended operational forces.

However, minor design optimizations could further enhance durability and efficiency.

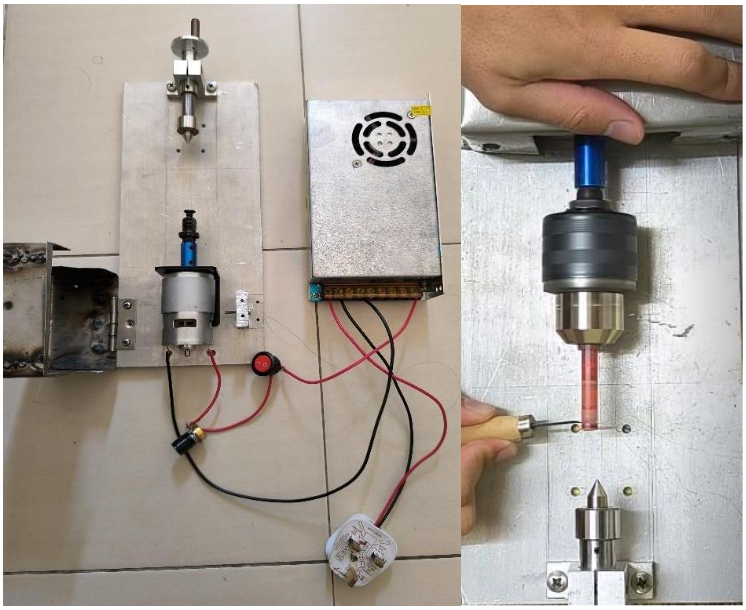

Fig 3.: Assembling the parts and wiring with test the prototype

The prototype successfully meets its intended objectives, demonstrating practical functionality in machining operations as in Figure 3. The motor speed and chisel sharpness enable smooth execution of cutting, grinding, and turning processes with minimal difficulties. The chuck securely clamps the workpiece, ensuring stability and preventing it from slipping or falling out during operation.

Operating the mini lathe machine is straightforward and user-friendly. Since it uses a three-pin plug, it can be connected to any standard electrical outlet available in Malaysia. Once plugged in, the power supply activates, providing energy to the motor. The workpiece is then secured in the chuck and tightened while the tailstock offers additional support at the other end.

The switch is turned on to begin operation, and the motor speed can be adjusted using the potentiometer. As the workpiece rotates, the chisel is applied against it to remove material from the surface, enabling precise cutting, shaping, or finishing as required.

5 CONCLUSIONS

This research aimed to develop a compact, cost-effective mini lathe machine capable of producing small, precise components. While the machine's reduced size allows for fine fabrication, it is limited to working with wood due to the motor's insufficient power for metal machining. The project encountered some challenges, particularly in working with stainless steel, which proved difficult to machine. Regular maintenance is required to ensure the machine's longevity, and it is categorized into daily, weekly, and monthly tasks. Despite the challenges, the project successfully met both primary objectives: designing the mini lathe machine using SolidWorks and fabricating the working prototype. The outcome validates the feasibility of a small-scale lathe for woodworking applications.

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CHAPTER 17

Design and Development of Robotic Arm Car for Lightweight Object Handling

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ABSTRACT

Traditional robotic arm systems provide challenges for application in educational enviroments since they frequently remain stationary with limited workspace and need sophisticated technical expertise to handle. This project addresses these challenges through the design and development of an integrated robotic arm car specifically designed to pick and move lightweight objects in indoor conditions. The goal is to build a robotic arm car with a working grabber that ensure structural stability, controlled movement, and simplicity of usage. The methodology involved a systematic design approach using SolidWorks for 3D modelling and stress analysis, followed by fabrication using laser-cut acrylic and 3D-printed PLA components. The robotic system integrates a grabber and 3-DOF arm on a four-wheeled platform with a Bluetooth connectivity and a custom MIT App Inventor interface as controller. The results from stress analysis verified the structural integrity of critical components, which demonstrates minimal deformation for all components. The successful implementation validates that the integrated design approach successfully creates a prototype of robotic arm car capable of executing basic object manipulation tasks while offering useful hands-on experience with robotic fundamentals.

Keywords: Robotic arm car, Grabber, Lightweight object

1 INTRODUCTION

The robotic arm combined with mobile platforms have produced versatile systems that combine spatial mobility with manipulation capabilities, therefore providing potential across industrial manufacturing and service applications. However, many of the current designs are too complicated and require specialized technical knowledge, which limits the accessibility of robotic arm car in education settings where hands-on experiences with robotic principles is valuable. This project develops an integrated robotic arm car with a working grabber to solve this challenge. The design focuses on small sizes, structural stability, controlled motion, and operational safety. The prototype integrates four key components which are a base structure, 3 degrees of freedom (3-DOF) robotic arm, a four-wheeled mobility system, and a functional grabber mechanism. The design process focused on material selection and structural integrity using SolidWorks software, and user-friendly control through a Bluetooth-enabled mobile interface. The following sections outline the relevant literature (Section 2), methodology (Section 3), results and discussion (Section 4), and conclusion (Section 5).

2 LITERATURE REVIEW

Robotic arm systems have advanced significantly from stationary industrial manipulators to transportable platforms with diverse applications. Traditional robotic arms excel in production settings where repeatability and accuracy are vital [1], but their fixed nature restricts workspace flexibility. This limitation has driven research aimed at combining mobile platforms with robotic arms for manipulation capabilities. Kruthika et al. [1] have established fundamental design principles for robotic arms, while more recent work by Comari et al. [2] demonstrated successful integration of robotic arms with mobile platform for autonomous material handling.

Educational applications give a significant opportunity for the robotic arm development, where systems must balance between functionality with accessibility. Zeng et al. [3] created iArm, an instructional robotic kit aimed at fostering computational thinking. In addition, Benitez et al. [4] created a cost-effective open-source robotic arm for online education emphasizes user-friendly design interfaces. These educational and indoor platforms often use 3-DOF or 4-DOF arm configurations, which offer ideal balance of simplicity, functionality, and cost-effectiveness [5].

The choice of suitable materials, mobility systems, and control interfaces significantly impacts the efficacy of educational robotic platforms. In this project, acrylic was selected as the primary structural material for the robotic arm and base based on practical engineering considerations including its ease of machining, low-cost, transparency (for educational purpose), and lightweight structure [6]. This material choice enabled accurate fabrication through laser cutting. For mobility system of robotic arm cars, four-wheeled mobility system is commonly used for indoor applications due to their balance of stability, maneuverability, and ease of control [7]. The four-wheeled configuration can provide a solid platform that can sustain the weight and dynamic movements of robotic arms [8]. In education and prototyping settings, robotic arm cars driven by Arduino Uno with Bluetooth-enabled and Android apps created using MIT App Inventor have grown even more popular [9-10]. These systems often utilize Arduino Uno microcontroller as the primary processing unit, interacting with Bluetooth modules like HC-05 to facilitate wireless communication between the robot and smartphone app. The Android app, which is frequently designed with MIT App Inventor because of its simplicity of use, delivers instructions to the robot that control both the mobility system, the robotic arm’s motors, and the grabber’s motor.

3 METHODOLOGY

The robotic arm car prototype was designed based on four sub-systems, which are the base, the wheel and mobility system, the arm, and the grabber. Each sub-system had specific functional and dimensional criteria. The base structure required a compact and stable platform (27–44 cm in length) fabricated from acrylic to house internal electronics and support the robotic arm. The wheel and mobility system featured four rubber wheels (approximately 10 cm in diameter) driven by four worm gear DC motors each, enabling smooth indoor movement. The robotic arm offered 3 degrees of freedom (3-DOF), comprising a rotating base and two pitch joints, with a reach of approximately 20–30 cm. It was constructed using lightweight acrylic material and actuated through servo motors. The grabber mechanism was designed using PLA filament (3D-printing), capable of gripping objects up to 55 mm wide and 187 g in weight. Control integration involved an Arduino UNO microcontroller paired with Bluetooth connectivity, controlled through a MIT App Inventor interface.

The methodology followed a systematic product development cycle as illustrated in Fig.1. It began with defining user and environmental requirements, followed by sketching early design concepts. Through Morphological analysis and the Pugh decision matrix, component options were shortlisted and evaluated against criteria such as size, safety, cost, and functionality. The selected design was then developed in SolidWorks to create 3D models and assembly drawings. Material selection and stress analysis were conducted to validate design strength. Fabrication involved laser cutting and 3D printing of structural and functional parts, followed by mechanical and electronic integration. Programming was performed using Arduino IDE to control motion, gripping, and wireless communication. The final prototype underwent testing for functionality, user-friendliness, and structural integrity. Based on test results, refinements were implemented to ensure optimal performance for its intended setting.

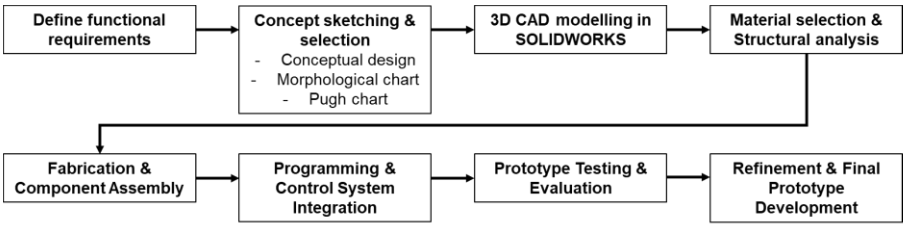


Fig.1: Robotic arm car prototype design flowchart

Fig.2 illustrates the layered schematic diagram of the robotic arm car prototype, showing how each functional layer contributes to the integrated system. The top layer defines the major sub-systems, including the base, mobility, robotic arm, and grabber. Supporting these sub-systems, the structure layer identifies key mechanical elements such as the frames, rotating base, arm's shoulder, arm's elbow, and gripper frame, which provide physical support and alignment for components. The actuator layer consists of worm gear DC motors and servo motors, responsible for motion in both locomotion and manipulation tasks. These actuators are governed by the control layer, which includes the Arduino board and Bluetooth module to enable signal processing, communication, and system coordination. The bottom software layer integrates programming through Arduino IDE and a user interface developed in MIT App Inventor, allowing real-time control through a mobile device.

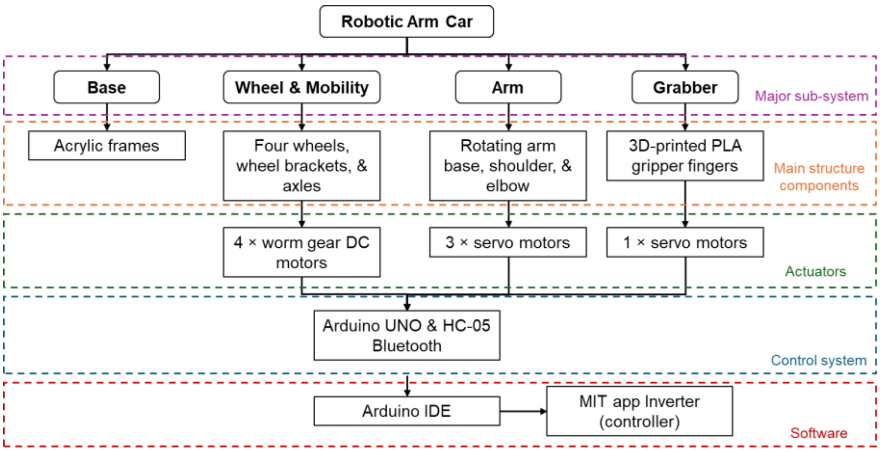
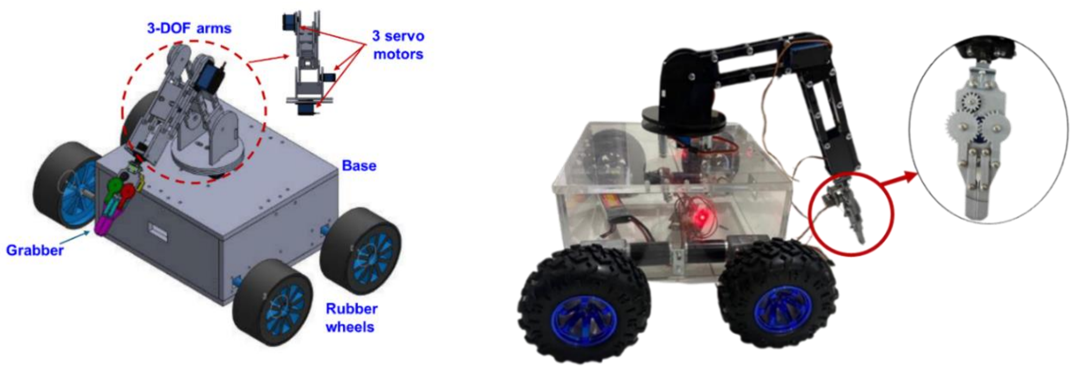


Fig. 2: The schematic diagram of robotic arm car system

4 RESULTS AND DISCUSSION

The final 3D model and the robotic arm car prototype displayed in Fig. 3, demonstrate successful integration of major subsystems, base, wheels, robotic arm, and grabber, into a compact and functional platform. The chassis supports the full assembly and houses internal wiring, while the robotic arm (3-DOF) is anchored on a rotating base and actuated through servo motors for vertical and rotational movement. The gripper, made of PLA, is positioned at the end of the arm and designed to manipulate lightweight objects. Four rubber wheels which each connected to a DC worm gear motor provide ground mobility. This layout validates the functional requirements discussed in earlier sections.



(a) (b)

Fig 3: The robotic arm car, (a) 3D model, and (b) the built prototype

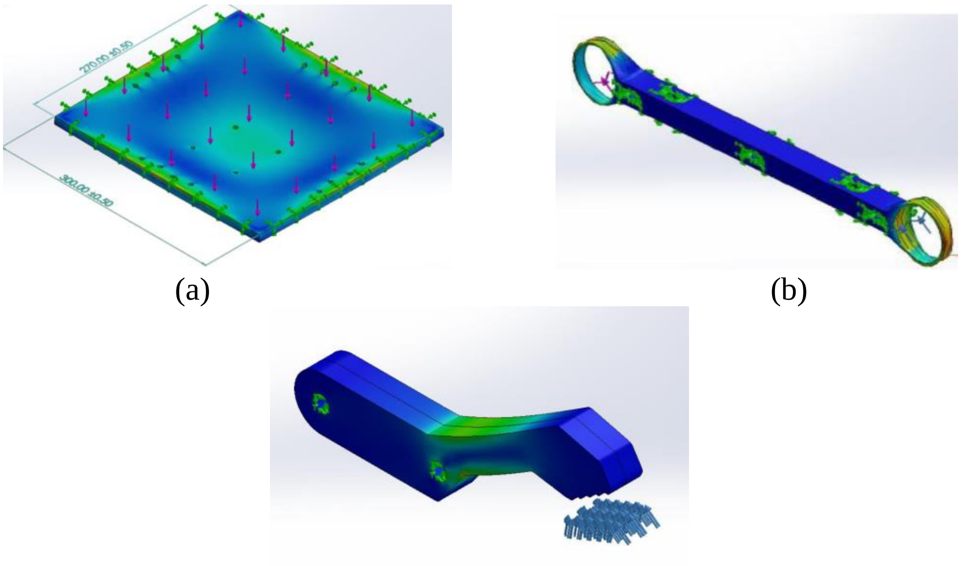
The structural integrity and reliability of the robotic arm car critically depend on several key components which are the base, the robotic arm, and the grabber. Stress analyses were conducted using SolidWorks software which highlights critical regions subjected to operational forces. This analysis aimed to verify whether the chosen materials and dimensions are sufficient for the robotic arm to lift and move the object (maximum 1 kg mass). The summary of simulation results is presented in Table 1, while Fig. 5 visually illustrates the corresponding stress distribution across critical components.

Table 1: SolidWorks simulation analysis of critical part

Component	**Analyzed Part**	**Dimensions (mm)**	**Material**	**Applied Force (N)**	**Max Stress (MPa)**	**Max Deformation (mm)**
Base Structure	Upper platform	300 × 250 × 10	Acrylic	50	25.5	0.2
Robotic Arm	Second member arm	200 × 40 × 5	Acrylic	98.1	49.5	1.3
Grabber Mechanism	Grabber lips	80 × 30 × 5	PLA	9.81	49.52	9.15

The applied forces used in the stress analysis were determined based on practical operational scenarios to reflect realistic loading conditions under realistic loading conditions. The base structure was applied with a distributed force of 50 N to represent the static and dynamic loads from the arm, grabber, and any objects during operation. The robotic arm received a force of 98.1 N, representing the total effective load applied through two faces during extension and listing tasks. Meanwhile, a force of 9.81 N was applied to the grabber mechanism to represent the gripping load needed to securely handle the operations of grabbing and moving objects up to 1kg of mass.

As summarized in Table 1, the upper platform of the base structure exhibited minimal deformation (0.2 mm) and a maximum stress of 25.5 MPa which is lower than the yield strength of acrylic material of 70 MPa. This confirms the selected material and dimension of the upper part of base structure demonstrates outstanding load-bearing capacity. The members of robotic arm experienced moderate deformation (1.3 mm) and a maximum stress of 49.5 MPa, approaching the limit of yield strength of acrylic’s material. This indicates that this part needs to be reinforced in terms of its dimension. The grabber mechanism recorded the deformation of 9.15 mm with a maximum stress of 49.52 MPa, nearing the PLA yield strength of 60 MPa. This justified structural dimension improvements in the final design, which include the increase in lip thickness, a reduction in opening width from 80 mm to 62 mm, and a decrease in overall size to better match the lifting capability of the arms.



(a) (b)

(c)

Fig. 5: Stress distribution analysis on the critical components, (a) upper platform of the base structure under 50 N load, (b) arm member under 98.1 N load, and (c) grabber lips under 9.81 N gripping load

The robotic arm car integrates several key electrical components to enable remote-controlled operation. The electrical system was developed using an Arduino UNO board, four DC motors for wheels system, and six servo motors (TD-8230MG for the arm and MG95s for the grabber) for articulated movements, as shown in Fig. 6. Communication between the microcontrollers and user interface was established using a Bluetooth receiver connected to a custom mobile application developed with MIT App Inventor, enabling remote control of the robotic car through a smartphone or a tablet.

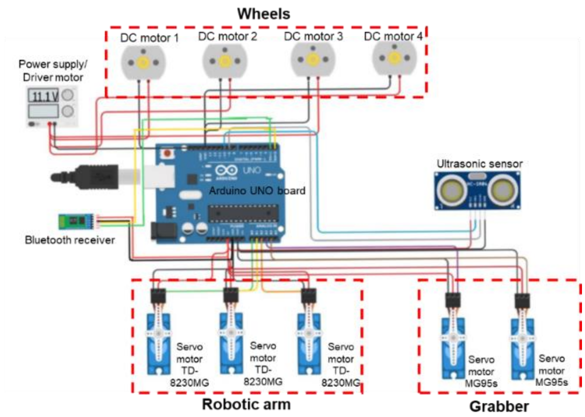


Fig 6: Electrical wiring diagram showing integration of Arduino UNO, DC motors, servo motors, Bluetooth module, and ultrasonic sensor

5 CONCLUSIONS

This project outlines the design, construction, and validation of a robotic arm car prototype designed for handling lightweight objects in indoor settings. The prototype successfully integrates four primary subsystems which are a base platform, wheels system, 3-DOF robotic arm, and functional grabber, into a compact and operational unit. The mechanical design was verified by finite element stress analysis, which also proved that important parts such as the base and arm structure operate within the limits of material strength under certain loads. For grabber, the modifications to its design, including adjusted dimensions and reinforced structure, were implemented based on stress analysis and deformation findings. The control system is constructed using an Arduino UNO microcontroller, servo and DC motors, and a Bluetooth-enabled mobile interface via MIT App Inventor. The combination of mechanical functionality and electrical coordination produced a reliable robotic arm car prototype capable of performing basic object manipulation tasks. This prototype offers a practical solution for educational and service-oriented robotics applications, establishing a basis for future enhancements in automation, sensor integration, and autonomous behaviour.

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CHAPTER 18

Design and Fabrication of Nutmeg Grater

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ABSTRACT

A nutmeg grater is essential for grinding nutmeg into a fine powder, but conventional designs pose risks of accidental cuts. To address this issue, a safer and more user-friendly nutmeg grater should be developed, ensuring ease of use for both adults and children. This innovation aims to reduce kitchen injuries while simplifying the cooking process. To gather relevant data, surveys will be distributed, and online research will be conducted to analyse existing designs and user concerns. The project focuses on designing and fabricating a scaled-down, manually operated nutmeg grater with a simple hand crank mechanism, making it both practical and efficient for home kitchens. The methodologies for this project outlining as the design, material selection, and fabrication process. The expected outcome is a fully functional and safe nutmeg grater capable of efficiently grating nutmeg, fruits, and soft vegetables, ultimately enhancing kitchen safety and usability.

Keywords: Design, Fabricate, Nutmeg grater

1 INTRODUCTION

Nutmeg is the seed of an evergreen plant native to Asia, Australasia, and the Caribbean. When kept in its shell, whole nutmeg can last up to nine years, whereas grated nutmeg has a significantly shorter shelf life of about a year or less. Freshly grated nutmeg enhances recipes with a stronger aroma and richer flavour [1].

Grater come in various designs with different slot sizes, making them versatile tools for food preparation. They are commonly used to grate nutmeg, cheese, and citrus peels to create zest. Additionally, they are essential for dishes like toasted cheese, Welsh rarebit, egg salad, macaroni and cheese, and cauliflower cheese, where finely grated ingredients improve texture and taste [2].

Unlike food processors, which produce uniform shreds, hand grater create pieces that taper at the ends, allowing for better melting and even cooking. This is particularly beneficial in recipes that require smooth blending, such as sauces or baked dishes. Hand-scraper nutmeg, for instance, integrates more effectively into cooking, enhancing both consistency and flavour.

2 LITERATURE REVIEW

Benchmarking and comparison with available nutmeg graters highlight key differences in design, functionality, and cost. The William Bounds Nut Twister Mill features an easy-turning crank, serrated stainless steel blades, and includes whole nutmeg seeds, but it is relatively expensive. The Cole & Mason Classic also has a serrated blade but is noted for its somewhat inconsistent output and less durable construction. On the other hand, the Plastic Nutmill is the most affordable option while still incorporating a serrated stainless steel blade. These comparisons help determine the most effective design features to incorporate into the proposed nutmeg grater [3].

The manufacturing process for the new design includes the use of PVC pipe for the body, a steel rod for the handle, and sheet metal for the grating component. Sustainability aspects include cost reduction, eco-friendliness by allowing the grater to be repurposed into other household items, and improved safety features to minimize kitchen injuries. The ergonomic design ensures user comfort and efficiency, making the grating process smoother and more accessible for various users. Additionally, patent research references US patent US6315224B1, which details a grating plate with staggered rows of sharp-edged openings designed to enhance food processing.

Historically, nutmeg graters have evolved from simple flat designs with collection compartments in the 18th century to more sophisticated, egg-shaped models in the 19th century. These earlier designs inspired modern improvements aimed at efficiency and user convenience. The proposed project seeks to further enhance usability by developing an ergonomic, efficient nutmeg grater using sheet metal instead of stainless steel and a PVC body for durability and affordability. Ultimately, the goal is to create a practical, user-friendly grating tool that reduces effort while maintaining effectiveness in food preparation.

3 METHODOLOGY

The development process begins with a discussion with the supervisor to finalize the project title and objectives. Once the direction is established, multiple design sketches are evaluated, and the best concept is selected for further development. Using SolidWorks software, the chosen design is then transformed into a detailed digital model for visualization and analysis as in Figure 1[4].

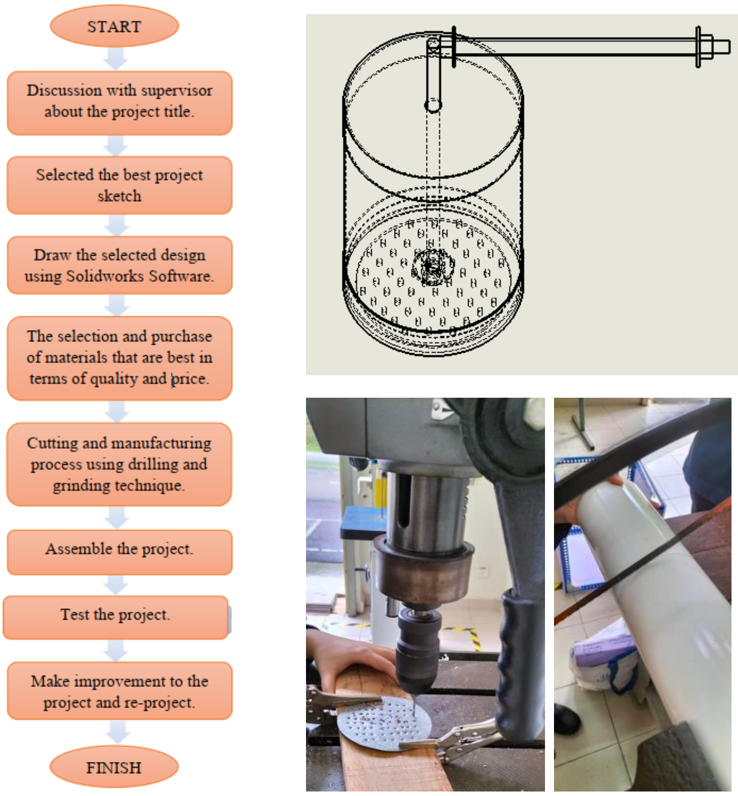

Fig. 1: Fabrication process

This section outlines the process of sketching, drawing, and selecting suitable materials for the chosen nutmeg grater design. The first step involves selecting the best sketch that meets standard product requirements. Once finalized, the design is measured and drawn using SolidWorks Software 2017 for accuracy and visualization. Following this, the appropriate materials are chosen to align with the design specifications. Before fabrication, all parts are measured precisely using a ruler to prevent errors during production.

The manufacturing process begins with cutting the PVC pipe using a hand saw, followed by cutting the steel threaded rod with a grinder machine and sheet metal with a cutting machine. The sheet metal is then marked and punched using a hole puncher and hammer to create holes. Milling is performed on the bottom PVC cap using a milling machine, and drilling is done on the sheet metal and top PVC cap using M3 and M10 drill bits, respectively. The steel threaded rod is bent as needed to fit the design requirements.

For the finishing process, the PVC pipe is sanded with sandpaper to achieve a rough surface before being painted along with the PVC cap using spray paint. Once all components are fabricated and assembled, a final inspection ensures the product is fully complete and ready for use.

4 RESULTS AND DISCUSSION

The completed prototype undergoes rigorous functionality and safety testing to ensure its effectiveness. Any identified areas for improvement are addressed, and necessary modifications are made to enhance the design. The final refined product is then ready for implementation, completing the project workflow.

Following the design phase, the appropriate materials are selected based on quality and cost-effectiveness, ensuring an optimal balance between durability and affordability. The manufacturing process involves cutting, drilling, and grinding techniques to fabricate the necessary components. Once fabrication is complete, the components are assembled into the final product as in Figure 2.

Fig. 2: Final product of nutmeg peel off

5 CONCLUSIONS

This study focused on developing a manual grater machine designed to press and compress for nutmeg peel off which making food preparation more convenient. The first objective was successfully achieved by creating a device that simplifies the process, reducing effort and time in the kitchen. The second objective was met by utilizing manual components, which, although less efficient than automated systems, offer ease of use and preserve the traditional cooking experience. Ultimately, this fabricated product provides a practical solution for nutmeg grater, enhancing both cooking and consumption.

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CHAPTER 19

Floating Mechanism of The Passive Electronic Component of The Die-Side Capacitor

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ABSTRACT

Reflow soldering is a widely used process in mass production, particularly in electronic assembly lines. However, defects such as solder bridging, fillet lifting, and tombstoning often arise due to capillary forces that act on molten solder during the transient liquefaction phase. This study investigates the floating mechanism of passive electronic components, specifically the Die-Side Capacitor, by analyzing the wettability of molten solder under dynamic capillary wetting behaviour. The research employs analytical force equations to evaluate solder joint formation. Results indicate that controlling solder volume and optimizing surface tension properties can enhance capillary pressure, increase gap height and reduce defects such as solder bridging, ultimately improving soldering reliability in electronic components.

Keywords: Electronic component, Die-Side Capacitor, Reflow process

1 INTRODUCTION

Surface Mount Technology (SMT) has revolutionized electronic manufacturing by enabling high-speed and high-precision assembly of components [1, 2]. However, the reflow soldering process, a critical step in SMT, often encounters defects such as solder bridging, fillet lifting, and tombstoning. Figure 1 show the Die-Side Capacitor position on the electronic terminal. These defects are primarily caused by improper wettability and capillary forces acting on the molten solder during liquefaction. Solder bridging, for example, occurs when excess solder forms unintended connections between adjacent pads, leading to electrical shorts. Fillet lifting and tombstoning result from imbalanced surface tension forces, which cause components to shift or detach during reflow [3]. Addressing these issues requires a deeper understanding of the factors influencing solder behaviour, particularly the floating mechanism of passive components like Die-Side Capacitors [4].

Fig. 1: Die-Side Capacitor position on the electronic terminal

2 LITERATURE REVIEW

The reflow soldering process involves heating solder paste to a controlled temperature, allowing it to transition from solid to liquid and back to solid, forming strong electrical and mechanical bonds [3, 5]. During the transient stage of liquefaction, capillary wetting behavior determines how molten solder interacts with the component and substrate [6]. Factors such as solder volume, pad design, and heating profiles significantly impact joint formation and defect rates. Excess solder causes bridging, whereas insufficient solder weakens connections. This study investigates how dynamic forces, including capillary pressure and surface tension, influence component stability during reflows, with an emphasis on optimizing solder volume and wettability to reduce common SMT defects.

One of the key physical principles affecting solder behavior is surface tension, which governs the shape and distribution of molten solder [3]. Additionally, the buoyancy force exerted by the molten solder plays a crucial role in determining the floating behavior of passive components. If surface tension is not properly controlled, components may shift or misalign due to imbalanced forces. By analyzing the interaction between buoyancy and surface tension, this study aims to develop optimized soldering techniques that enhance component stability, reduce defects, and improve overall manufacturing quality.

3 METHODOLOGY

The schematic diagram as illustrates in Figure 2 shows the key forces acting on a passive electronic component, such as a Die-Side Capacitor, during the reflow soldering. These forces, gravity, surface tension, capillary pressure, dynamic friction, and hydrostatic force, collectively determine the floating behaviour and wettability of the molten solder. Understanding these forces is crucial for optimizing soldering conditions and minimizing common defects such as solder bridging and tombstoning.

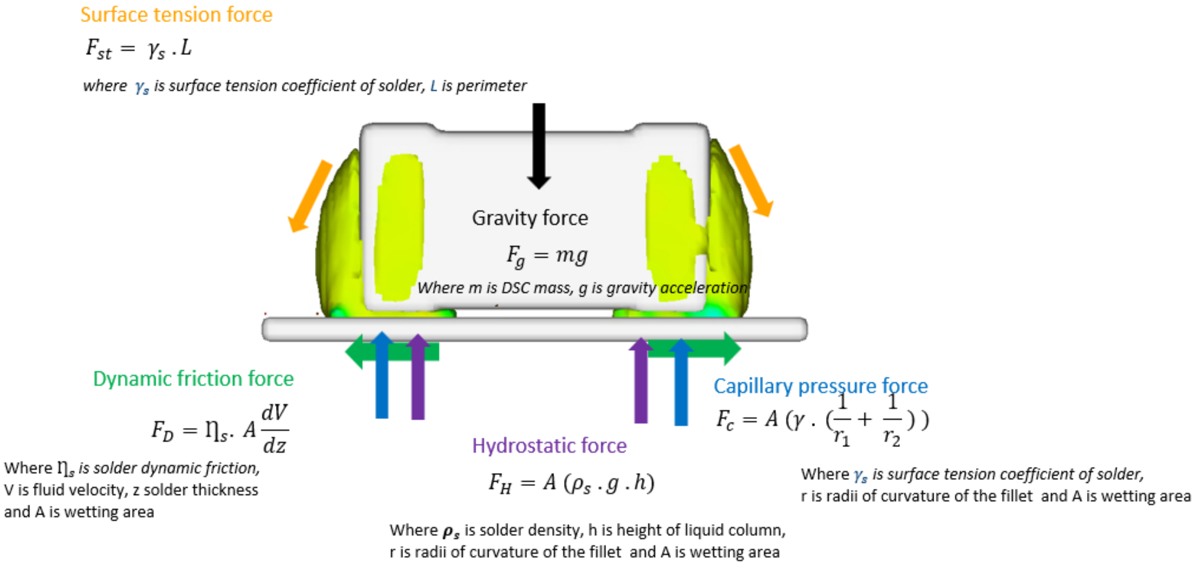

Fig. 2: Acting Forces on a passive electronic component

Gravity force, F_g acts downward on the component, where m is the mass of the Die-Side Capacitor, and g is the gravitational acceleration.

$$F_g = mg$$

Surface tension force F_{st} helps stabilize the component on the molten solder by balancing external forces, where γs represents the solder's surface tension coefficient, and L represents the contact perimeter.

$$F_g = mg$$

Capillary pressure force, F_c influences the solder flow around the component,

$$F_c = A\,(\gamma\,.\;(\frac{1}{r_1} + \frac{1}{r_2}\,)\,)$$

where A is the wetting area, and $r_1$and r_2 are the radii of curvature of the solder fillet. Proper control of this force helps prevent defects such as solder bridging.

Dynamic friction force, F_D plays a role in the movement of the molten solder,

$$F_D = \eta_s.\;A\frac{dV}{dz}$$

where ηs is the solder's dynamic viscosity, V is fluid velocity, and z represents the solder thickness.

$$F_H = A\,(\rho_s\,.\;g\,.h)$$

Additionally, Hydrostatic force provides buoyancy support, where is the solder density and *h* is the liquid column height.

4 RESULTS AND DISCUSSION

The manual calculation of forces acting on the Die-Side Capacitor (DSC) during the reflow soldering process highlights the dominant forces influencing component stability. The surface tension force, a function of the solder geometry, was calculated where the surface tension coefficient of the solder was 530 µN, and the perimeter was 1.5e-3 m. This results in a surface tension force of 795 µN, which counteracts external disturbances to maintain the component's position. The gravitational force acting on the DSC was computed where the mass of the DSC was 1.64e-6 kg, and gravitational acceleration was 9.81 m/s^2. The resulting gravity force was 16 µN, which was relatively small compared to surface tension and capillary forces, indicating minimal gravitational influence on component movement during soldering.

Additionally, the capillary pressure force, which depends on the wetting area and the curvature of the solder fillet, was calculated using the equation. Assuming r1=r2, and using values A=2.92e−7 m^2, γLG = 530 mN/m, and r=5.42 e−4 m, the capillary force was determined to be 570 µN. This force was critical in ensuring proper solder joint formation by influencing the molten solder's ability to wet the component leads and pads. The calculations emphasize that surface tension and capillary forces were significantly larger than gravity, indicating their dominant role in determining the floating mechanism of passive electronic components during reflow soldering.

5 CONCLUSIONS

The analysis confirms that surface tension and capillary forces dominate the floating mechanism of passive electronic components during reflow soldering, significantly outweighing gravitational effects. Proper control of solder volume and wettability is crucial to minimizing defects like solder bridging, ensuring stable component placement, and improving overall solder joint quality in SMT assembly.

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CHAPTER 20

Development of Candy Sorting Machine

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ABSTRACT

This project focuses on the development of a candy sorting machine designed to automate the process of sorting candies based on color detection. With the increasing demand for efficiency in production, manual sorting can be time-consuming and prone to errors. The proposed machine aims to overcome these challenges by automatically sorting candies according to their colors. The primary goal of the project is to achieve precise color detection, uniform distribution, and effective sorting through the use of Arduino-based control. The design of the system includes an Arduino microcontroller, color sensors for detection, motors for sorting, and a mechanism to handle the sorted candies. The project also involves developing custom Arduino code to manage the color detection process, sorting algorithm, and control mechanisms. The expected outcome is a fully operational candy sorting machine capable of accurately sorting candies by color, significantly enhancing productivity and reducing the reliance on manual sorting processes. By automating the sorting procedure, the machine aims to improve efficiency in the candy production process.

Keywords: Candy sorting, Sorting machine

1 INTRODUCTION

A critical aspect of many candy-related applications involves sorting candies by colour, particularly for creating visually attractive displays or ensuring consistency in packaging. However, this process is typically performed manually, which can be time-consuming and inefficient. For instance, sorting a batch of 1,000 candies by hand can take up to 2-3 hours, depending on the number of colours involved [1][2][4]. Scaling this effort to larger quantities or meeting tight deadlines becomes increasingly challenging. Despite the high demand for colour-sorted candies, there are currently not widely available or affordable machines designed to automate this process. A survey conducted among small and medium-sized confectionery businesses revealed that 85% of respondents relied on manual sorting methods, with 78% citing labour intensive sorting as a bottleneck in their operations [4][5]. Moreover, manual sorting introduces the potential for errors and inconsistencies, further affecting product quality.

Manually sorting candies into different color piles is a time consuming which extends preparation time for events. Additionally, inconsistencies arise due to variations in individuals' color perception and sorting methods, affecting the quality and presentation of the finished product. Achieving an even distribution and balanced assortment of colors requires meticulous attention to detail, further complicating the task and potentially increasing preparation time. To address these issues, the main objectives of this project are to design an automatic candy sorter machine using SolidWorks software. Then, proceed to second objective to fabricate the machine as a proof of concept.

2 LITERATURE REVIEW

There are many different candy sorting and packaging products that are available nowadays, each with its own unique design, ergonomics, efficiency, and price point. While these products may share similar functionality, the specific features and performance characteristics can vary significantly between manufacturers and models.

Table 1: Summary the potential of benchmark product

Available Product	**Advantages**	**Disadvantages**
 Veryx Digital Sorting Platform for Gummy Candy [3]	• Unique sensor configurations. • Defect detection capabilities. • Fast sorting mechanism.	• Expensive • High maintenance cost. • Not suitable for short production runs.
 DhimanGroup's Automatic Candy Sorter Machine [2]	• Use high precision sorting mechanism. • Less wastage and time consumption.	• High operational cost. • High maintenance cost.

3 METHODOLOGY

Project flowchart was designed to ensure that the project will run smoothly. Figure 2 displays the project flowchart. This project begins by finding a problem statement and then proceed to objectives. While designing stages, three concept model was design, then has been evaluated by using Pugh Chart. Figure 2 shows the concept designs. This preliminary evaluation has been provided the most promising concept design before extended to the final featuring model. Then, the purchasing of material is being made based on bill of materials came from final featuring model (final design). The fabrication for the main frame has been conducted by workshop methods because of the require steel cutting and welding joints. After that, the other components is being produces by using 3D printing methods. The machine then is being install with the electronic controller executed by Arduino and sensors.

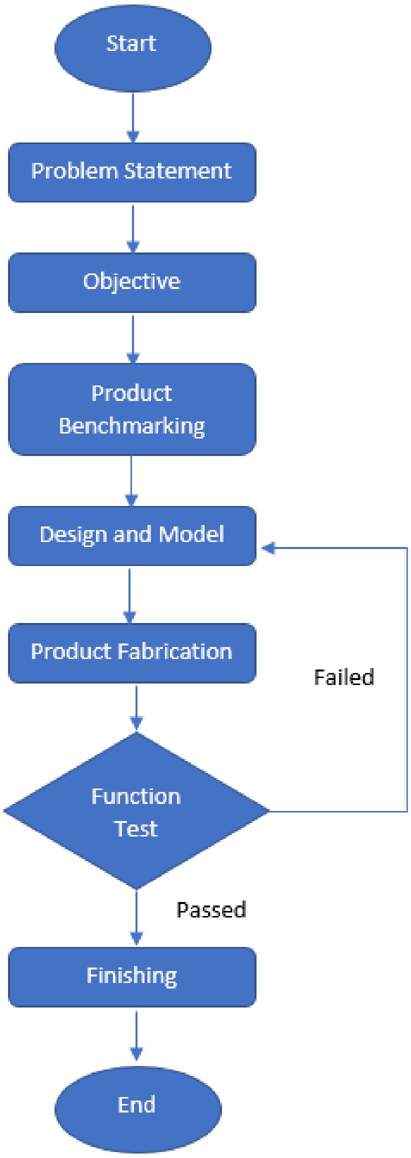
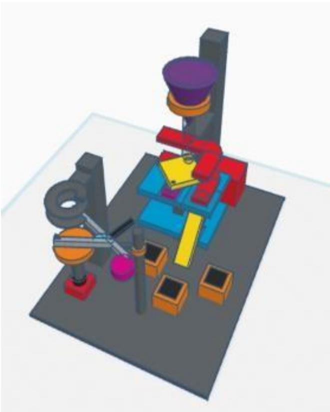
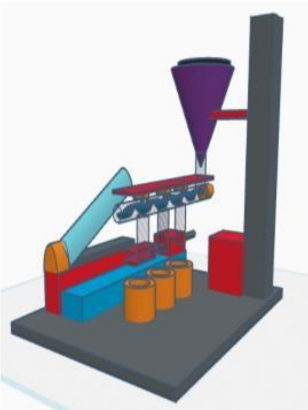


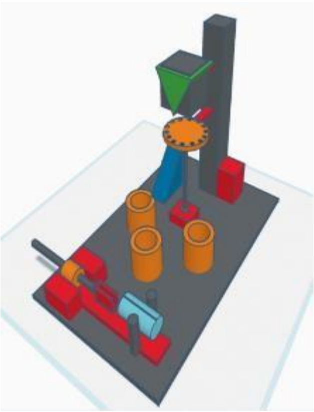
Fig. 1: Project flowchart



(a) Concept design 1



(b) Concept design 2

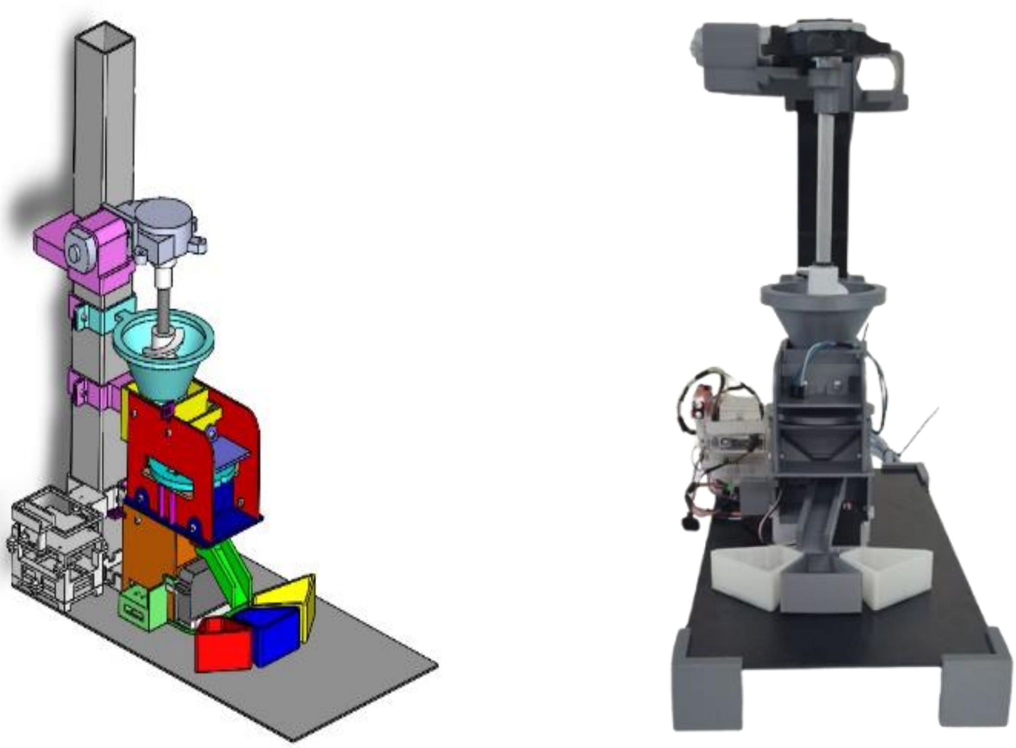


(c) Concept design 3

Fig. 2: Preliminary design (Concept design stages)

4 RESULT AND DISCUSSION

The Candy Sort and Pack Machine prototype is fully assembled and functioning as designed, with all mechanical and electrical components working together seamlessly. The 3D-printed parts, like the wheel, sorting chute, and hoppers, are securely assembled using fasteners and snap-fit mechanisms. The electrical system, controlled by an Arduino UNO, operates smoothly, ensuring accurate color detection and sorting. For example, the sorting chute moves precisely to sort Skittles candies into the correct storage compartments, while the LED and buzzer provide clear feedback during operation. This completed design demonstrates careful planning and ensures the machine runs efficiently and reliably. Figure 3 (a) shows the final designed model meanwhile Figure 3 (b) shows the final fabricated prototype.



(a) Final design (b) Final prototype

Fig. 3: Final design model and fabricated prototype

5 CONCLUSIONS

The fabrication of the Candy Sort and Pack Machine successfully brought the conceptual design to life, serving as a proof of concept to validate its functionality. To enhance the efficiency and functionality of the Candy Sort and Pack Machine, it is recommended to integrate a conveyor belt system for automated candy feeding. This addition would eliminate the need for manual loading, ensuring a continuous flow of candies into the system and increasing the throughput. A conveyor belt system could also be paired with sensors to detect candy jams and pause operations temporarily to prevent mechanical damage.

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