

# Prototype Design and Research Collection

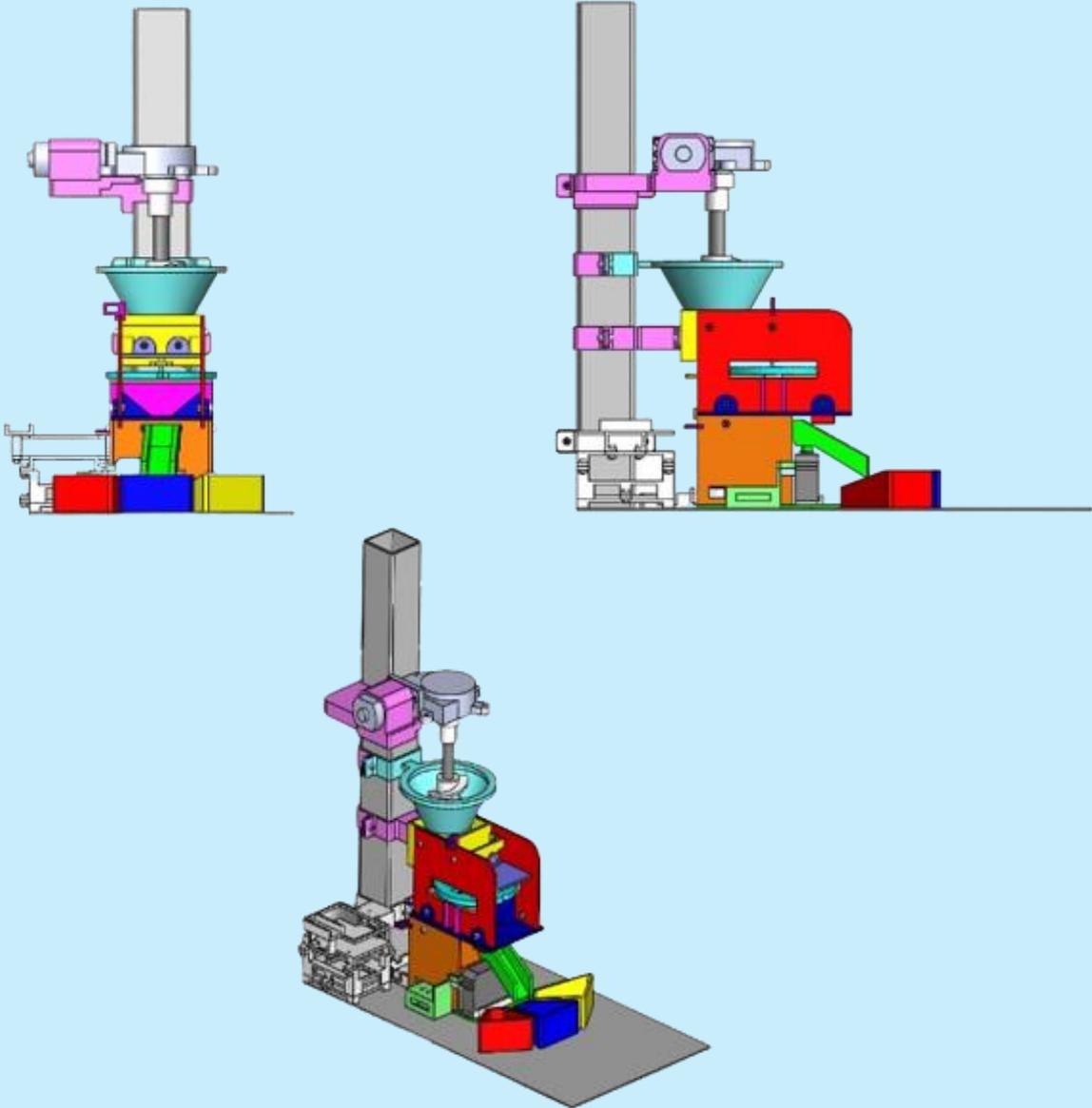
Series 1



Universiti Teknologi MARA  
Pasir Gudang Campus

# Prototype Design and Research Collection

## Series 1



AHMAD NAJMIE RUSLI

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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 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)	<ol style="list-style-type: none"> <li>1. The luxurious design includes wheels for mobility and storage choices, making this BBQ grill a coveted item for all.</li> <li>2. Gas grills have an uninterrupted fuel supply.</li> <li>3. Has a stable gas emitting [6] and offers easy with fast heating, allowing precise temperature control.</li> </ol>	<ol style="list-style-type: none"> <li>1. Higher in price.</li> </ol>
Electric Barbeque Grill Korean Pan	<ol style="list-style-type: none"> <li>1. Versatility in terms of they can be used both indoors and outdoors, making them suitable for various settings such as balconies or countertops.</li> <li>2. The adjustable temperature controls allow for precise cooking and consistent results.</li> </ol>	<ol style="list-style-type: none"> <li>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].</li> </ol>
Charcoal Grill	<ol style="list-style-type: none"> <li>1. The use of different types of charcoal and wood can result in a wide range of flavors.</li> <li>2. Charcoal grills tend to be more affordable overall, especially smaller and portable models that commonly utilize charcoal as their fuel source [8]</li> </ol>	<ol style="list-style-type: none"> <li>1. Produce a lot of smoke and less precise temperature control.</li> </ol>

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.

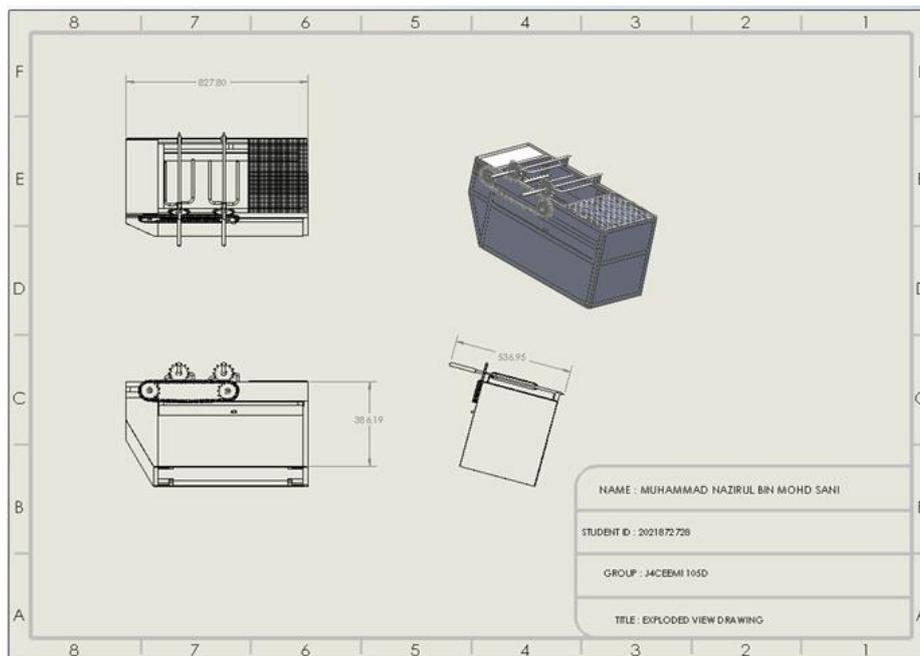


Fig.3.1: Final solid work prototype drawing

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.

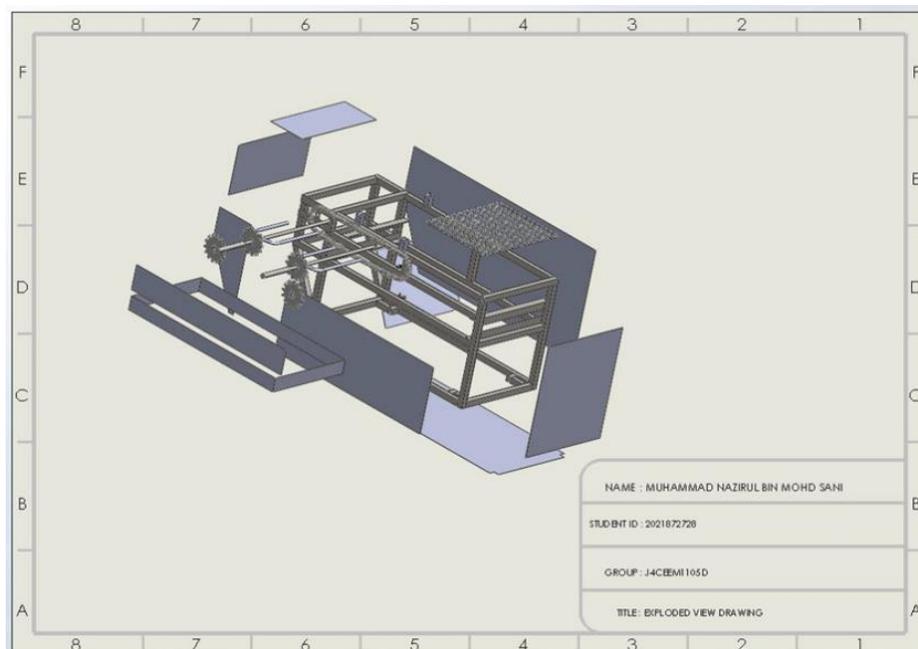


Fig. 3.2: The assembling drawing of the proposed prototype

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

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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