# Prototype Design and Research Collection

Series 1


Universiti Teknologi MARA
Pasir Gudang Campus

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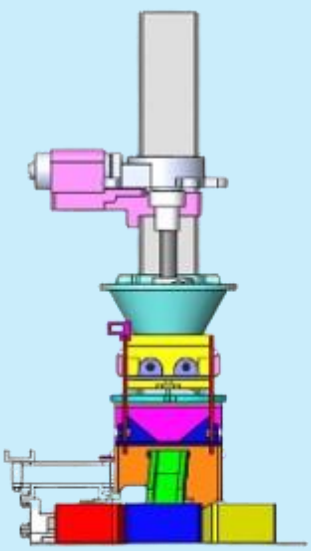

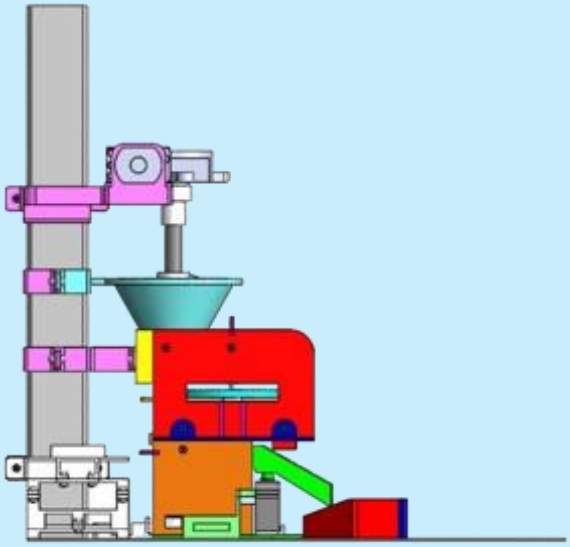

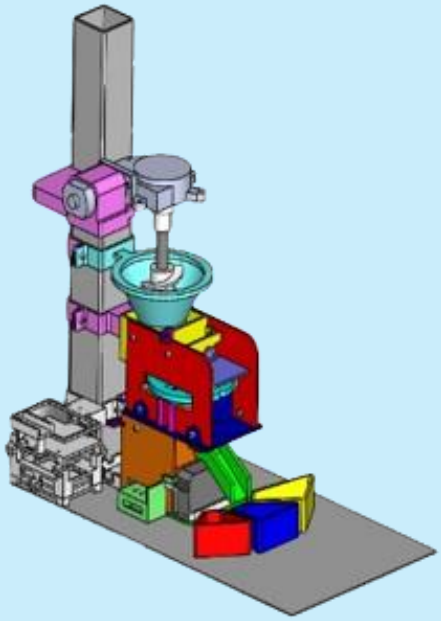

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# FOREWORD

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

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

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# CHAPTER 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.

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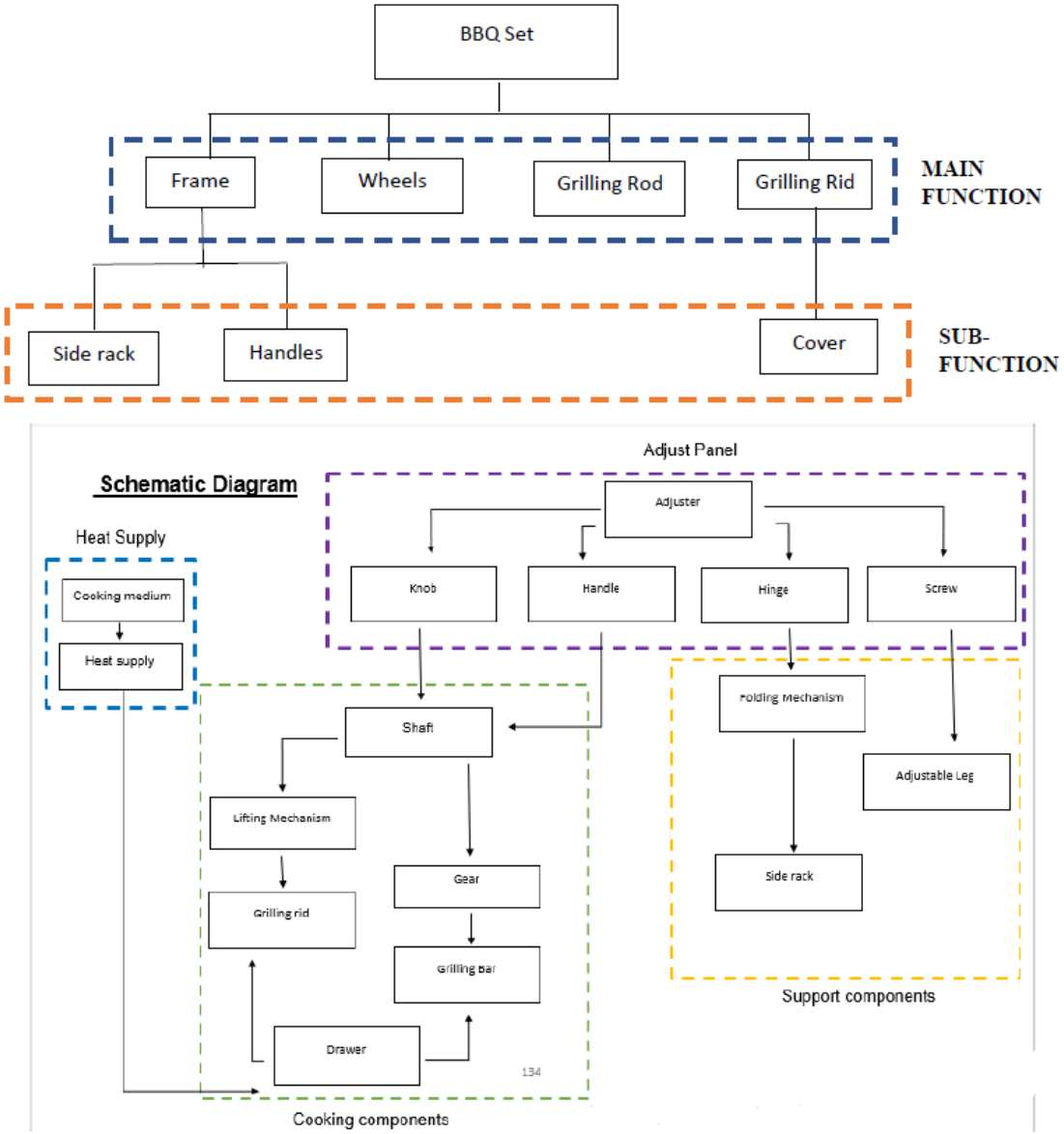


Fig. 1: The schematic diagrams of the multifunction BBQ set

*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.

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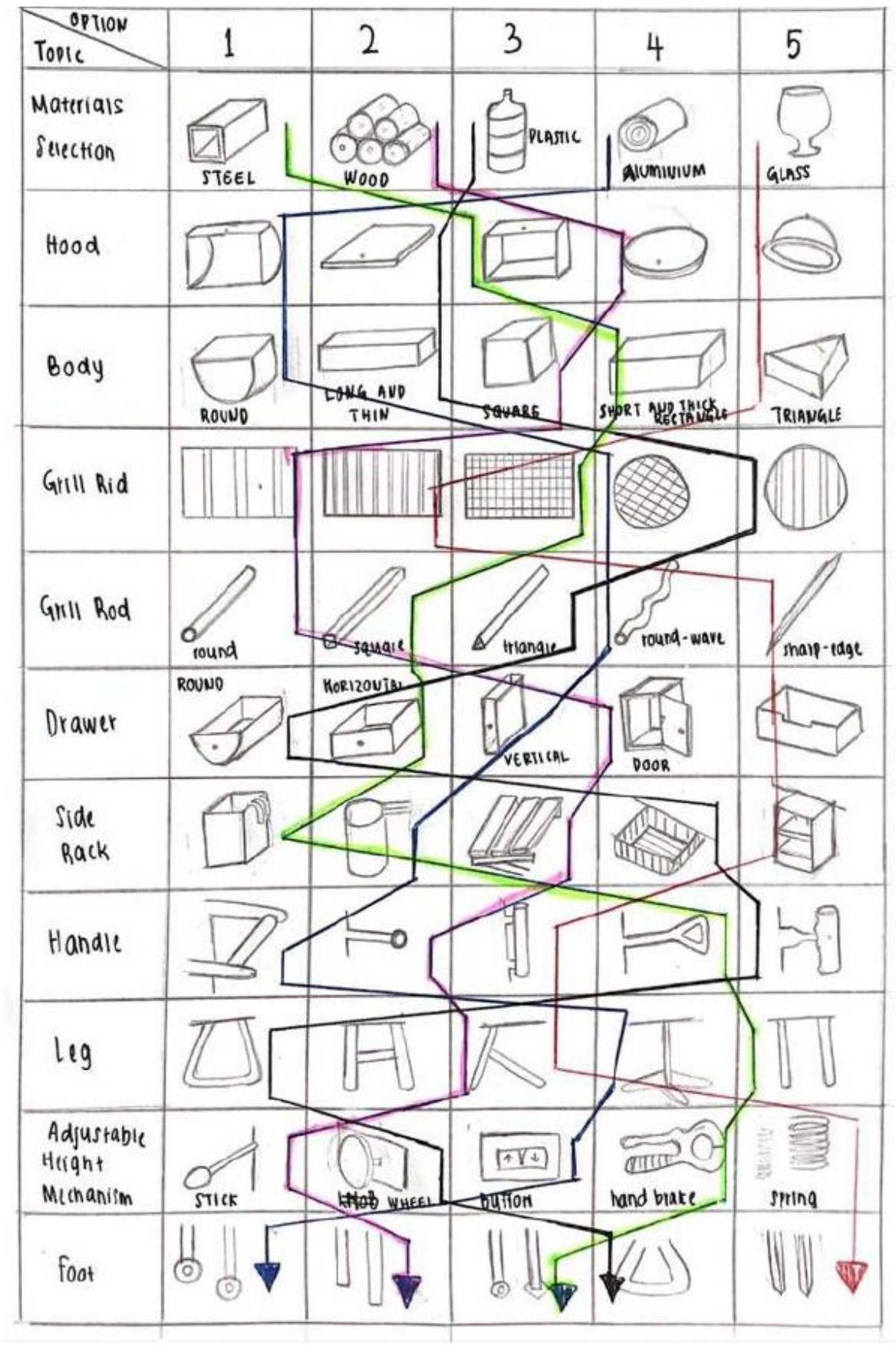


Fig. 2: Morphological chart

*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

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

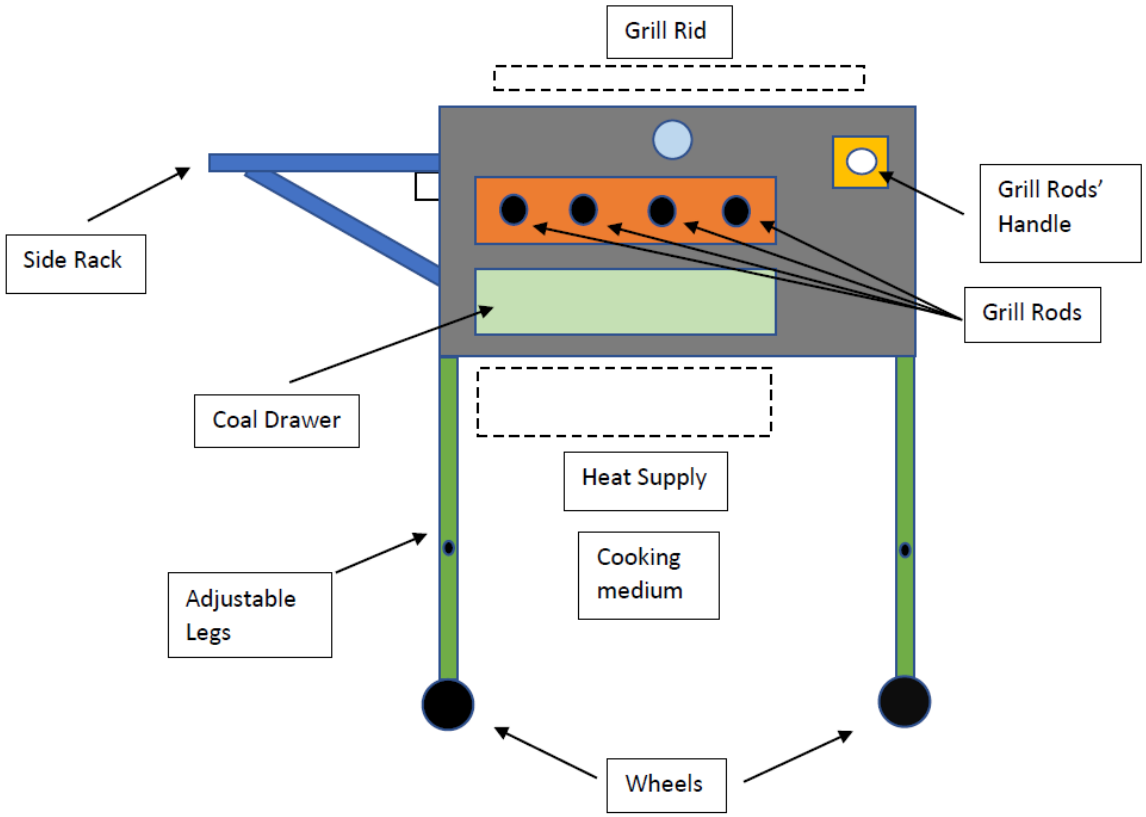


Fig.4: The front viewed sketch of final concept design of multifunction BBQ set

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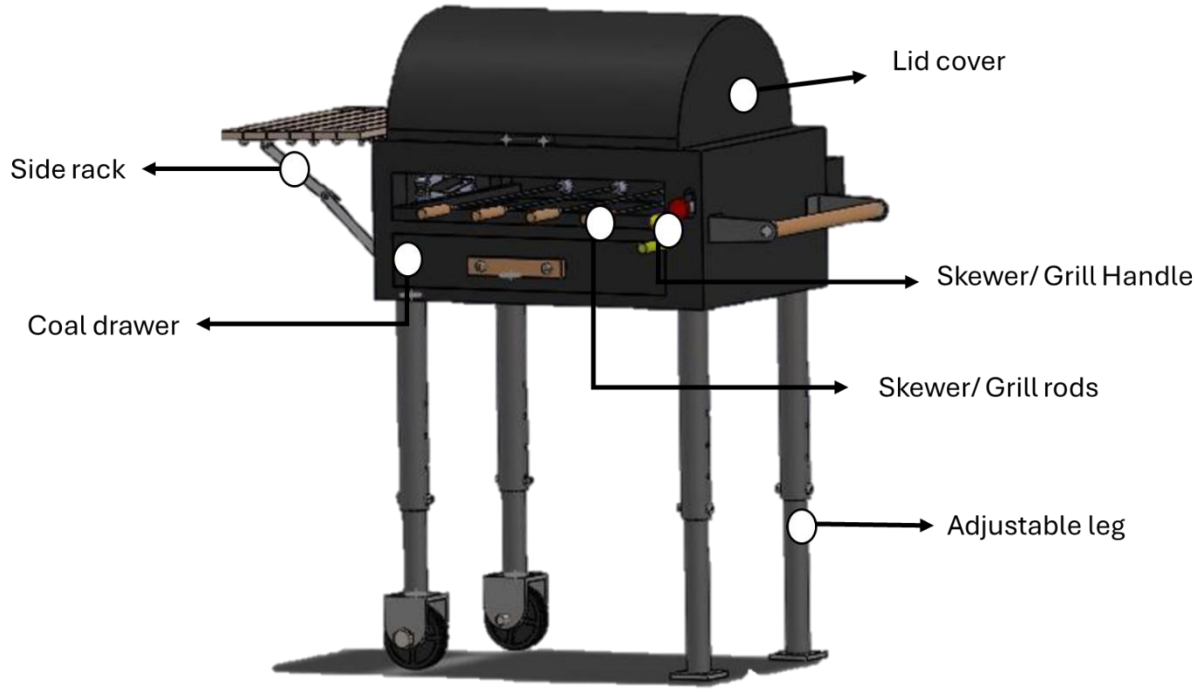


Fig 5: The front viewed Solidwork illustration of final concept design of multifunction BBQ set with its respective labels.

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.

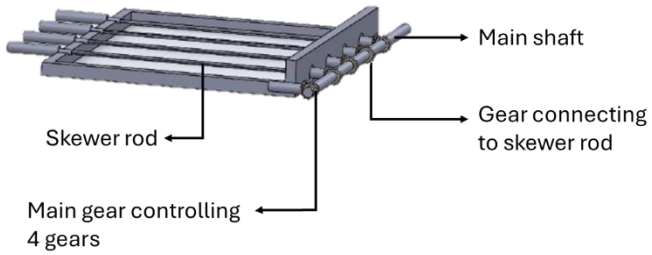


Fig. 6: The Solidworks illustration depicts an assembly of four steel rods connected to individual gears, controlled by a main gear, forming a mechanism for the four-skewer setup.

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].

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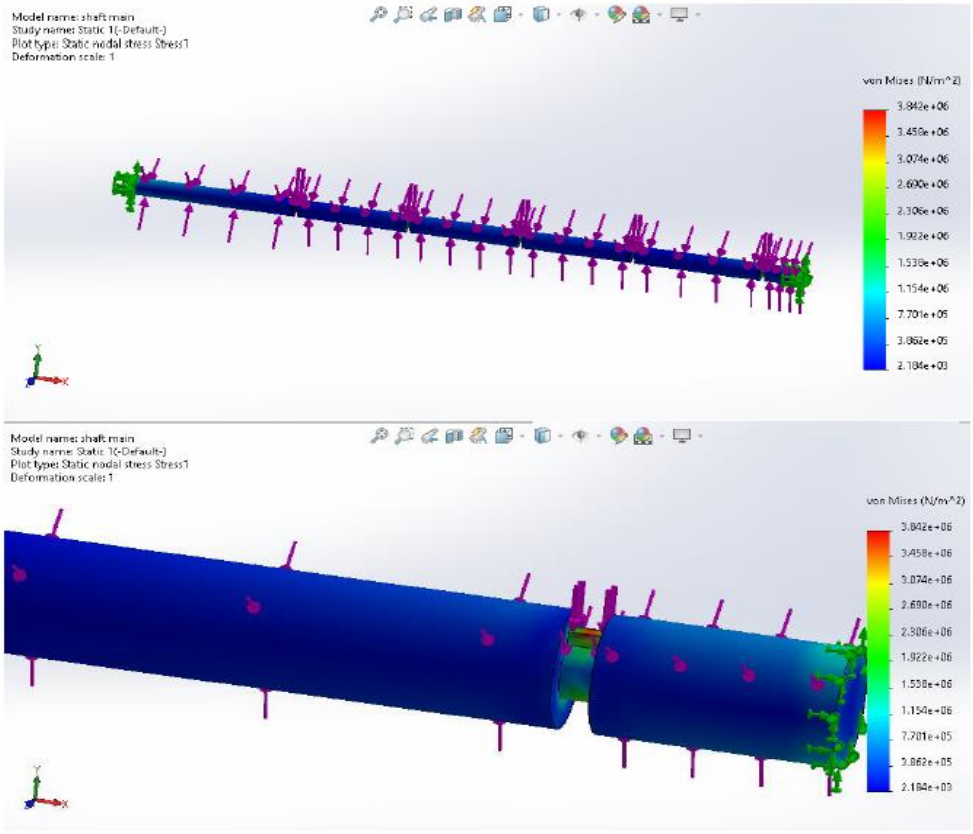


Fig.7: The strength analysis of the main shaft of diameter 25 mm subjected to a uniform load of 20 kg

## 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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