

Charcoal Barbecue / Fire pit

Bellgrill

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Abstract

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<p>The charcoal barbecue/fire pit was designed with the aim of combining grilling, frying, and smoking features into one movable and lightweight unit. Its round shape promotes friends/family gatherings, while its disassemblable structure allows for easy storage during winter. The need for equipment for different cooking methods, such as open fire smoke, grilling, and frying, inspired the design to consolidate these functionalities. Additionally, the safety concerns associated with traditional open fire grilling, especially in natural settings, drove the development of a safer alternative.</p> <p>The design process involved thorough research into the requirements of each cooking method and the integration of appropriate features into the fire pit/barbecue. Key findings indicate that consolidating multiple cooking functionalities into one unit simplifies outdoor cooking experiences and promotes safety, especially in natural settings. The versatile nature of the firepit/barbecue enhances its usability for different cooking preferences and occasions. Furthermore, the lightweight and moveable design make it convenient for users to transport and set up the unit in various outdoor environments.</p>		
Keywords		
Charcoal barbecue, fire pit, food, grilling, frying, cooking, smoking.		

Contents

1	Introduction.....	1
1.1	Introduction and project brief	1
1.2	History of charcoal barbecue	2
1.3	Objectives.....	3
1.4	Delimitations	4
2	Research	5
2.1	Material research.....	5
2.1.1	Benefits of cast iron for grilling	5
2.1.2	Benefits of stainless steel for grilling	6
2.1.3	Advantages of using aluminium in design.....	7
2.2	Benchmarking.....	8
2.2.1	Shape	8
2.2.2	Price	8
2.2.3	Versatility	9
3	Design process.....	11
3.1	Ideation.....	11
3.2	Sketches.....	11
3.3	Early 3D.....	13
4	Components	20
4.1	Main pit.....	20
4.2	Internal pit.....	23
4.3	Lid	25
4.4	Handles	27
4.5	Cooking grid and griddle.....	29
4.6	Smoker grid and smoker mesh	31
4.7	Small and big smoker combs with shaft.....	34
4.8	Smoker holder	36
4.9	Smoker adapter	38
4.10	Behind legs.....	41
4.11	Front legs	42
4.12	Wheels	44
5	Summary	48
	References	49

1 Introduction

1.1 Introduction and project brief

Indeed, outdoor grilling has surged in popularity among people of all ages and backgrounds. This trend (tomsguide 2024.) can be attributed to several factors, including the enjoyment of cooking and dining freshly, the social aspect of gathering around a grill with friends and family, and the desire for flavorful, freshly prepared meals. Additionally, outdoor grilling allows individuals to explore diverse culinary techniques, experiment with different recipes, and savor the unique smoky flavors imparted by grilling over an open flame or charcoal. Furthermore, the convenience and versatility of outdoor grilling make it a preferred choice for casual weeknight dinners, celebratory gatherings, and everything in between.

Traditional methods (barbecue 2020.) may involve multiple equipment pieces or risky open fire arrangements, leading to inconvenience and safety concerns. Moreover, the need for versatility in accommodating different cooking techniques, coupled with the desire for mobility and ease of storage, remains largely unmet. As people continue to embrace outdoor living and seek out memorable dining experiences, the popularity of outdoor grilling shows no signs of slowing down (cottagelife 2024.).

The modern outdoor culinary experience demands versatility, convenience, safety and sustainability. In response to these needs, we present a groundbreaking design: a multifunctional charcoal barbecue/firepit that seamlessly integrates grilling, frying, and smoking capabilities within a single unit. Crafted with a round shape and a spacious 800 mm diameter, this fire pit serves as the focal point for family gatherings and outdoor festivities. What sets this product apart is its emphasis on mobility and ease of storage, with two wheels underneath enabling effortless transportation, and the ability to disassemble all components for compact storage during winter months. Beyond convenience, safety for the environment is paramount, as the design ensures contained fire usage, minimizing the risk of spreading flames in open areas. By consolidating all essential cooking functions into one versatile unit, our aim is to redefine the outdoor cooking experience, offering users a harmonious blend of functionality, mobility, and ecological mindfulness.

In response to these challenges and considerations, the design and development of a charcoal barbecue/firepit that integrates grilling, frying, smoking, and cooking functionalities emerge as a compelling solution. This innovative apparatus aims to provide outdoor cooking enthusiasts with a comprehensive and versatile cooking experience, while also addressing concerns related to safety and convenience.

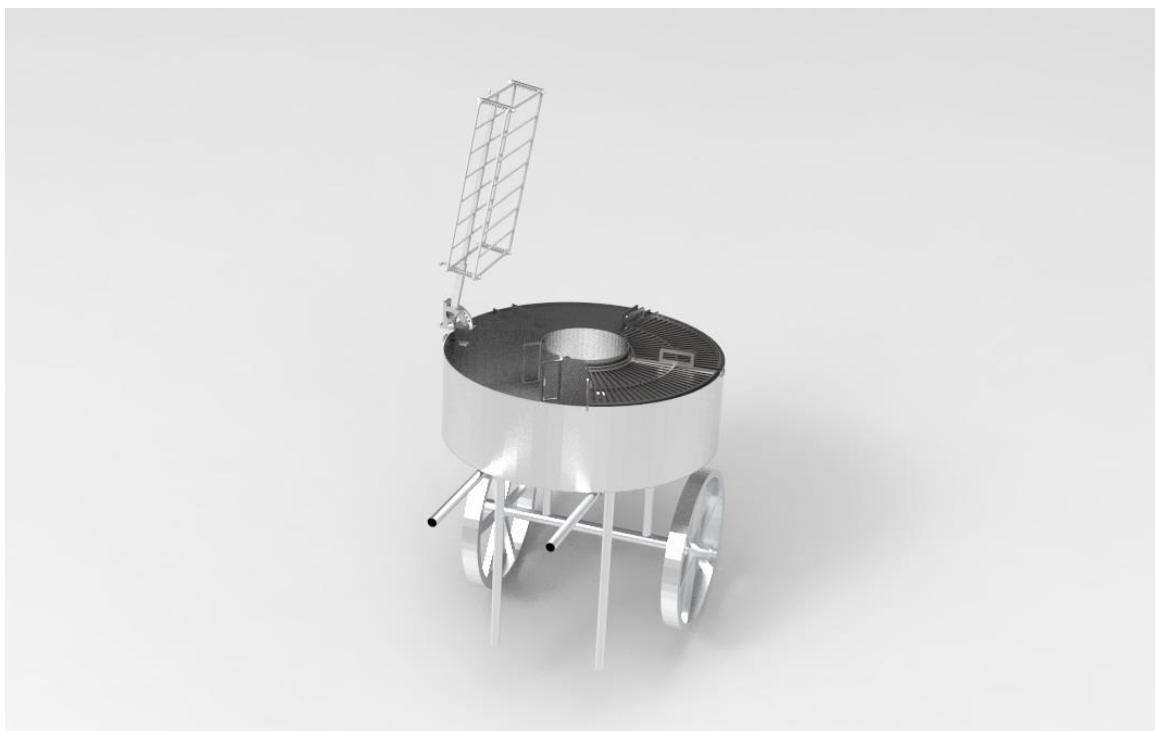


Figure 1. Product overview in SolidWorks

1.2 History of charcoal barbecue

The history of charcoal barbecue (barbecue 2020.) dates back thousands of years, with evidence of early humans using fire and rudimentary grilling techniques to cook food. Ancient civilizations, such as the Greeks and Romans, practiced forms of barbecue, often as part of communal feasts and celebrations. The significance of charcoal barbecue in culinary culture lies in its ability to impart unique flavors and textures to food, creating a distinct dining experience. Charcoal grilling is prized for its ability to produce high temperatures, resulting in caramelization and Maillard reactions that enhance the flavor of meats, vegetables, and other foods.

Throughout history, barbecue has evolved into a cultural phenomenon, with distinct regional styles and traditions emerging in various parts of the world, such as American barbecue, Argentine asado, and Japanese yakitori. These traditions are often deeply rooted in local customs, ingredients, and cooking techniques, reflecting the cultural diversity and culinary heritage of different regions (Figure 2).

In contemporary culinary culture, charcoal barbecue continues to hold a special place, celebrated for its simplicity, versatility, and the social experience it offers. Whether it's a backyard cookout with friends and family or a gourmet barbecue restaurant, charcoal grilling remains a beloved culinary tradition cherished by many.

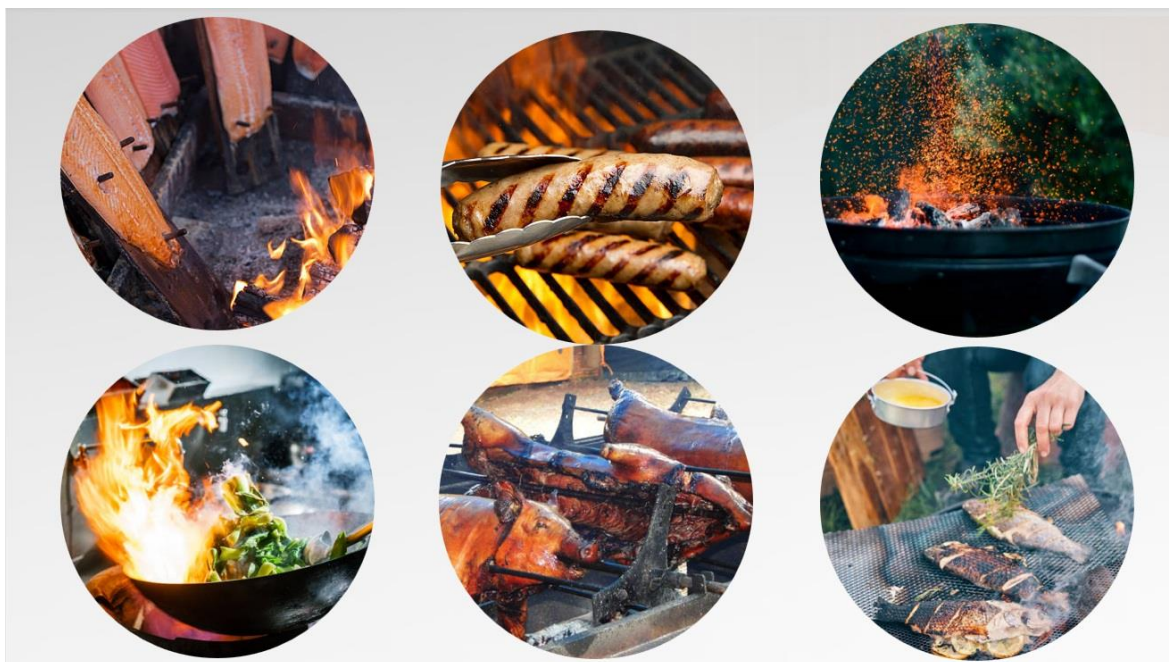


Figure 2. Different type of grilling on fire (istockphoto, 2024)

1.3 Objectives

The objectives of charcoal barbecue discusses various goals within the realm of design. It touches upon the importance of versatility, emphasizing the integration of multiple functionalities into a single cohesive unit. Additionally, it highlights the significance of mobility, underscoring the ease of transporting the design to different outdoor settings. Safety is also addressed, stressing the implementation of measures to reduce risks associated with open fire cooking. Lastly, the text mentions the importance of ease of storage, acknowledging the need for convenient disassembly and storage during periods of non-use or inclement weather.

In versatility the primary objective of this design is to consolidate grilling, frying, smoking, and cooking functionalities into one cohesive unit, offering users the flexibility to experiment with various culinary techniques.

In mobility the design prioritizes mobility, allowing users to easily transport the barbecue/firepit to different outdoor settings, whether it be backyard gatherings, camping trips, or beach picnics.

Ensuring safety is paramount, with measures in place to mitigate risks associated with open fire cooking, such as contained fire pits and secure construction materials.

Lastly in ease of storage recognizing the seasonal nature of outdoor cooking, the design facilitates easy disassembly for convenient storage during winter months or when not in use.

1.4 Delimitations

The design outlines various limitations, or delimitations, that need consideration in the design process. Firstly, there's the size limitation, where the goal is to balance accommodating family gatherings with the need for portability, potentially impacting the cooking area size. Secondly, complexity is addressed, aiming for versatility without sacrificing user-friendliness by avoiding unnecessary intricacies.

Lastly, budget constraints are taken into account, ensuring the design remains accessible through careful material selection and construction decisions.

Ultimately, by tackling these objectives and constraints, the envisioned charcoal barbecue/firepit aims to transform outdoor cooking by offering a solution that combines functionality, safety, and convenience. While the barbecue/firepit aims to accommodate family gatherings, there may be limitations on the size of the cooking area due to portability considerations.

While striving for versatility, the design aims to strike a balance between functionality and user-friendliness, avoiding unnecessary complexity that may hinder usability. The design aims to remain accessible to a wide range of users, considering budget constraints in material selection and construction.

By addressing these objectives and delimitations, the envisioned charcoal barbecue/firepit seeks to revolutionize the outdoor cooking experience, offering a comprehensive solution that combines functionality, safety, and convenience.

2 Research

2.1 Material research

Among the selected materials, three types are chosen for this design: Aluminium, stainless steel, and cast iron (Figure 3). Aluminium is selected for its lightweight properties, making it ideal for components that require mobility or reduced weight. Stainless steel is chosen for its durability and resistance to corrosion, ensuring the longevity of the design in various environmental conditions.

Cast iron is also selected for its strength and stability, particularly in applications where heavy loads or high temperatures are involved. Each material is carefully considered for its specific characteristics and suitability for different parts of the design. The combination of these materials ensures a balanced approach, optimizing performance and longevity while meeting the design requirements.

2.1.1 Exploring the benefits of cast iron for grilling

Cast iron has excellent heat retention properties (seriouseats 2024.), which means it gets hot and stays hot evenly across its surface. This allows for consistent cooking temperatures and helps achieve uniform grill marks and caramelization on food.

Cast iron distributes heat evenly, reducing hot spots and ensuring that food cooks uniformly. This helps prevent overcooking or undercooking certain areas of the grill.

Cast iron is incredibly durable and can withstand high temperatures without warping or deforming. It is also resistant to scratches and corrosion, making it a long-lasting option for grilling.

Cast iron grates are versatile and can be used for various grilling techniques, including high-heat searing, low-and-slow smoking, or even baking or roasting. They are suitable for cooking a wide range of foods, from meats and vegetables to seafood and pizzas.

Over time, cast iron grates develop a natural seasoning layer, which is a non-stick surface formed by oils and fats from food. This seasoning layer adds flavor to grilled foods and helps prevent sticking, making cleanup easier.

While cast iron requires some maintenance to keep it in top condition, such as regular seasoning and proper cleaning, it is relatively low-maintenance compared to other grill materials. With proper care, cast iron grates can last for generations.

Overall, cast iron grates are a popular choice among grill enthusiasts for their excellent heat retention, durability, versatility, and flavor-enhancing properties, making them ideal for achieving delicious grilled dishes.

2.1.2 Exploring the benefits of stainless steel for grilling

Stainless steel is highly durable and resistant to rust, corrosion, and damage from heat (seriouseats 2024.). This makes stainless steel grates suitable for outdoor grilling, where they are exposed to the elements and high temperatures.

Stainless steel grates are relatively easy to clean compared to other materials. They can be scrubbed with a grill brush or washed with soap and water, making maintenance simple and convenient.

Stainless steel is non-porous, which means it does not harbor bacteria or absorb flavors from food. This makes stainless steel grates a hygienic option for grilling, as they can be thoroughly cleaned between uses.

While stainless steel does not retain heat as well as cast iron, it still conducts heat efficiently, allowing for even cooking and consistent grill marks on food.

Stainless steel has a sleek and modern appearance that complements many outdoor grill designs. It adds a professional look to the grill and can enhance the overall aesthetic of the outdoor cooking space. Stainless steel grates are less prone to warping or bending under high heat compared to other materials, ensuring that they maintain their shape and performance over time.

Overall, stainless steel grates are a popular choice for grilling due to their durability, ease of cleaning, hygiene, heat conduction properties, and attractive appearance. They offer a reliable and long-lasting option for outdoor cooking enthusiasts. Compared to cast iron, stainless steel is generally lighter in weight.

Cast iron is known for its density and heavy weight, making it substantially heavier than stainless steel. This difference in weight is a significant factor to consider when choosing between the two materials for various applications, particularly in situations where weight is a concern, such as in automotive, aerospace, or outdoor equipment design.

2.1.3 Advantages of using aluminium in design

Aluminium is a lightweight material, making it ideal for applications where weight is a concern, such as in the aerospace, automotive, and transportation industries (amcaluminum

2024.). Its low density allows for easier handling, transportation, and installation of aluminium components.

Despite being lightweight, aluminium exhibits an excellent strength-to-weight ratio, meaning it can withstand high loads and stresses while still being relatively light. This makes aluminium suitable for structural applications where strength and durability are essential.

Aluminium naturally forms a protective oxide layer on its surface, which helps prevent corrosion and rusting. This corrosion resistance makes aluminium suitable for outdoor and marine applications, as well as in environments with high humidity or exposure to corrosive substances.

Aluminium is highly malleable and can be easily formed into various shapes and profiles through processes such as extrusion, casting, and machining. This versatility in shaping allows designers to create complex and intricate designs with ease.

Aluminium is highly recyclable, with the ability to be melted down and reused without loss of quality or properties. Recycling aluminium requires significantly less energy compared to producing it from raw materials, making it an environmentally sustainable choice for designers and manufacturers.

These advantages make aluminium a popular choice in various industries, including construction, transportation, electronics, packaging, and consumer goods.

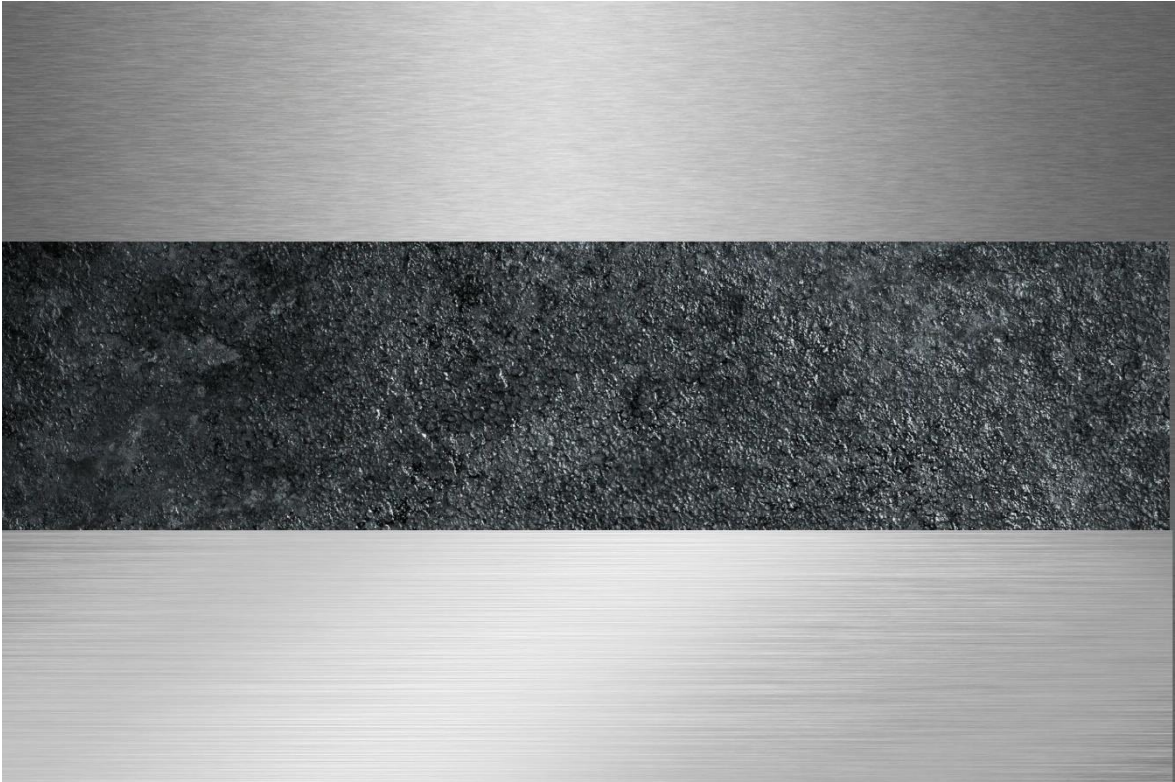


Figure 3. Three types of materials used in this design (istock 2024)

2.2 Benchmarking

In this report, we analyze and compare the offerings of three prominent agents in the barbecue/fire pit segment: Puuilo (Figure 5), Tokmanni (Figure 6), and K-Rauta (Figure 4). We evaluate each brand's products based on various factors including price, quality, features, and customer reviews.

2.2.1 Shape

Puuilo offers a diverse range of shapes catering to different preferences, including traditional designs and innovative shapes to enhance functionality and aesthetics.

Tokmanni features simple, no-frills designs with basic shapes, focusing on affordability rather than intricate designs.

K-Rauta provides premium options with sophisticated shapes and designs, incorporating advanced features for optimal performance and aesthetics.

2.2.2 Price

Puuilo generally offers competitive prices catering to various budgets, offering a balance between quality and affordability.

Tokmanni is known for affordable pricing, targeting budget-conscious consumers seeking cost-effective options without compromising basic functionality.

K-Rauta offers premium products with higher price points, reflecting the superior build quality, advanced features, and durable materials used.

2.2.3 Versatility

Puילו is known for versatile options, catering to different cooking styles and preferences with features like adjustable grills and built-in thermometers.

Tokmanni provides basic functionality suitable for casual outdoor cooking and gatherings, lacking some advanced features found in higher-end models.

K-Rauta offers versatile options with advanced features, suitable for enthusiasts and professionals seeking optimal performance and versatility in their barbecue and fire pit equipment.

Each brand caters to a specific market segment based on shape, price, and versatility. Puילו balances quality and affordability, Tokmanni focuses on budget-friendly options, and K-Rauta provides premium products for discerning customers. The choice ultimately depends on individual preferences, budget constraints, and desired features.

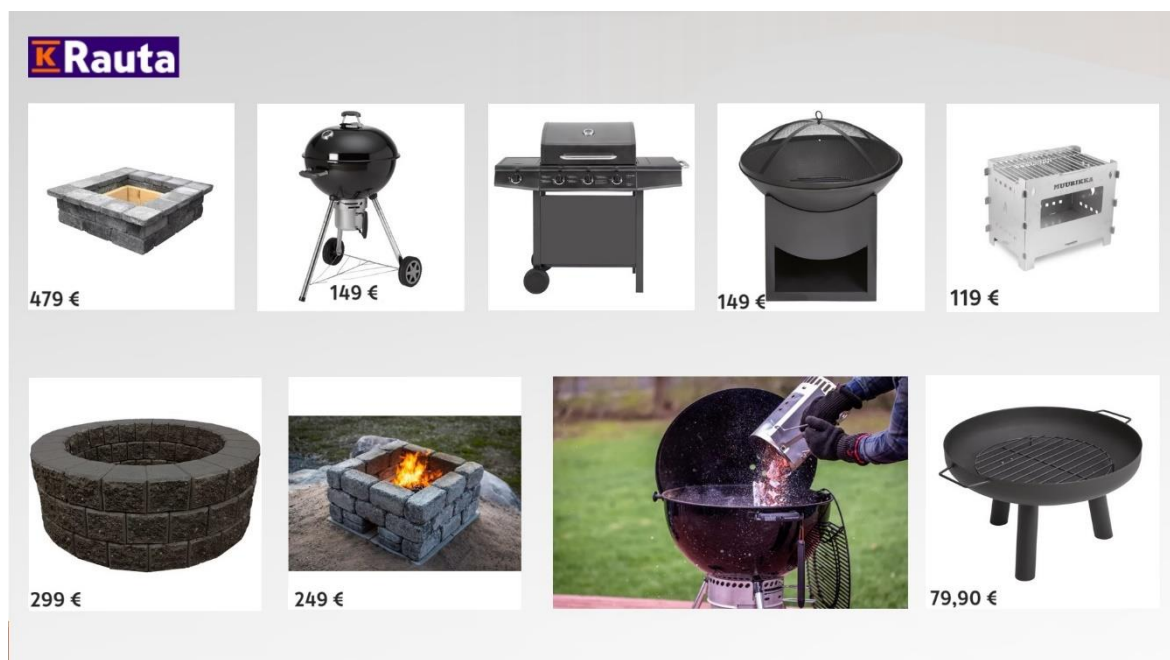






Figure 4. Different type of grills in K-Rauta (K-Rauta 2024)

PUUILO

			
Mustang ulkotulisija Redding	Mefisto Luxus pallogrilli 22"	Mefisto hiiligrilli De Luxe XXL	Mustang kaasusavustin kymi
49,90 €	69,00 €	149,00 €	199,00 €








		
Mefisto nuotiogrilli	Mustang ulkotulisija Lemoore 60cm	Char-Griller Akorn 14 Junior Kamado Hiiligrilli
34,90 €	79,90 €	199,00 € <small>Ale -43%</small> 349,00 €

Figure 5. Different type of grills in Puuilo (Puuilo 2024)

TOKMANNI

			
MUSTANG Grillausjärjestelmä Kamado M	MUURIKKA Kesäkeittiö Muurikka sähkö harmaa	BBQ KING Pallogrilli BBQ King, Ø 44 cm	BBQ KING Tulisija Ø 76 cm
149,00	399,00	24,95	109,00




		
KOTAKEITTIÖ Kotakeittiö Notski 60	MUSTANG Kaasugrilli Mustang Sapphire, 5 + 1 + 1 poltinta	MUURIKKA Kesäkeittiö Muurikka kaasu mad musta
369,00	1 699,00	429,00

Figure 6. Different type of grills in Tokmanni (Tokmanni 2024)

3 Design process

3.1 Ideation

The idea for the versatile charcoal barbecue/fire pit that could accommodate open fire salmon, grilling, cooking, and frying all in one place originated from a series of observations and brainstorming sessions. It began with a recognition of the inconvenience and potential environmental impact of having separate fire areas for different cooking methods.

Initially, while enjoying outdoor activities like camping and barbecuing, the need to constantly move between different fire pits for various cooking tasks became apparent. It was not only cumbersome but also raised concerns about safety, especially in areas where open fires posed a risk to the environment.

As the idea took shape, discussions centered around creating a single, multifunctional solution that would streamline the outdoor cooking experience while minimizing the ecological footprint. Collaborating with outdoor enthusiasts, engineers, and environmentalists, the concept evolved into a portable charcoal barbecue/fire pit that could easily adapt to different cooking methods.

The design process involved incorporating features such as adjustable grilling racks, removable grid and griddle and dedicated areas for open fire cooking and smoking. Attention was also paid to safety measures, including heat-resistant materials and sturdy construction to prevent accidents and minimize environmental impact. Its moveable design allowed for easy transportation and storage, while its comprehensive functionality made it a convenient and eco-friendly solution for enjoying outdoor culinary adventures.

3.2 Sketches

The initial shape of the first fire pit was square (Figure 8). However, after discussions with a chef and designers, it was decided that a round shape would not only enhance its beauty but also make it easier to clean (Figure 7). The input from the chef highlighted the importance of a shape that promotes even heat distribution and efficient cooking. Meanwhile, the designers emphasized the aesthetic appeal and practicality of a round design. Taking these considerations into account, the decision was made to transition from a square to a round shape for the fire pit. This adjustment aimed to improve both the functionality and visual appeal of the product, aligning it more closely with the needs and preferences of users.

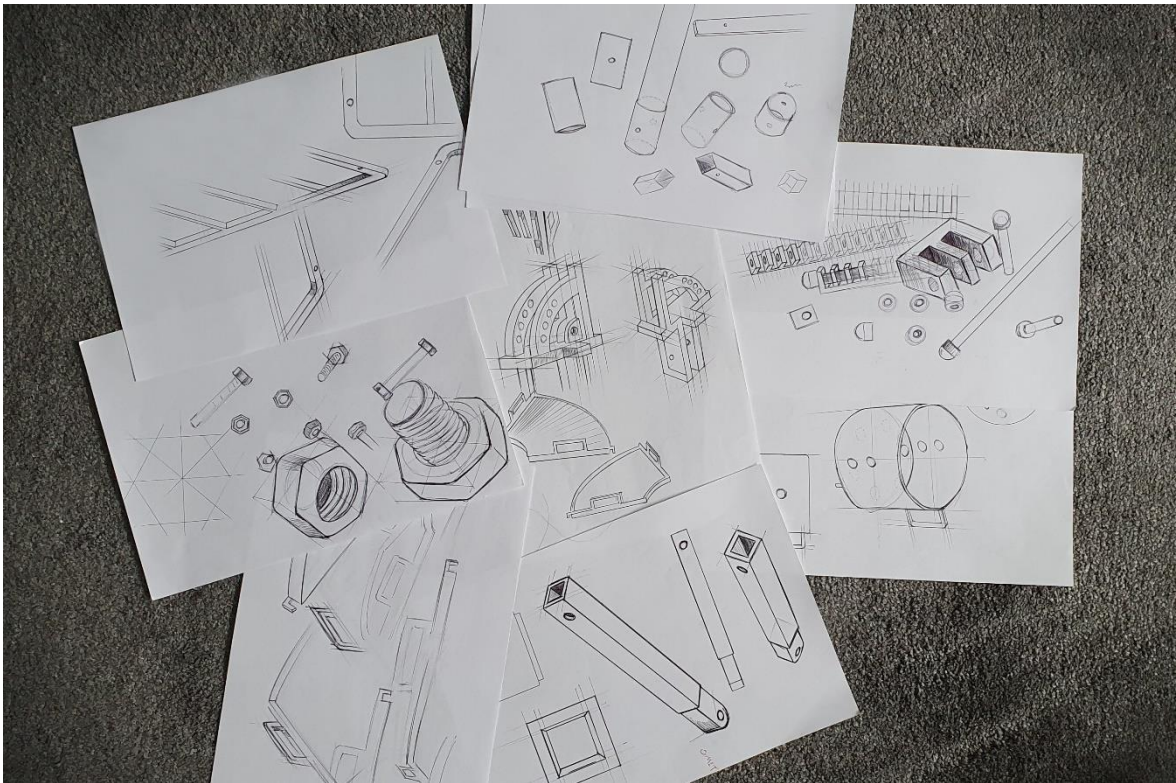


Figure 7. Sketches of the product

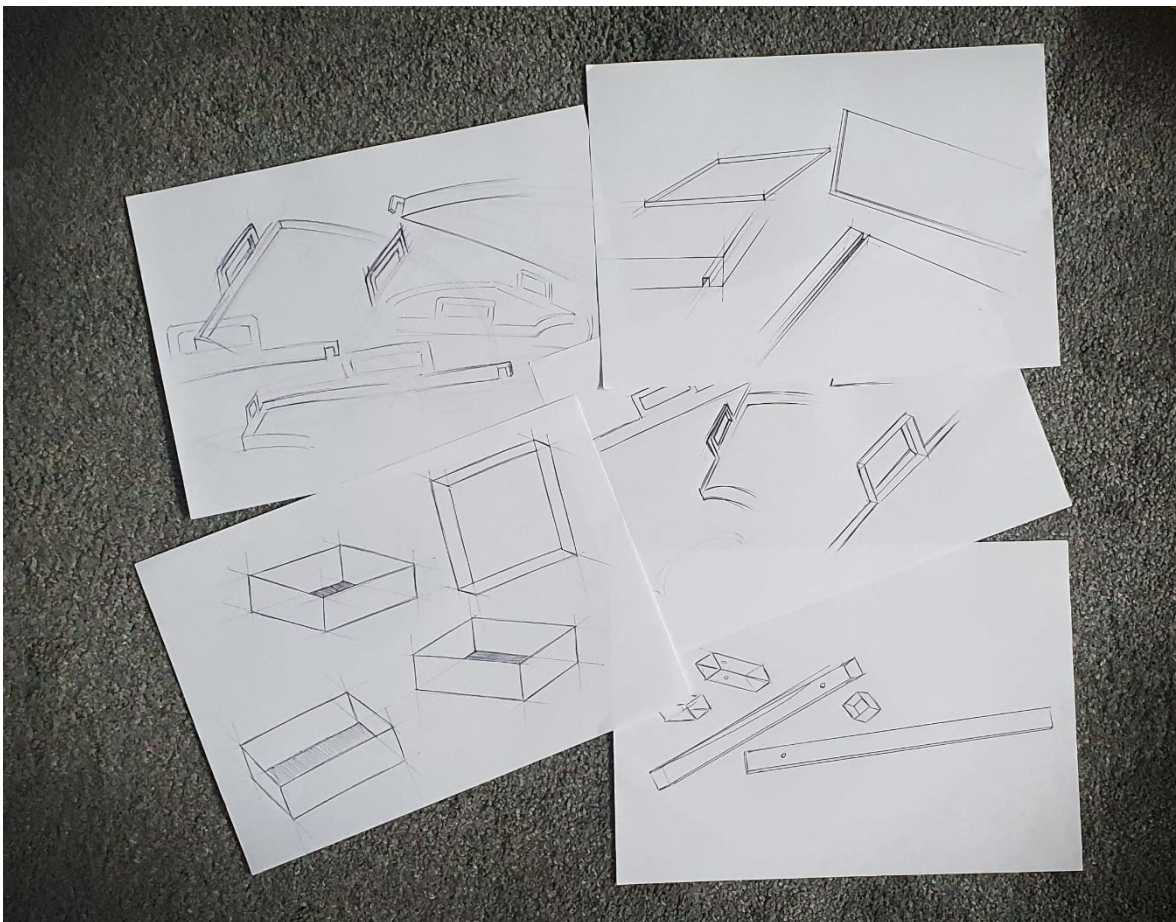


Figure 8. Early sketches

3.3 Early 3D

The original design of the charcoal barbecue was square and consisted of two grills and two griddles (Figure 9). There was no internal pit, and it was not portable.

However, since portability was crucial, the design undergoes a transformation from square to circular. This change enhanced the barbecue's portability, making it easier to transport.

Moreover, the circular barbecue facilitated social interaction. When everyone gathers around, there's no need to bend down to see friends, as the circular shape allows for better visibility.

The square barbecue presents challenges in visibility due to its angles, making it difficult to see someone sitting in line. This limitation prompted the shift towards a circular design.

Additionally, the circular barbecue offers practical advantages. It is easier to clean, eliminating the hassle associated with sharp edges that detract from its aesthetic appeal.

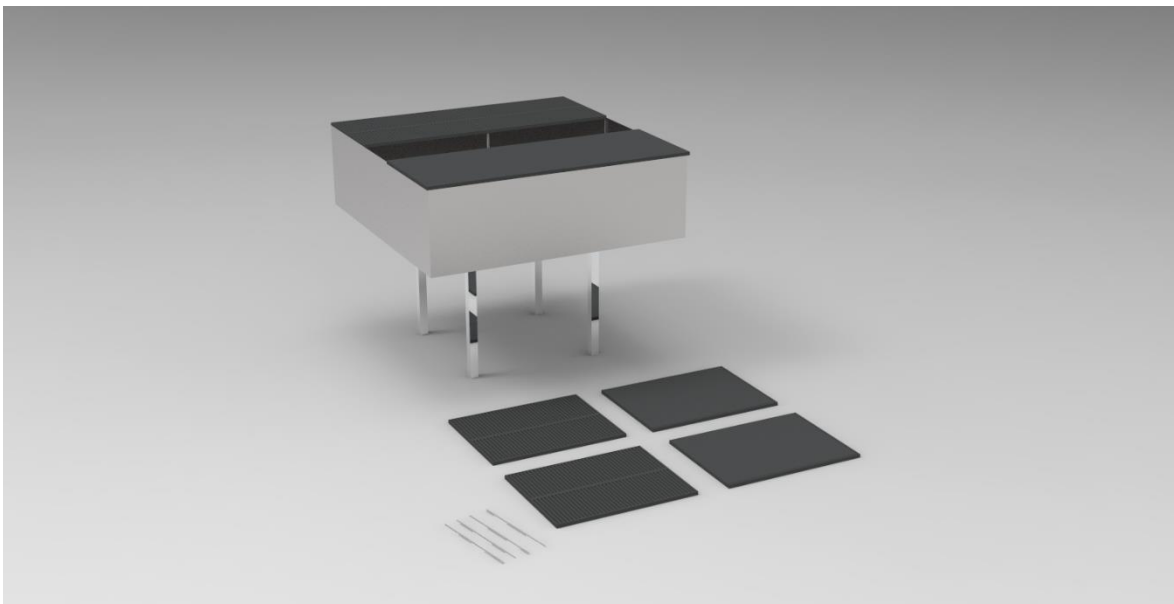


Figure 9. Initial 3D overview in SolidWorks

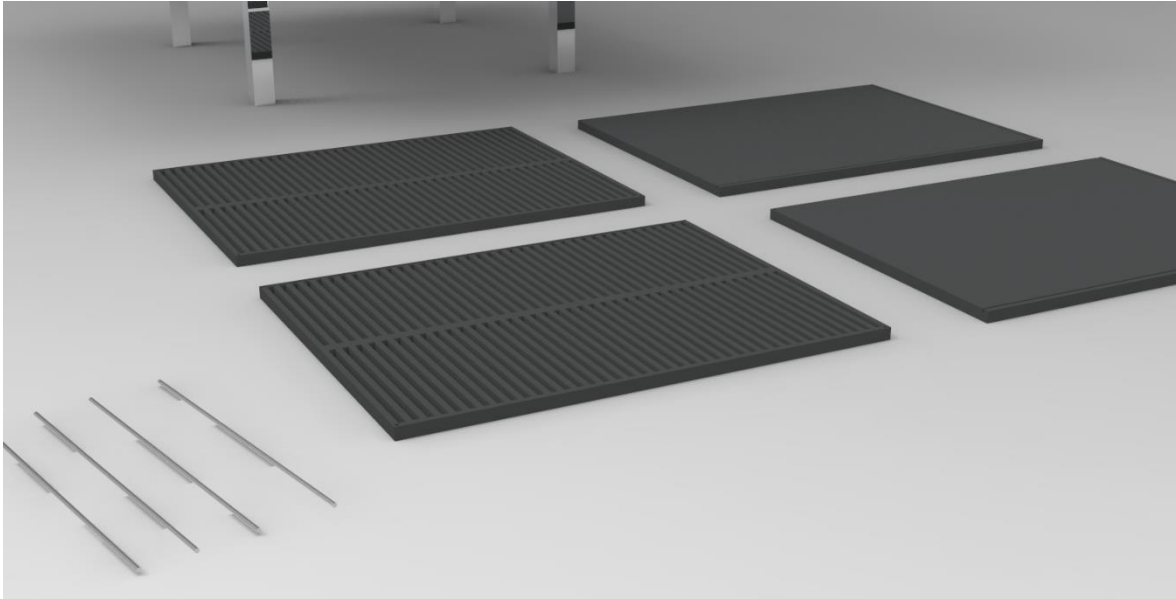


Figure 10. Initial view of grids and griddles with pins in SolidWorks

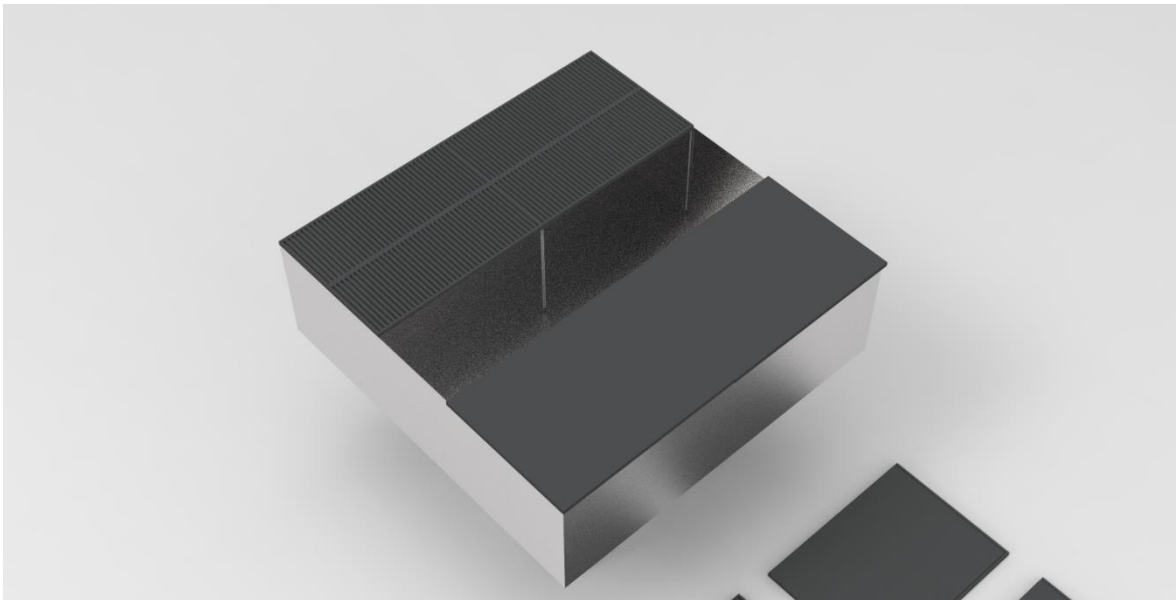


Figure 11. Initial 3D overview in SolidWorks

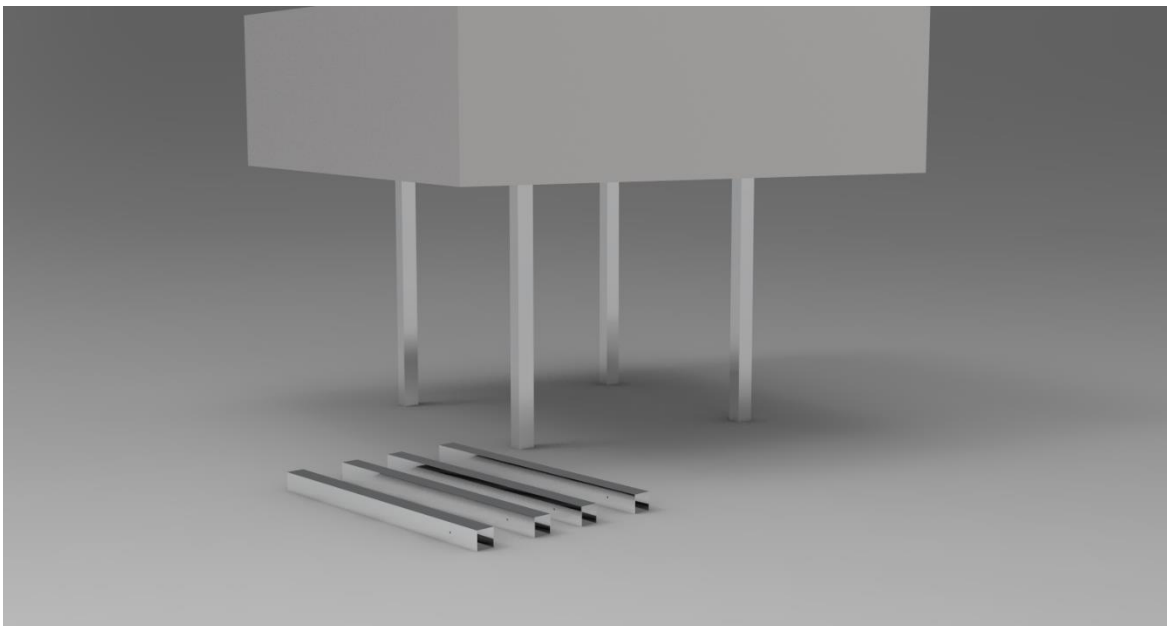


Figure 12. Initial 3D of the legs in SolidWorks

The initial development saw the barbecue taking on a round shape, yet the design remained a combination of round and square elements, resulting in an unappealing aesthetic with numerous sharp corners and angles (Figure 13). The handle featured a square profile, and a rather large stainless steel square profile was incorporated to connect the legs and handles to the main pit (Figure 14). This addition not only affected the product's weight but also increased material and manufacturing costs. Furthermore, unnecessary features such as square front legs and thicker, wider wheels were added (Figure 18).

The main pit's wall thickness was 10 mm, which contradicted one of the primary objectives of charcoal barbecues which was portability (Figure 17). The thick walls made the main pit excessively heavy and difficult to move (Figure 20). Similarly, the internal pit faced the same issue, with 70 mm legs that could extend higher than the main pit's wall, preventing the lid from closing properly (Figure 15). Additionally, the internal pit had only one handle, making it challenging to grasp, especially when hot or surrounded by charcoal.

The initial square shape of the handles on the cooking grill and griddle also posed aesthetic concerns (Figure 16)(Figure 19). Finally, the use of only one pin to connect the smoker holder to the main pit wall compromised security compared to having two pins.



Figure 13. Developed 3D overview of the product in SolidWorks

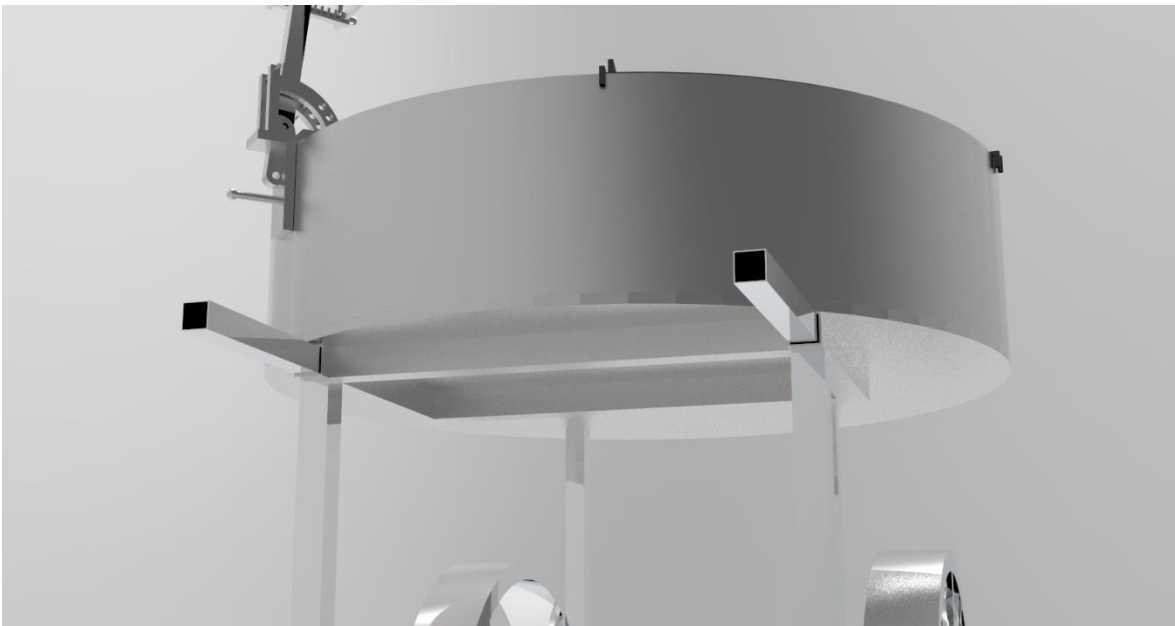


Figure 14. Initial view of the handles in SolidWorks

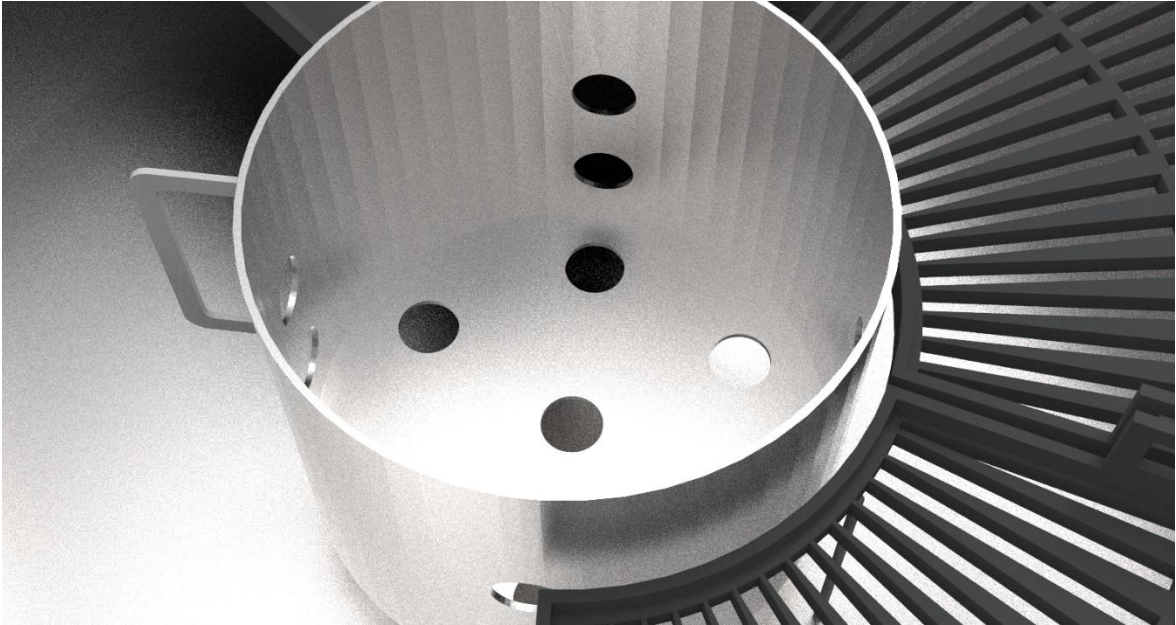


Figure 15. Initial view of the internal pit in SolidWorks

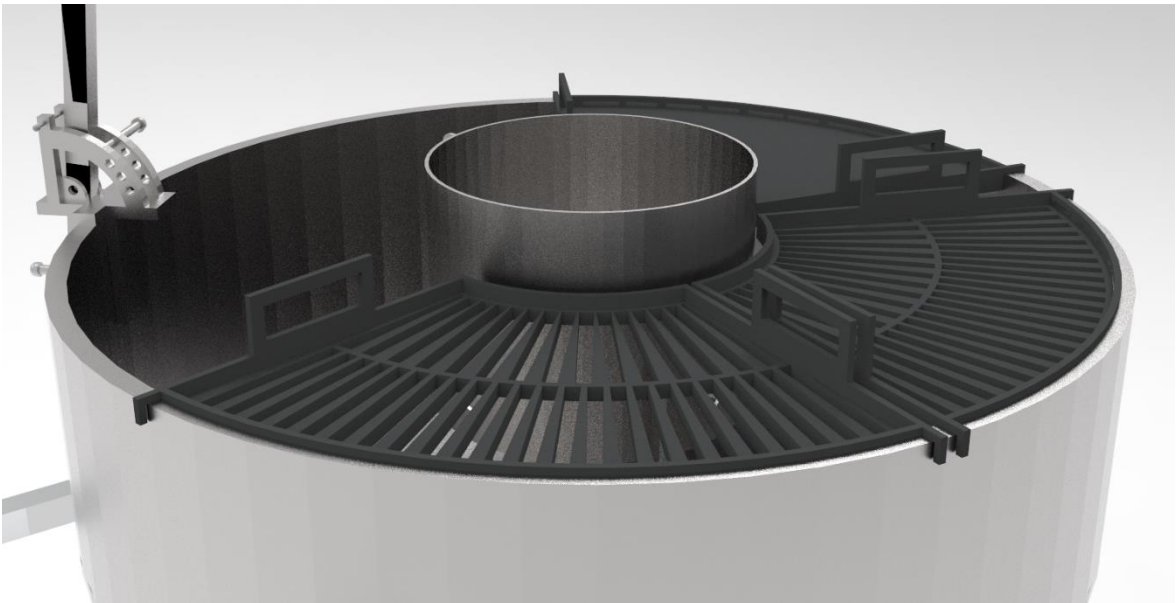


Figure 16. Initial view of the handles of grid and griddle in SolidWorks

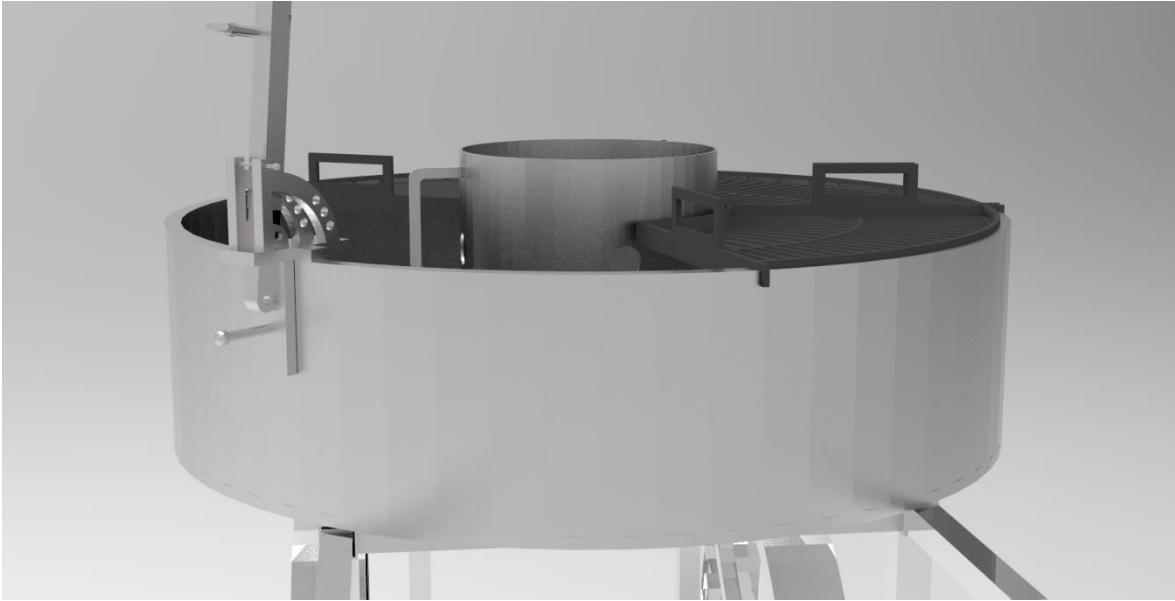


Figure 17. Initial view of the height of the main pit in SolidWorks

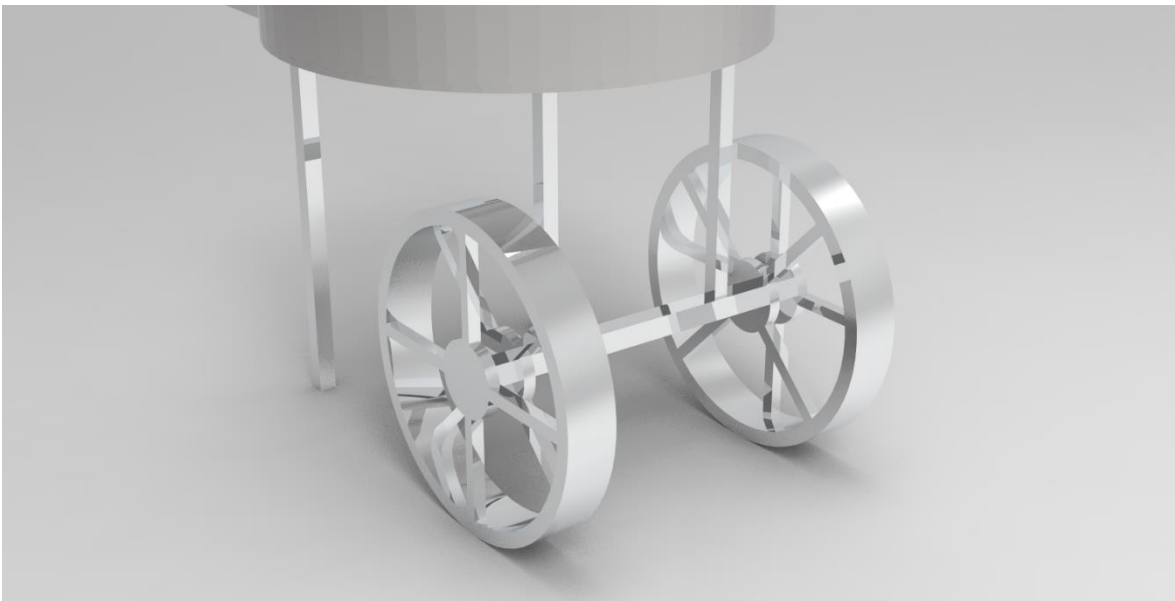


Figure 18. Initial view of the wheels in SolidWorks

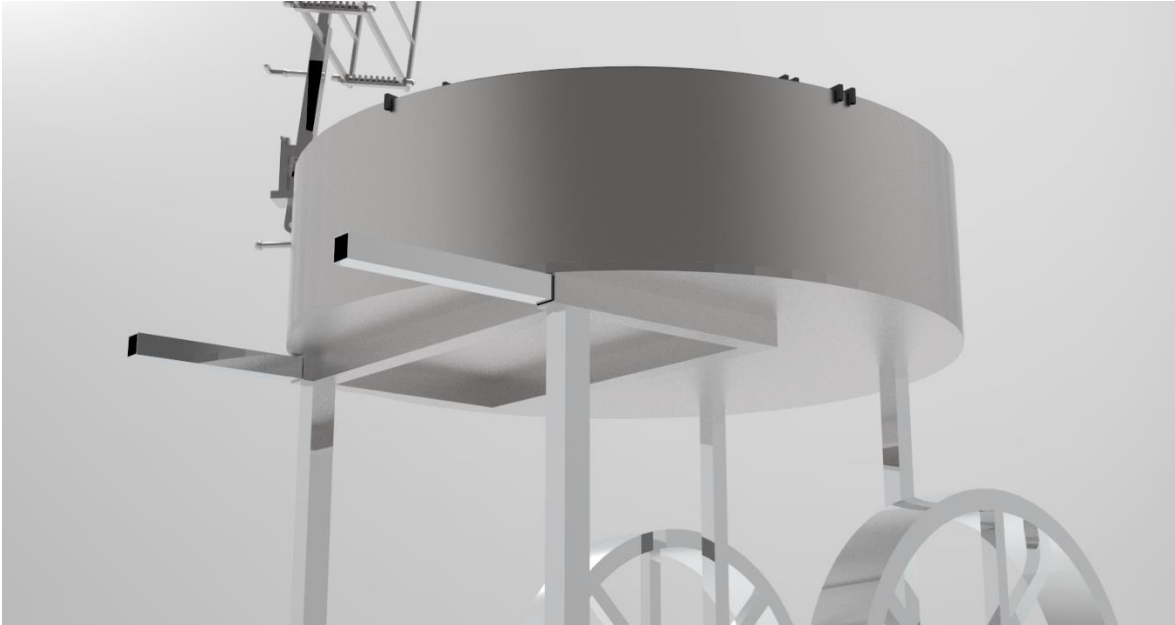


Figure 19. Initial view of the junction of the legs and handles in SolidWorks



Figure 20. Initial view of the thickness of the wall of the main pit in SolidWorks

4 Components

4.1 Main pit

In the quest to create the ultimate outdoor cooking experience, a novel fire pit/charcoal barbecue design was conceived and meticulously crafted. Crafted from resilient stainless steel, this innovative round-shaped fire pit/barbecue combines functionality with aesthetic appeal, offering a versatile platform for gathering family and friends to enjoy the art of grilling and smoking various meats and vegetables throughout the year. With a diameter of 800 mm and a height of 150 mm, this fire pit/barbecue is designed to foster a sense of togetherness and enjoyment, making it the perfect centerpiece for any outdoor gathering (Figure 22). The ideal distance between the charcoal and the meat on a charcoal barbecue depended on several factors, including the type of meat being cooked, the intensity of the heat, and personal preferences for cooking temperature and desired level of char or doneness.

A common guideline (zafill 2022.) suggested maintaining a distance of about 10 to 15 cm between the charcoal and the meat. This distance helped to ensure that the meat cooked evenly without burning or charring too quickly, allowing for proper heat distribution and control throughout the grilling process. Additionally, some grilling experts recommended (Russell, B. 2022.) adjusting the distance as needed during cooking to achieve the desired results for different cuts of meat or cooking techniques. Ultimately, experimentation and experience helped determine the best distance for achieving delicious and perfectly grilled meats. The design of round barbecues was chosen carefully, and the height of the barbecue was selected meticulously because it allows people to gather together in a circular shape, facilitating better social interaction as everyone can see each other. In contrast, square barbecues may require individuals to bend or reposition themselves to see others sitting parallel to them, potentially hindering socialization.

Additionally, two horizontal joints, located behind the rear leg joints, provide a convenient attachment point for the removable handle, facilitating easy transportation and maneuverability of the fire pit/barbecue. Similarly, for the anatomy of human hands, it was easier to get a circular profile than a square one (Figure 21). The round shape provided a more natural and comfortable grip, allowing for smoother and more efficient movement. This ergonomic design consideration was often taken into account when creating tools, utensils, and other objects intended for manual manipulation. Additionally, the circular profile offered greater versatility and adaptability to various hand sizes and shapes, further enhancing usability and user experience.

Overall, the preference for circular profiles over square ones was rooted in both functional and ergonomic considerations, making it a common choice in design practices.



Figure 21. Product overview compared to human size

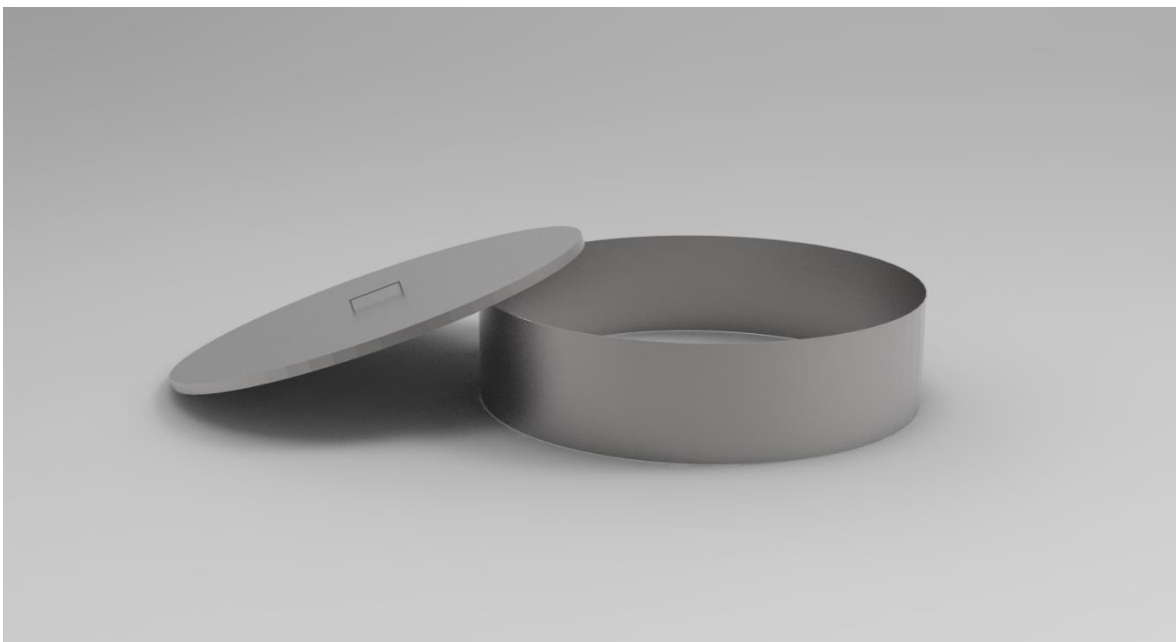


Figure 22. overview of the main pit with the lid in SolidWorks

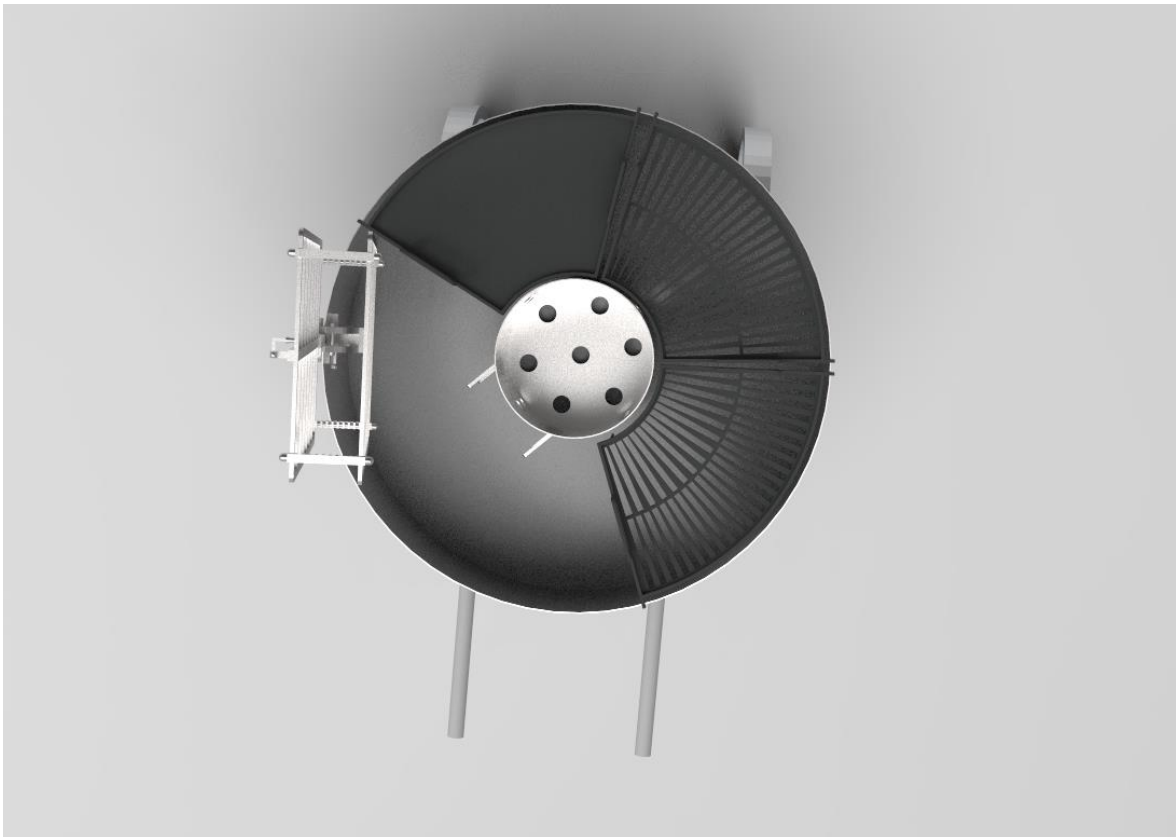


Figure 23. Top view of the product in SolidWorks

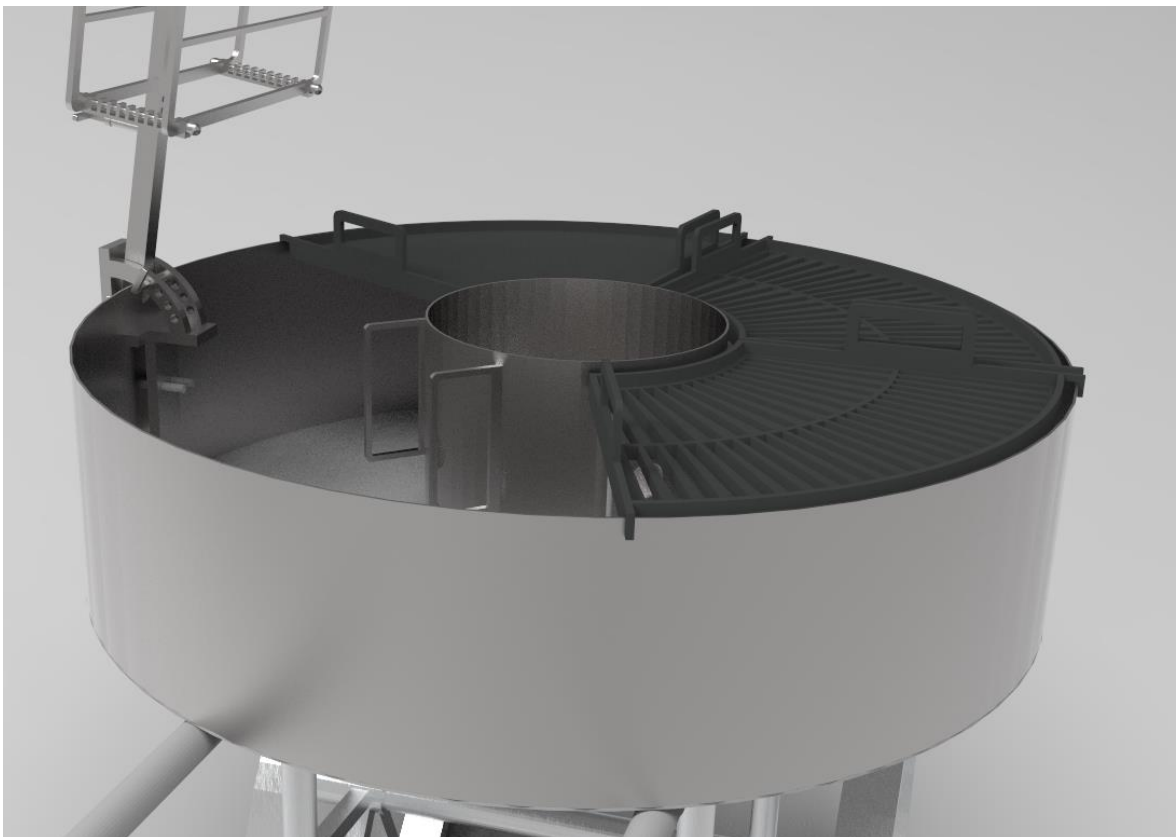


Figure 24. Developed the thickness of the wall and height of the product in SolidWorks

4.2 Internal pit

In the pursuit of enhancing the culinary experience, a stainless steel inner pit was designed and constructed with meticulous attention to detail. This inner pit, characterized by its cylindrical shape with a radius of 250 mm and a height of 190 mm, serves as a versatile tool for various cooking methods, including fire lighting, charcoal production, and smoking (Figure 25). To optimize airflow and facilitate the ignition process, strategic holes were installed both beneath the pit and along its walls, ensuring efficient oxygen intake and fire combustion.

Central to the design of this inner pit are the thoughtful additions aimed at enhancing usability and convenience. Four short legs, elevating the inner pit by 10 mm, were strategically positioned in the middle of the larger pit, providing stability and elevation for optimal cooking conditions. Additionally, the inclusion of two handles, measuring 120x10x5 mm each, further enhances the inner pit's functionality by facilitating easy mobility for the cook. These features collectively contribute to a seamless cooking experience, allowing for effortless movement and precise control over the cooking process.

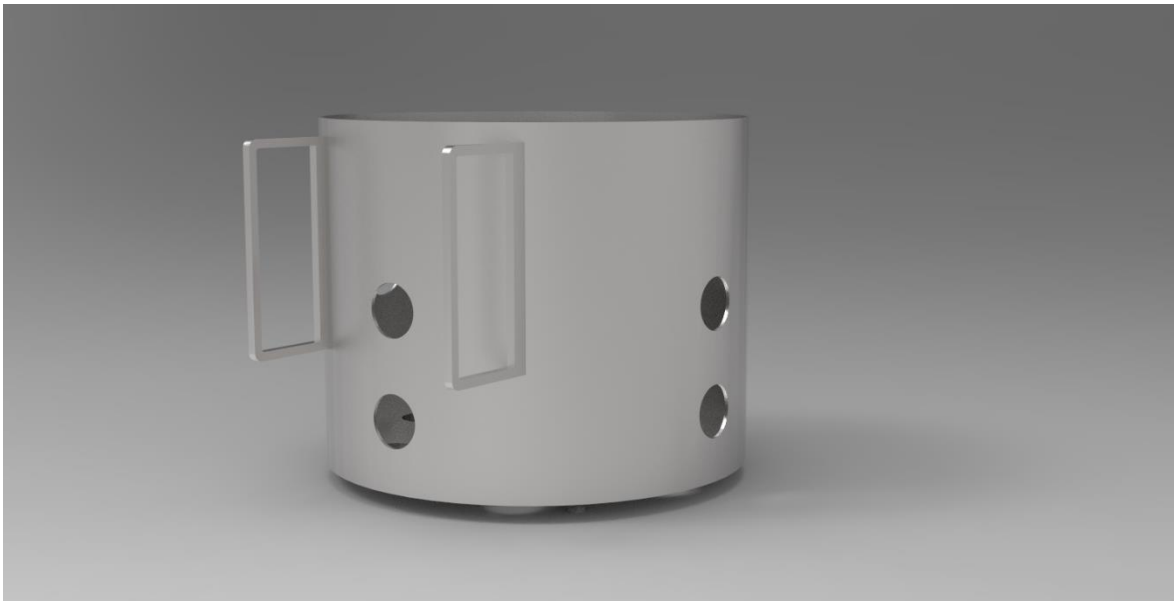


Figure 25. Developed overview of internal pit in SolidWorks

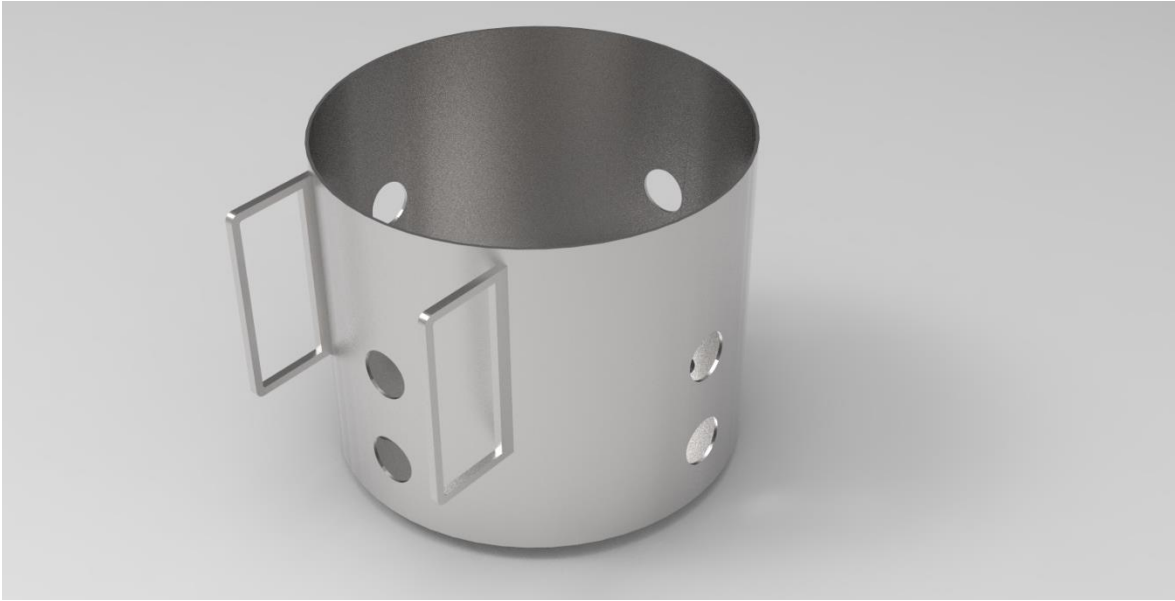


Figure 26. Developed overview of internal pit in SolidWorks

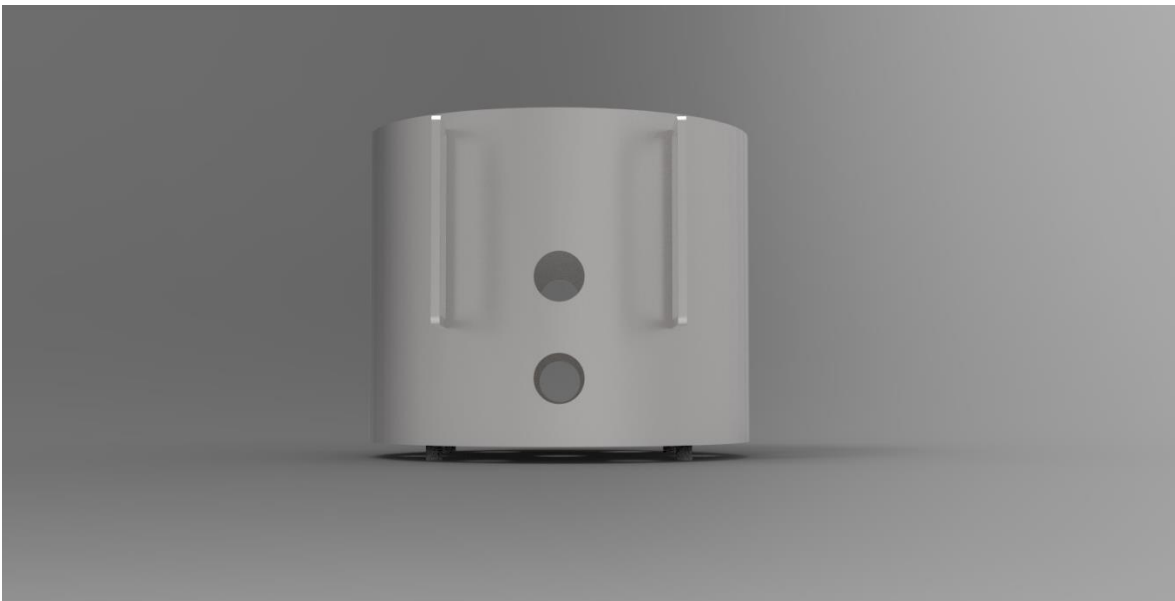


Figure 27. Developed overview of internal pit in SolidWorks

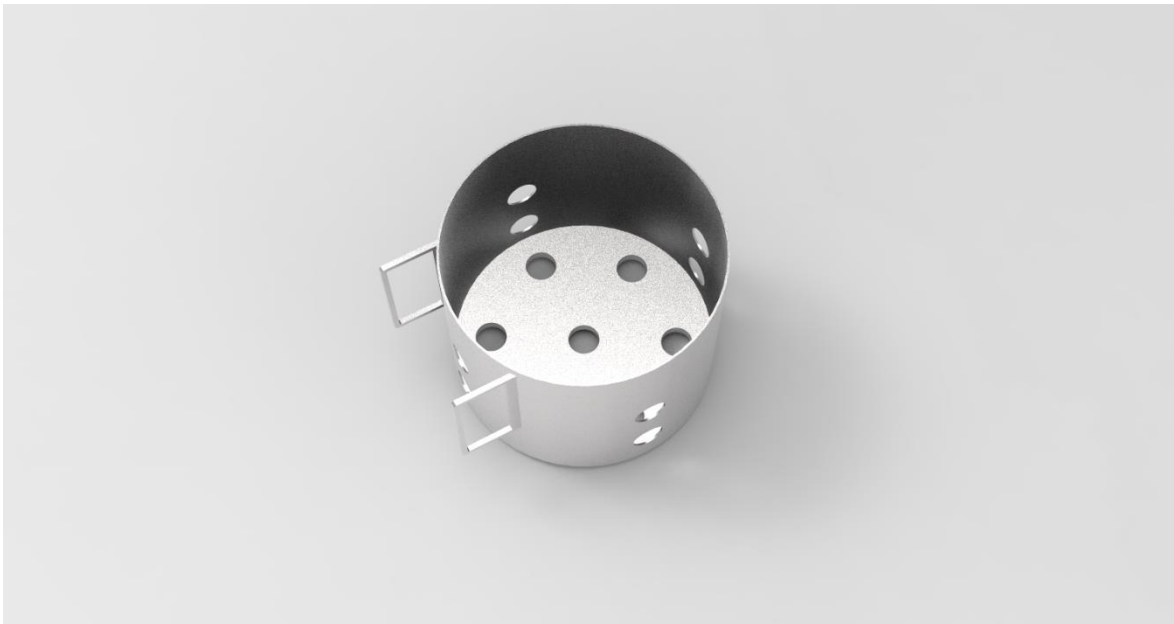


Figure 28. Developed overview of internal pit in SolidWorks

4.3 Lid

The design of a barbecue pit often involves careful consideration of not just its functionality during use, but also its practicality in storage and maintenance. In this regard, the incorporation of a lid with a height of two cm on the main pit serves a dual purpose in enhancing the overall user experience (Figure 29). Firstly, upon purchase, all the components necessary for assembly are neatly housed inside the pit, allowing for a convenient and hassle-free packaging experience. The lid serves as a key element in this process, providing easy access to the interior of the pit and ensuring that all parts are securely contained within.

Beyond its role in packaging and assembly, the lid on the main pit serves a crucial function in post-use maintenance and safety. Once the barbecue session is complete, placing the lid over the pit effectively seals off oxygen supply, extinguishing any remaining embers and reducing the risk of fire spreading. By preventing oxygen from entering the pit, the lid also minimizes the production of ash, ensuring that charcoal residue remains intact for the next use. This not only streamlines the cleanup process but also prolongs the lifespan of the charcoal, maximizing its efficiency and value. As consumers continue to seek out reliable and user-friendly outdoor cooking solutions, the incorporation of thoughtful design elements such as the lid on the main pit proves instrumental in meeting their needs and expectations.

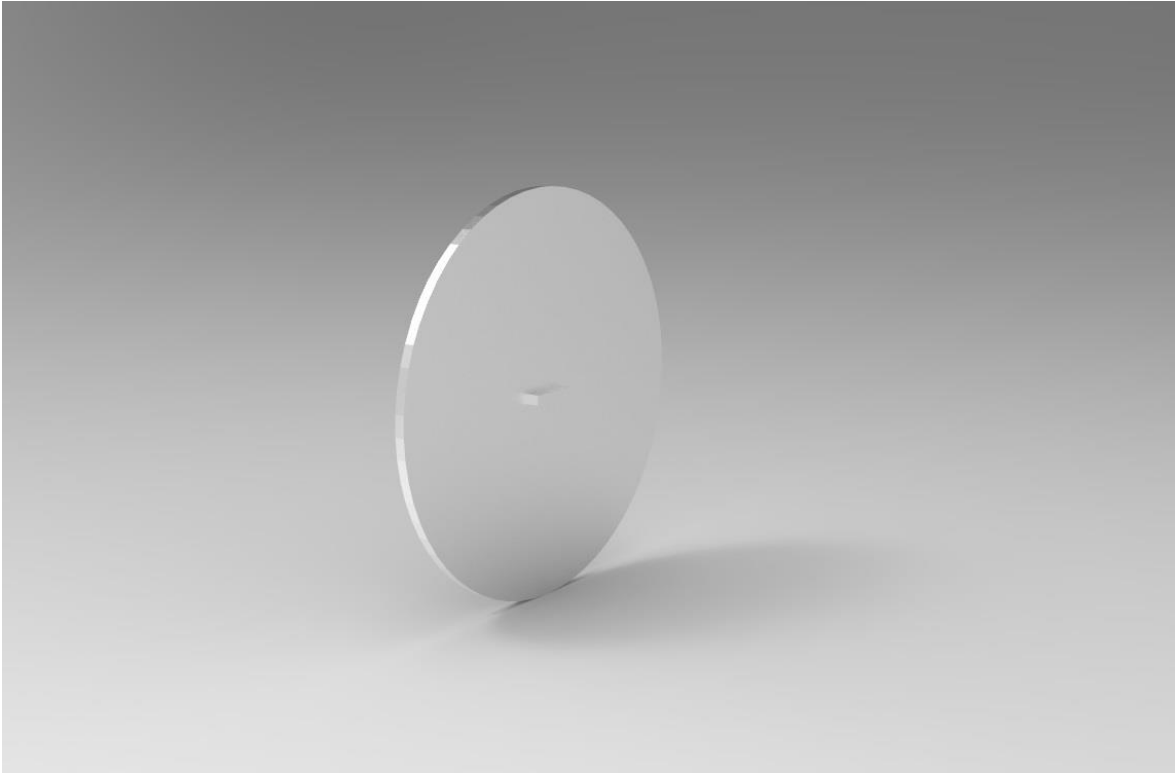


Figure 29. Developed overview of the lid in SolidWorks

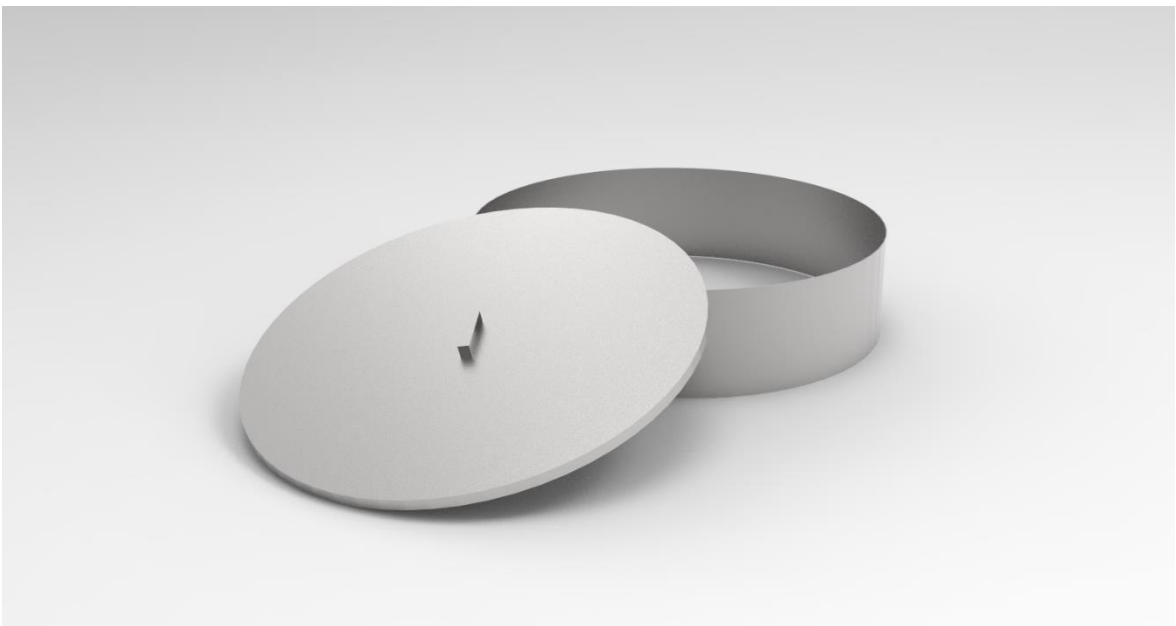


Figure 30. Developed overview of the pit and the lid in SolidWorks

4.4 Handles

The fire pit/barbecue is equipped with a removable handle made from durable aluminum. With a radius of 30 mm and a thickness of 2 mm, this handle offers a comfortable grip for users, enhancing the overall user experience. Measuring 440 mm in length, the handle can be easily inserted into the two horizontal joints, providing a practical solution for lifting and moving the fire pit/barbecue as needed (Figure 31). The first design of the handles was made of square aluminium profile, but due to the sharpness of the handles and the incompatibility of the square design with the circular barbecue, it was changed to a round profile. Similarly, for the anatomy of human hands, it was easier to get a circular profile than a square one. The round shape provided a more natural and comfortable grip, allowing for smoother and more efficient movement. This ergonomic design consideration was often taken into account when creating tools, utensils, and other objects intended for manual manipulation. Additionally, the circular profile offered greater versatility and adaptability to various hand sizes and shapes, further enhancing usability and user experience.

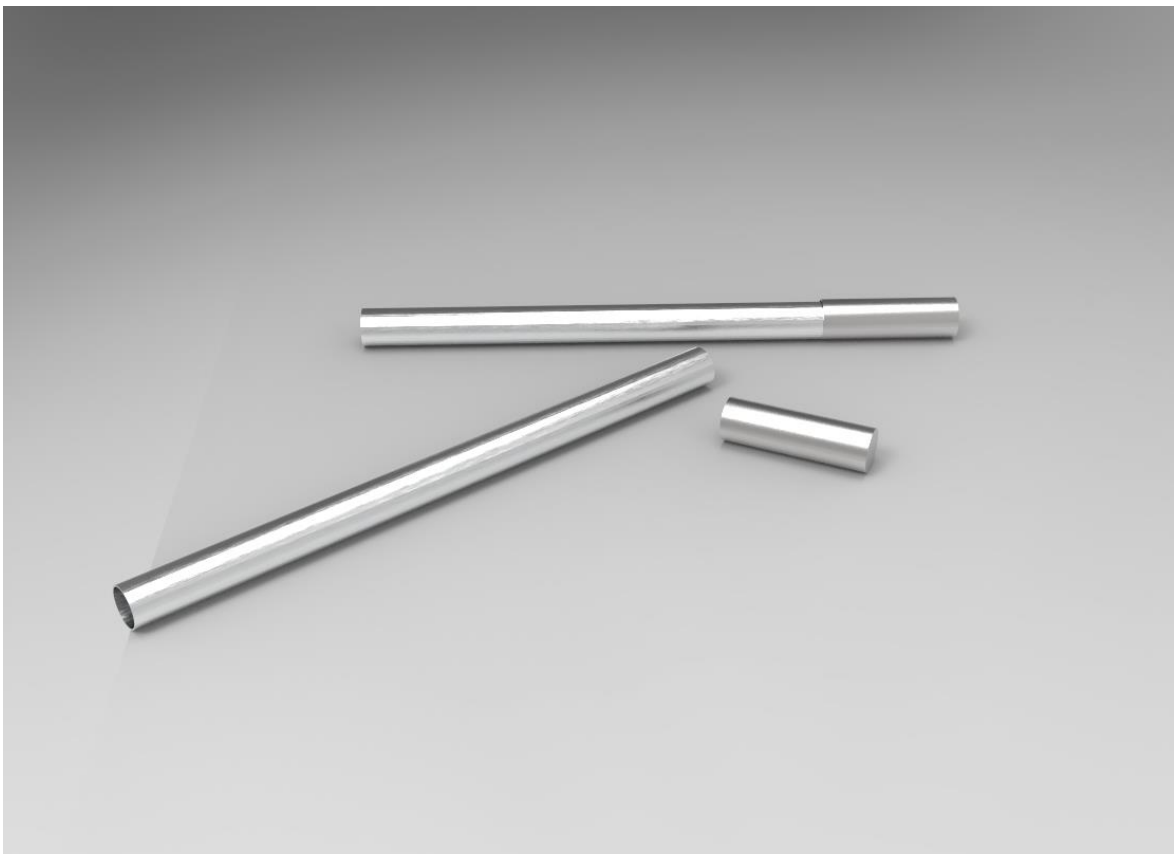


Figure 31. Developed overview of the handles and connectors in SolidWorks

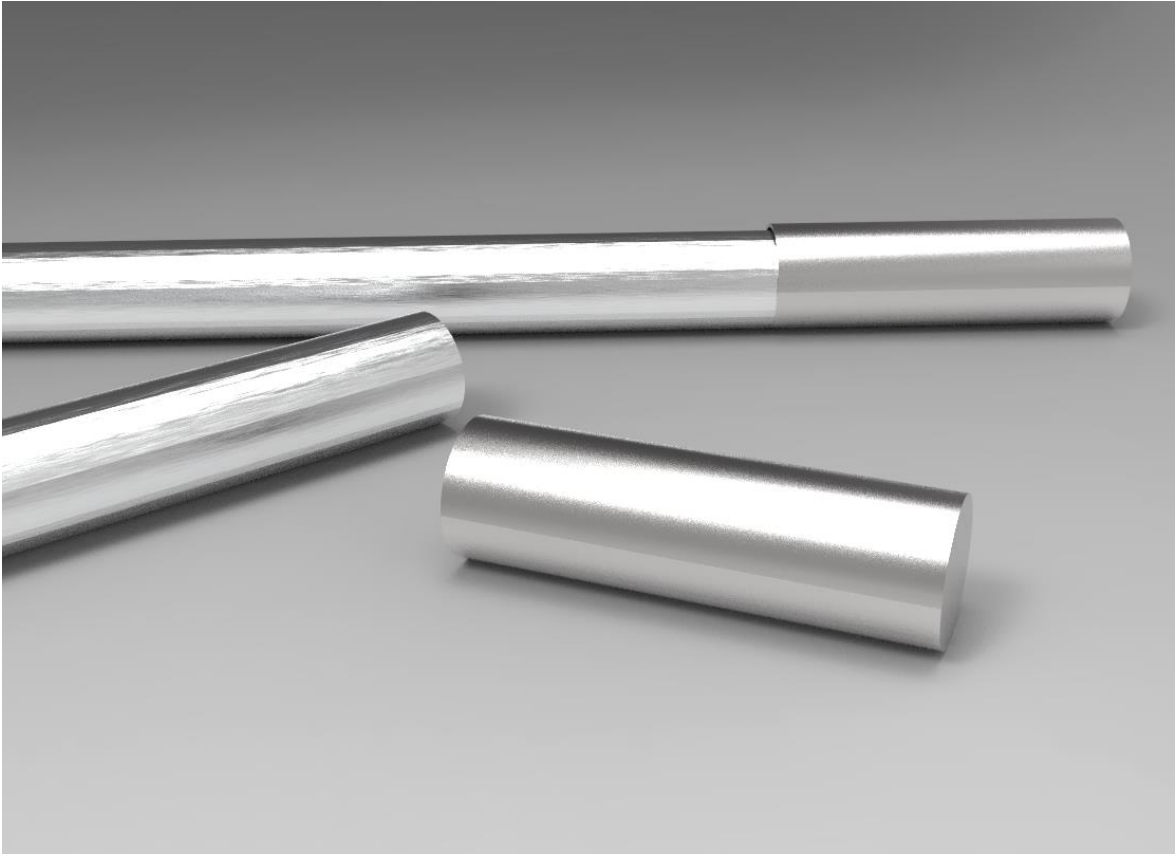


Figure 32. Closer view of the handles and connectors in SolidWorks

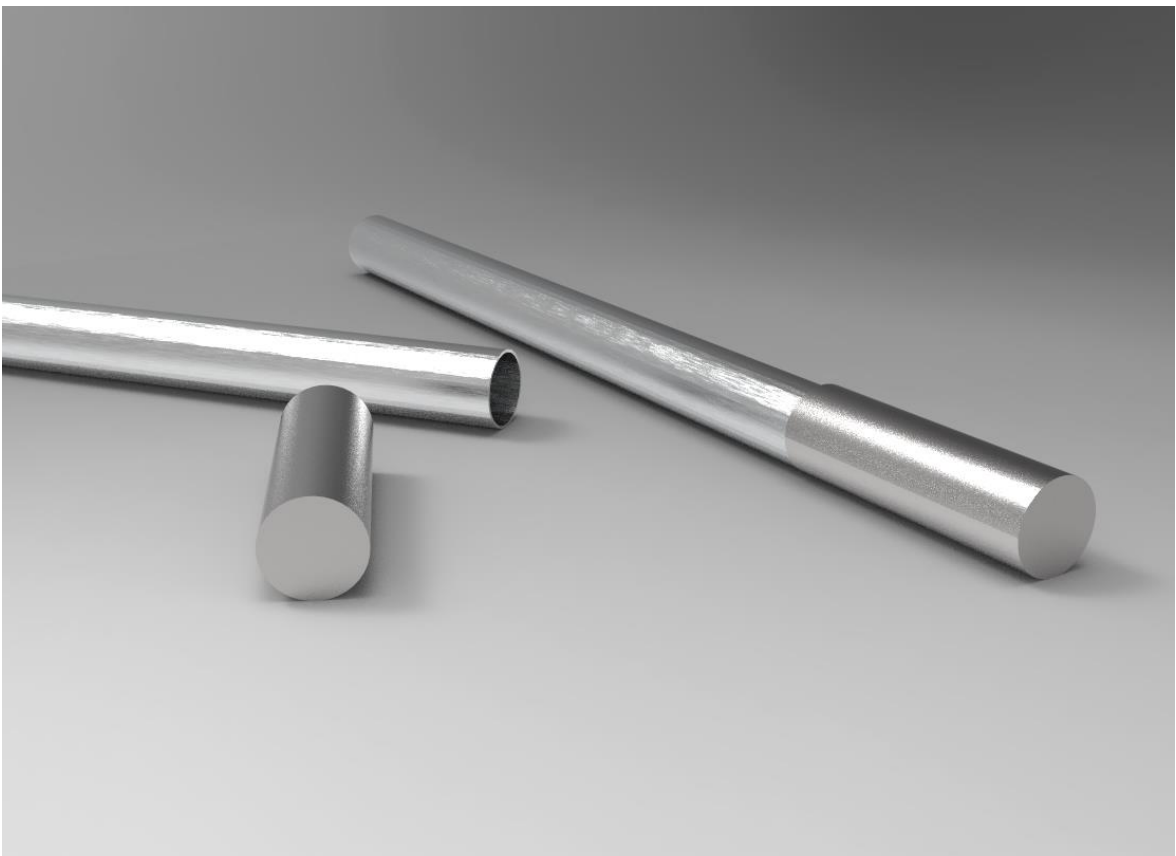


Figure 33. Closer view of the handles and connectors in SolidWorks

4.5 Cooking grid and griddle

In the creation of the firepit/charcoal barbecue, special attention was given to the design and functionality of the cooking grid and griddle. These essential components serve as the platform for grilling, providing a sturdy surface for culinary endeavors over an open flame (Figure 34). The aim was to develop a cooking grid and griddle that not only facilitated efficient grilling but also ensured stability and ease of use.

To achieve this, the cooking grid and griddle were equipped with two small handles, strategically positioned on the right and left side (Figure 35). These handles were meticulously designed to offer the chef a comfortable grip, allowing for effortless maneuvering of the grid as needed. Whether adjusting the position of the grid/griddle to control heat distribution or simply accessing different areas of the cooking surface, these handles proved to be invaluable tools for culinary precision.

Beneath the cooking grid and griddle, two legs were incorporated, each with a diameter of 5 mm (Figure 36). These legs played a crucial role in securing the grid and griddle to the surface of the firepit/charcoal barbecue, preventing any risk of it dislodging or falling during use. The decision to use legs of this size was based on the need for a balance between strength and subtlety, ensuring a solid connection without adding unnecessary bulk to the design. The difference between griddle and grid

Grids are usually made of metal rods or bars arranged in a grid pattern. This setup allows food to be directly exposed to the heat source, leading to the formation of grill marks and a charred exterior. It's an ideal method for grilling meats, vegetables, and seafood over an open flame or hot coals.

Additionally, the grid typically has perforations that serve an important purpose. These openings allow juices and fats from the cooking food to drip away. As they fall onto the heat source, they create a smoky flavor that enhances the taste of the grilled items. Moreover, the removal of excess fats helps prevent flare-ups, ensuring a more controlled and enjoyable grilling experience.

A griddle is typically a flat, solid cooking surface, commonly crafted from materials like metal, such as cast iron or stainless steel, or non-stick coatings. This design offers a large, smooth area perfect for cooking a variety of foods, ranging from pancakes and eggs to bacon and burgers.

One of the key advantages of a griddle is its ability to provide even heat distribution and precise temperature control across the entire cooking surface. This ensures that every part of the food cooks evenly, resulting in consistent and delicious results.

Moreover, a griddle is particularly suitable for cooking foods that require uniform heating without direct exposure to flames. This includes techniques like frying, sautéing, and searing, where maintaining a steady temperature is crucial for achieving the desired texture and flavor. Whether you're whipping up a hearty breakfast or preparing a savory dinner, a griddle offers versatility and reliability for a wide range of culinary tasks.

In summary, while both cooking grids and griddles are used for outdoor cooking, they serve different purposes and offer distinct cooking experiences based on their design and functionality.

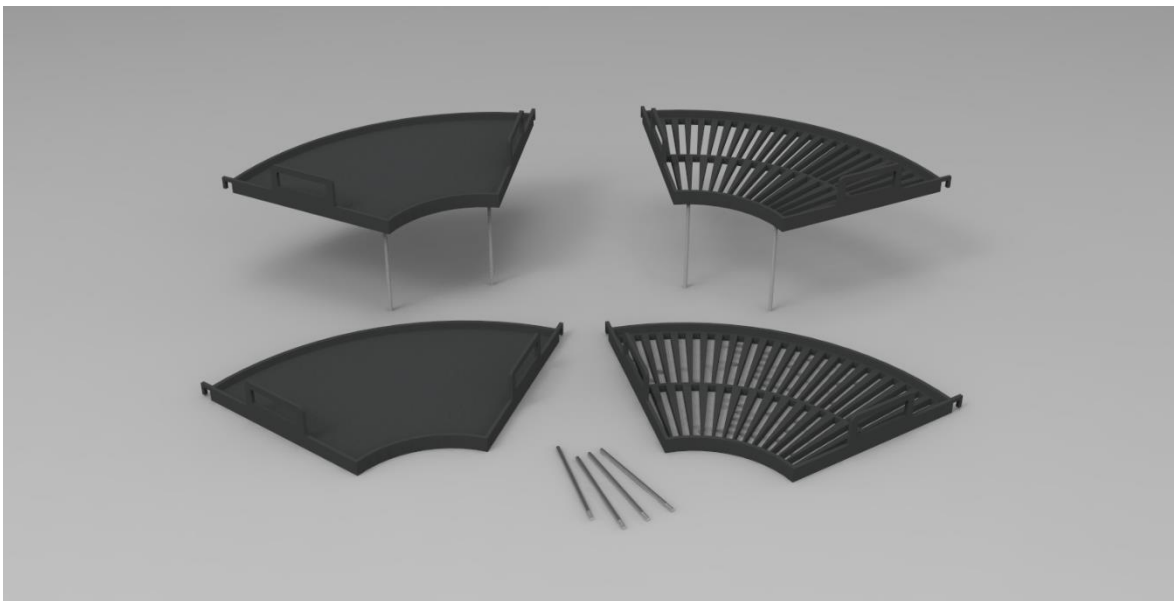


Figure 34. Developed overview of the grid and griddle and shafts in SolidWorks

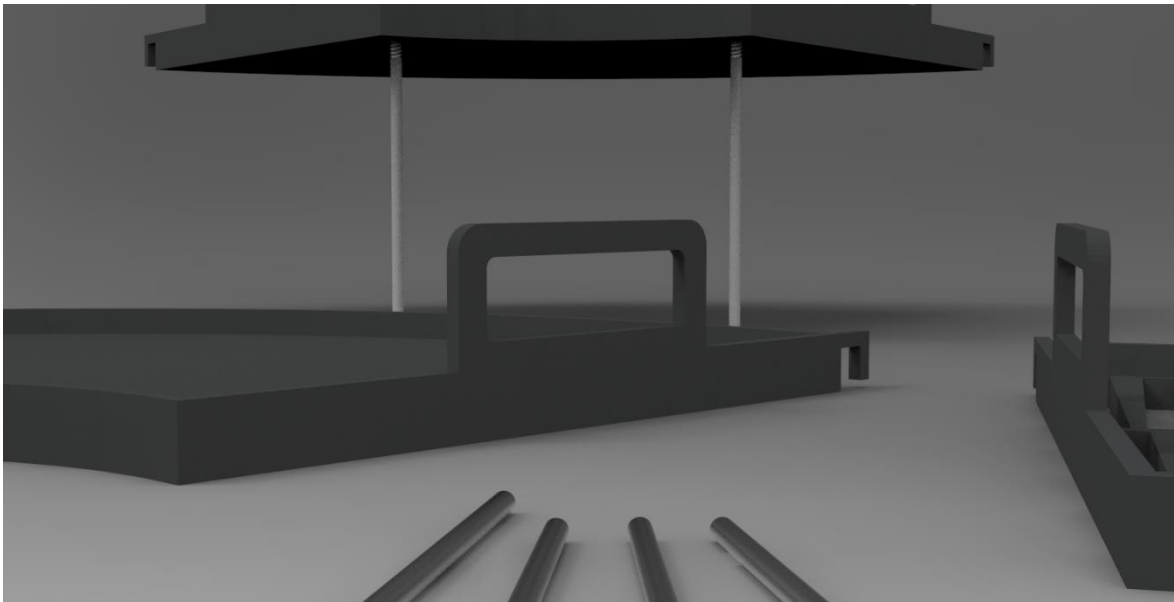


Figure 35. Closer view of the griddle and the shafts in SolidWorks

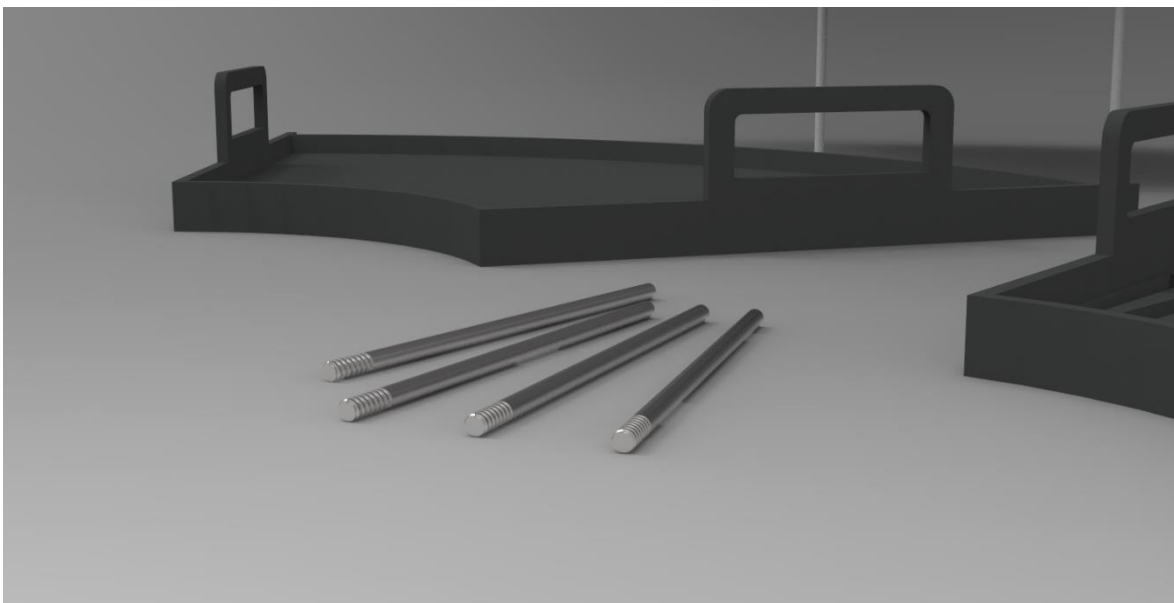


Figure 36. Closer view of the grid and the shafts in SolidWorks

4.6 Smoker grid and smoker mesh

In the creation of the firepit/charcoal barbecue, meticulous attention was paid to every detail to ensure an unparalleled grilling experience. Central to this design was the smoker grid, crafted from high-quality stainless steel, offering both durability and functionality (Figure 37). Its unique shape boasted a wide gap between the grids, strategically engineered to accommodate large pieces of meat and vegetables, allowing for thorough smoking and grilling.

The innovative connection mechanism between the two pieces of the smoker grid set this design apart. Utilizing a combination of a grill comb and pins, cooks were empowered to adjust the gap between the grids according to the thickness of the meat (Figure 38). With help of eight pins, strategically positioned to accommodate two types of grid combs, four for the small comb and four for the large comb. Crafted from durable stainless steel, these pins provide a secure and sturdy connection between the grid combs and the smoker grid/mesh, ensuring optimal performance during smoking sessions.

With the small comb measuring 28 mm to 5 mm and the large comb measuring 96 mm to 5 mm, this charcoal grill offers versatility and precision in smoking various types of meat, fish and vegetables. This dynamic feature provided flexibility and control, ensuring optimal cooking results for a variety of culinary creations.

Adding to its versatility, the handle of the smoker grid featured nine strategically placed holes, each with a diameter of 5 mm. These holes allowed cooks to adjust the distance between the meat and the heat source, enabling precise temperature control and customization of the grilling process. Additionally, an 8 mm L-shaped hook in the upper part of the grid, paired with a specialized ring mechanism, facilitated easy maneuvering of the grid, even when it was hot, enhancing safety and convenience for the user. A 50 cm long and 2.5 mm thick stainless steel stick with rings on both ends was used for this part. One end had a 15 mm ring while the other end had a 30 mm ring. The 15 mm ring was hooked to the L-shape of the smoker grid/mesh, and the cook held the other ring in his hand/finger. With the assistance of this stick, after cooking, the cook could pull the smoker grid/mesh toward him while it was still hot.

The smoker mesh was the same size as the smoker grid, but the only difference between the two was that the smoker mesh was for very thin and tiny pieces of meat and vegetables, and it had a mesh shape (Figure 39). The gap was not as big as the smoker grid (Figure 40). The smoker mesh provided better support for delicate pieces of food due to its smaller gaps, preventing them from falling through during cooking/smoking. This adjustment allowed for more versatility in grilling various types of food on the smoker.

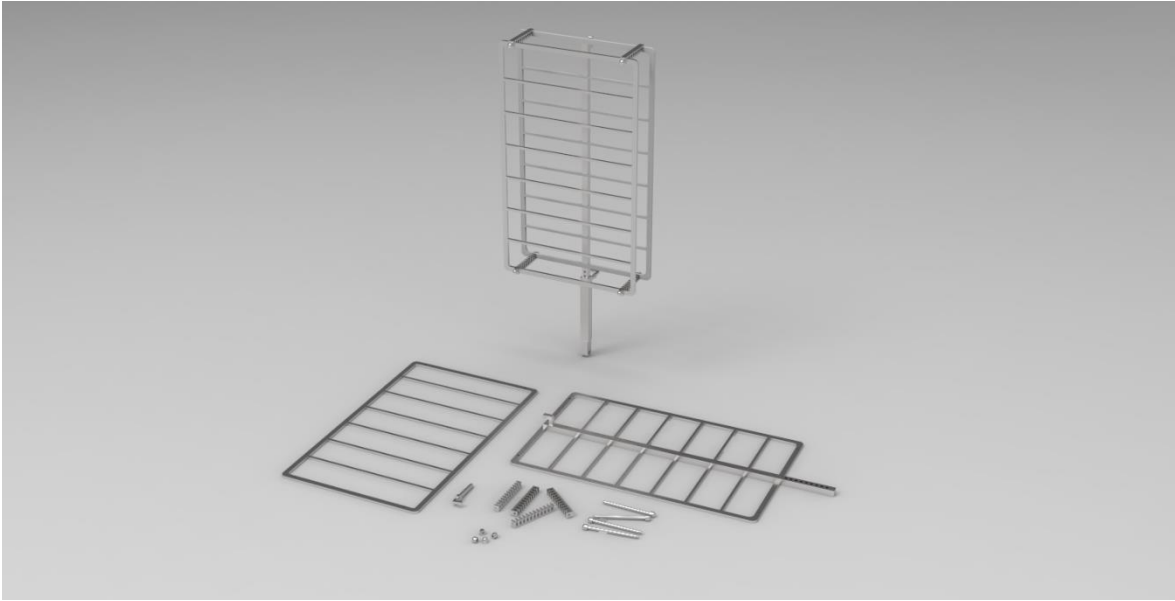


Figure 37. Overview of the smoker grid and all its connectors in SolidWorks

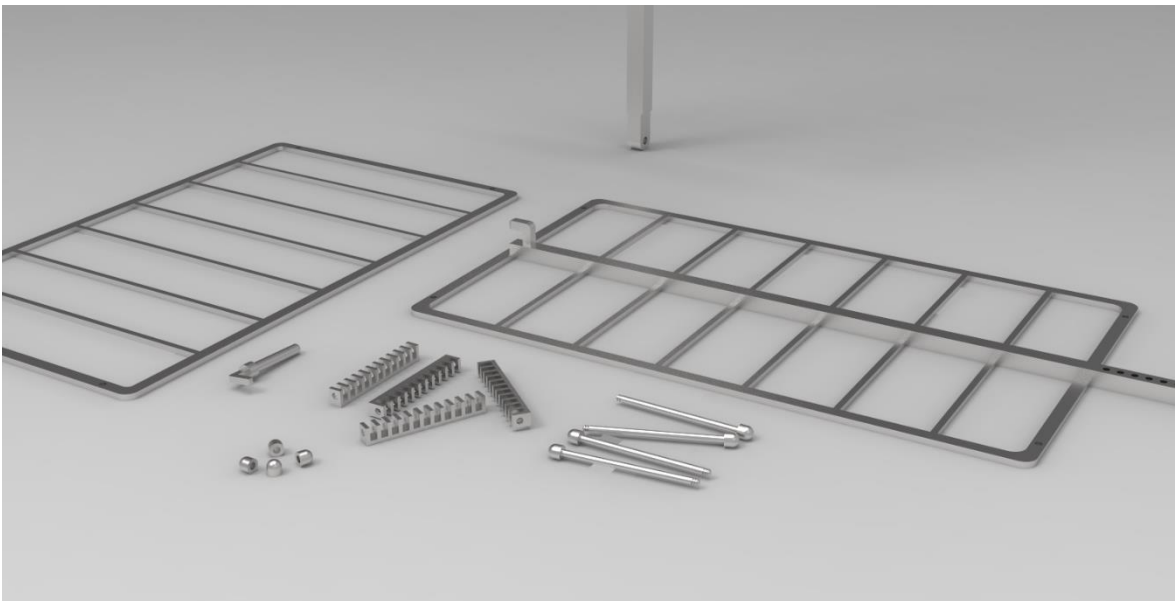


Figure 38. Closer view of the smoker grid and all its connectors in SolidWorks

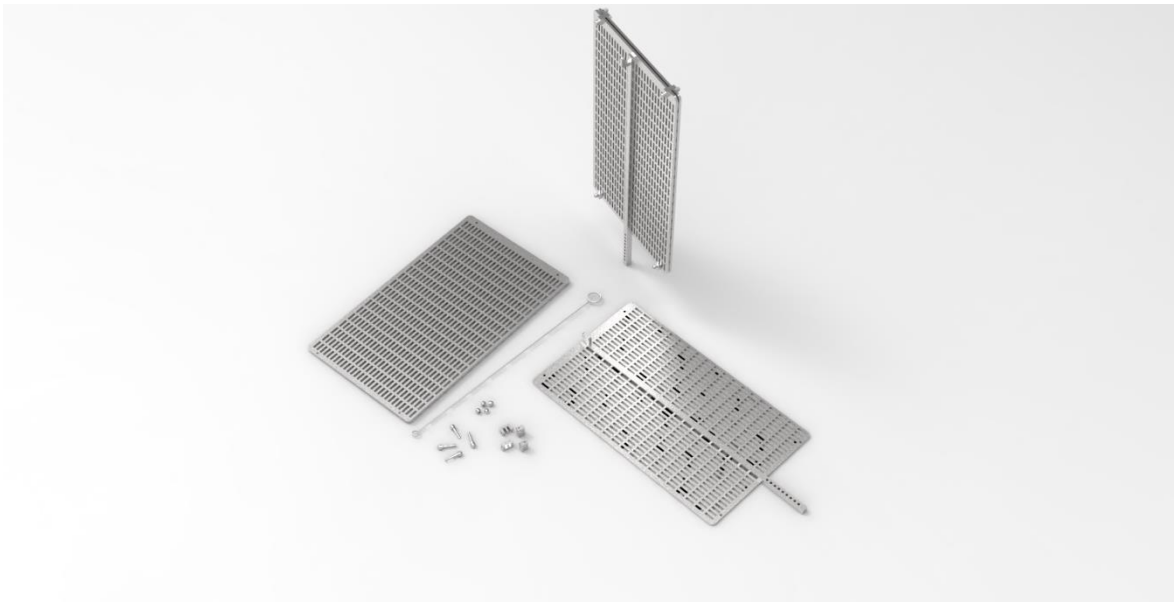


Figure 39. Overview of the smoker mesh and all its connectors in SolidWorks

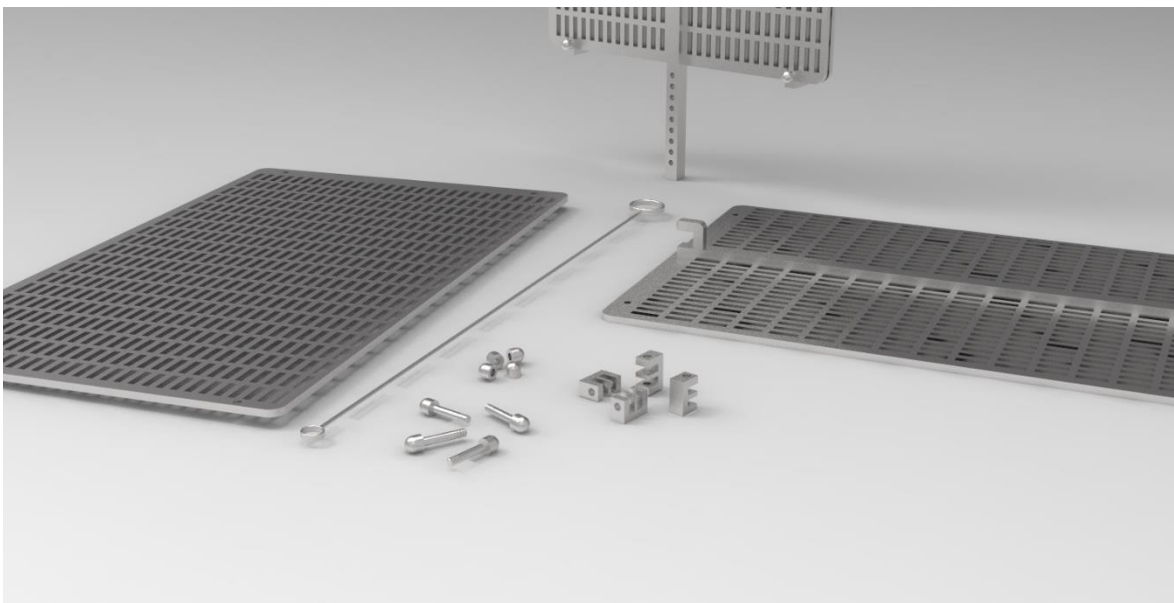


Figure 40. Closer view of the smoker mesh and all its connectors in SolidWorks

4.7 Small and big smoker combs with shaft

In the pursuit of culinary perfection, a revolutionary smoker grid design was conceived and meticulously crafted. Constructed from durable stainless steel, this innovative smoker grid is engineered to elevate the smoking experience for both meat and vegetable enthusiasts alike. Divided into two distinct pieces, the smoker grid offers enhanced flexibility, allowing cooks to tailor the smoking process to their specific preferences and culinary creations.

Central to the design of this smoker grid are the strategically positioned grill combs, ingeniously placed between the two grid pieces (Figure 41). These grill combs serve a dual purpose, not only dividing the smoker grid but also providing the means for adjustable gap settings. By simply adjusting the position of the grill comb, cooks can customize the gap between the grid pieces to accommodate a wide range of food items, from small cuts of meat to hearty vegetables. The smoker grid is equipped with two types of grill combs, each designed to cater to different grilling needs.

The small grill comb measures 28 mm by 5 mm, with three teeth spaced 5 mm apart, suited grilling smaller and thinner pieces, while the large grill comb measures 96 mm by 5 mm, boasting more teeth, accommodated thicker and larger items (Figure 42). Additionally, eight 5 mm diameter shafts, four short and four long, ensured secure connection of the grill combs to both the smoker mesh and grid. Both combs are secured to the smoker grid using 10 mm nuts. These specialized grill combs ensure optimal heat distribution and airflow, resulting in perfectly smoked delicacies every time.

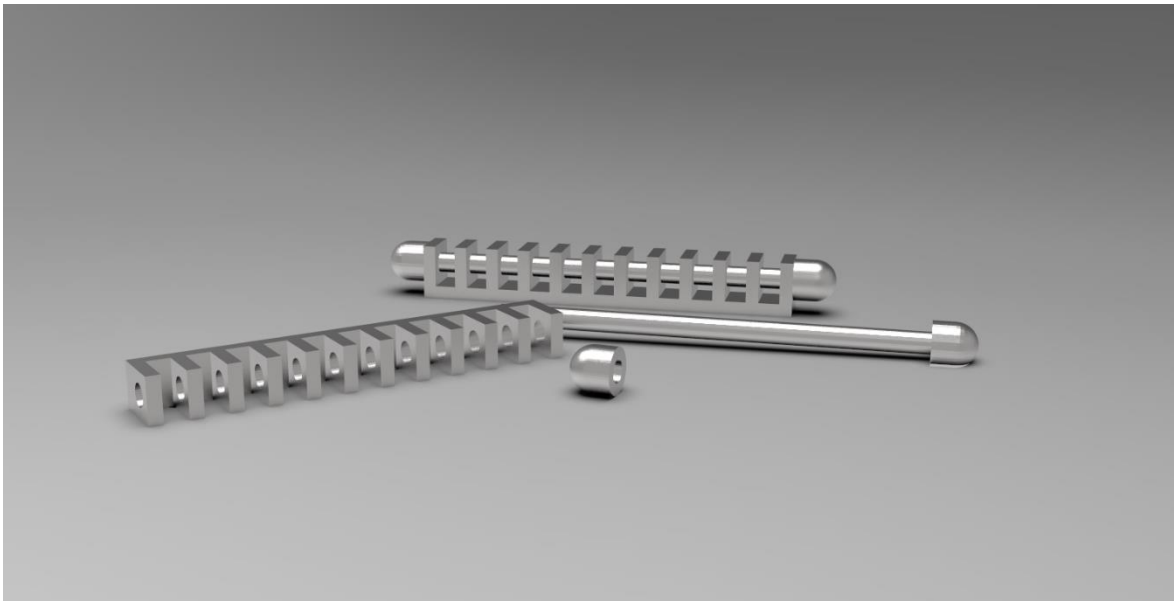


Figure 41. Overview of the big comb and its bolts and nuts in SolidWorks

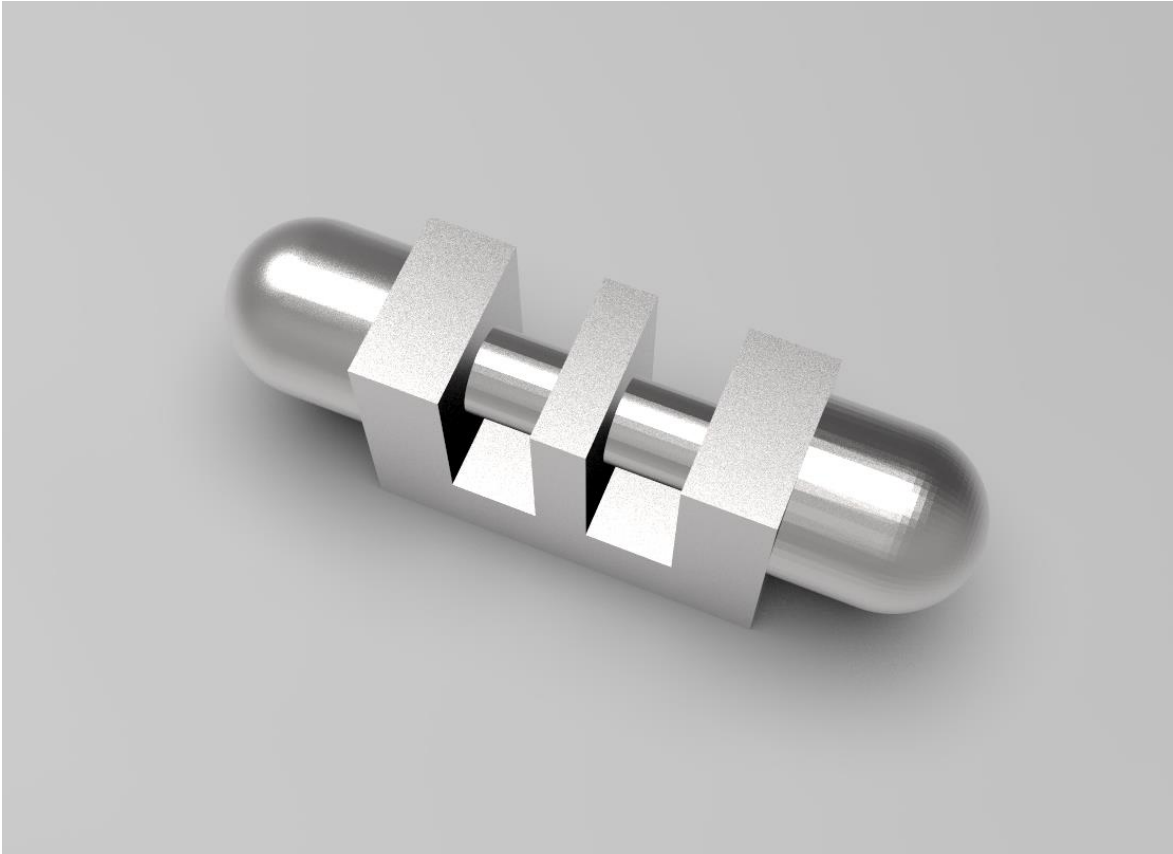


Figure 42. Overview of the small comb and its bolt and nut in SolidWorks

4.8 Smoker holder

In designing the firepit/charcoal barbecue, a primary goal was to create a versatile cooking experience that catered to the needs of grilling enthusiasts. The round shape of the firepit/charcoal barbecue provided a centralized cooking area, conducive to even heat distribution and optimal grilling conditions. To enhance functionality, a smoker holder was ingeniously crafted from stainless steel, serving as a pivotal link between the smoker and the main body of the grill.

The smoker holder featured a unique design, characterized by two 8 mm thick and 50 mm long pins, securely fastened to the wall of the firepit/charcoal barbecue (Figure 43). These pins not only provided stability but also facilitated the attachment of the smoker holder, ensuring a seamless integration between components (Figure 44). Additionally, the holder boasted five strategically positioned holes, including four angled holes and a single hole at the bottom, enabling users to effortlessly adjust the angle and distance of the smoker grid/mesh according to their preferences (Figure 45).



Figure 43. Overview of the smoker holder in SolidWorks



Figure 44. Overview of the smoker holder in SolidWorks

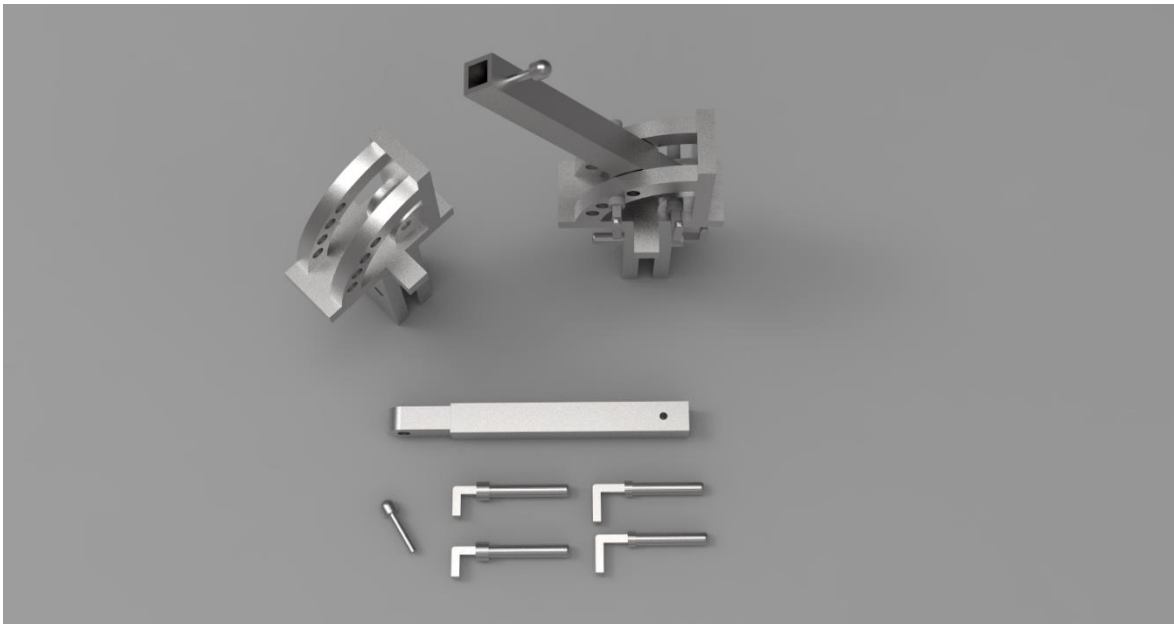


Figure 45. Overview of the smoker holder in SolidWorks

4.9 Smoker adapter

In the development of the firepit/charcoal barbecue, careful attention was paid to enhancing its functionality with the inclusion of a smoker adapter. Crafted from durable stainless steel, this adapter served as the crucial link between the smoker grid and mesh and the smoker holder, seamlessly integrating these components for optimal grilling performance. With dimensions of 190 mm in length, one side featured a square shape measuring 130 mm long, connecting securely to both the smoker mesh and smoker grid (Figure 46).

On the other side, the adapter transitioned into a 60 mm round shape, facilitating a robust connection to the smoker stand (Figure 47). This connection was further reinforced by an 8 mm pin, ensuring stability and strength during use. On the other hand, the adapter was connected to the grid and meshed with a five mm pin. The stainless steel construction of the adapter provided the necessary durability to withstand the rigors of outdoor cooking, making it a reliable addition to the firepit/charcoal barbecue's design.

As a result of this innovative smoker adapter, grilling enthusiasts could enjoy the convenience and versatility of seamlessly connecting the smoker part to the smoker stand. Whether smoking meats or grilling vegetables, this design enhancement offered a streamlined cooking experience, allowing for precise temperature control and optimal heat distribution. With the smoker adapter in place, the firepit/charcoal barbecue continues to set the standard for outdoor cooking, providing enthusiasts with the tools they need to create delicious and memorable meals.

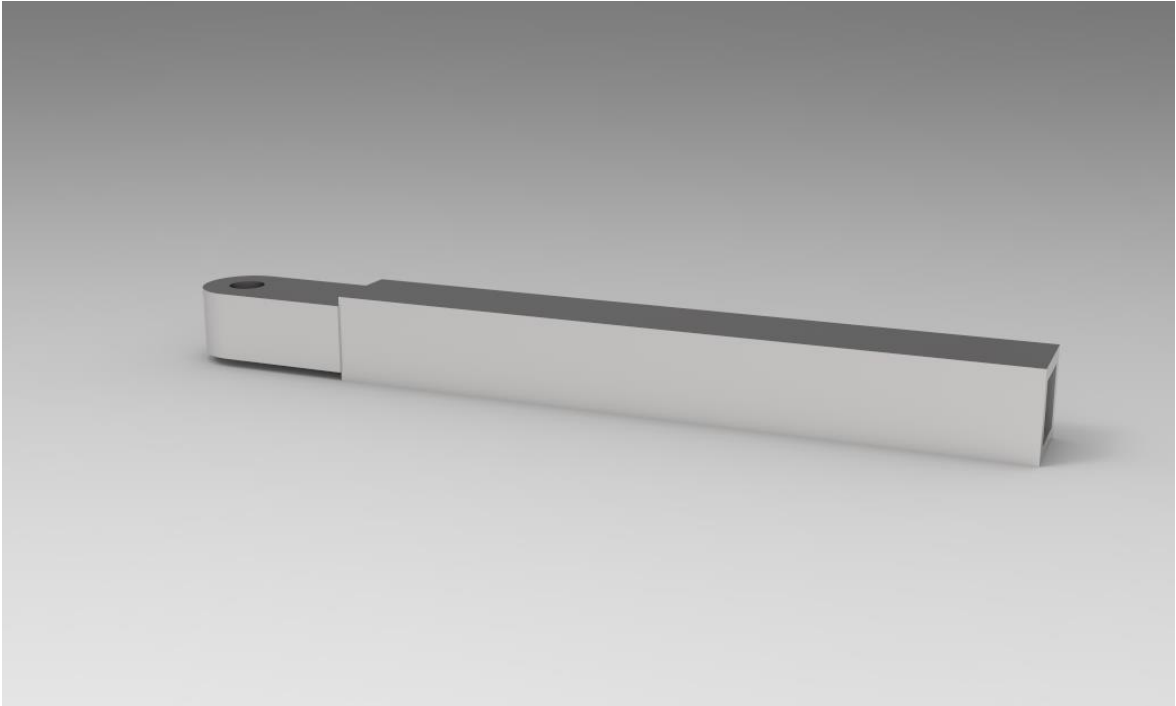


Figure 46. Overview of the smoker adapter in SolidWorks

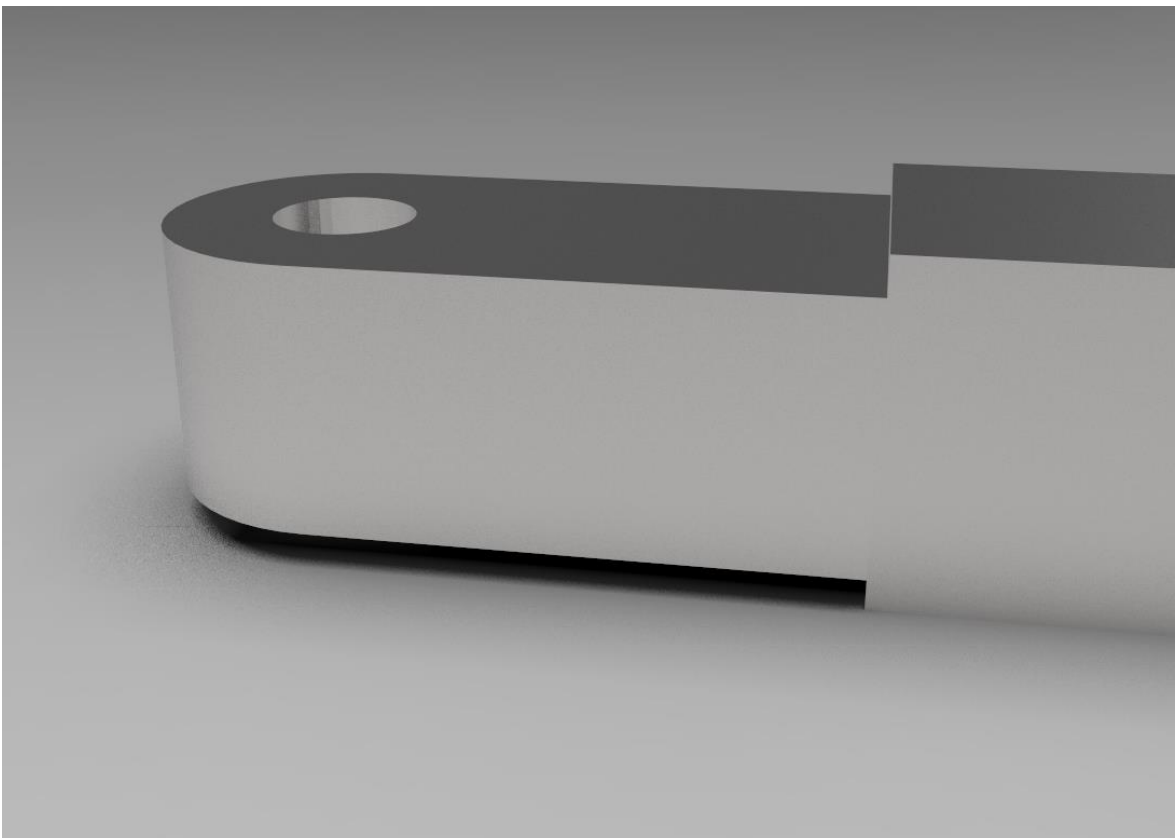


Figure 47. Closer view of the smoker adapter in SolidWorks

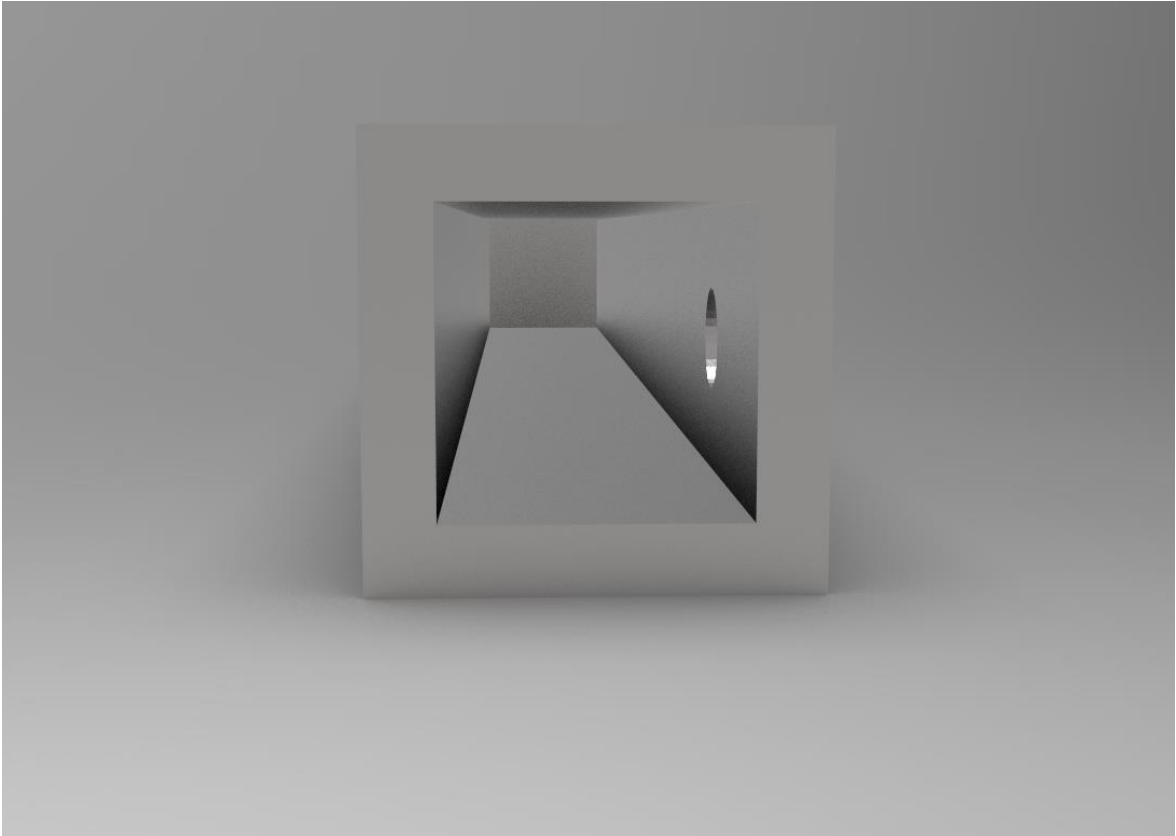


Figure 48. Closer view of the smoker adapter in SolidWorks

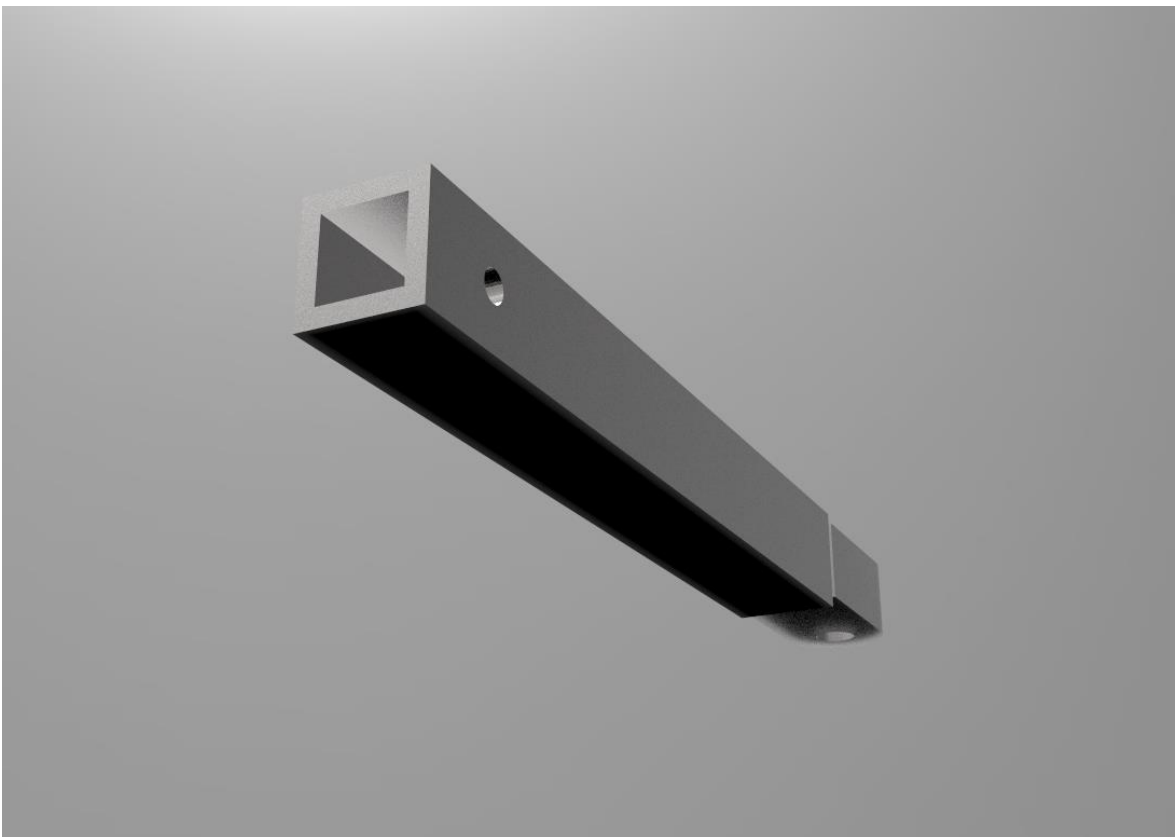


Figure 49. Overview of the smoker adapter in SolidWorks

4.10 Behind legs

The design process began with a thorough analysis of structural requirements and material characteristics. Aluminium was Overall, the preference for circular profiles over square ones was rooted in both functional and ergonomic considerations, making it a common choice in design practices. selected for the rear legs due to its lightweight yet durable properties. The first design of the bases was made of square aluminium profile, but due to the sharpness of the corners and the incompatibility of the square design with the circular barbecue, it was changed to a round profile. The round profile of the aluminium legs, with a diameter of 28 mm and a thickness of 2 mm and 640 mm height , provides adequate support while minimizing weight (Figure 50). To ensure a secure connection to the firepit/charcoal barbecue, stainless steel parts were introduced. These components feature a 30 mm diameter profile and a length of 5 cm, meticulously engineered to withstand the rigors of outdoor use. A robust 5 mm bolt and nut assembly firmly joins the aluminium legs to the stainless steel parts, enhancing stability and load-bearing capacity.

Additionally, the length of the legs was carefully determined to achieve an optimal height for comfortable cooking, while the distance between the two rear legs and two front legs, set at 33 cm, ensures balanced weight distribution and stability.

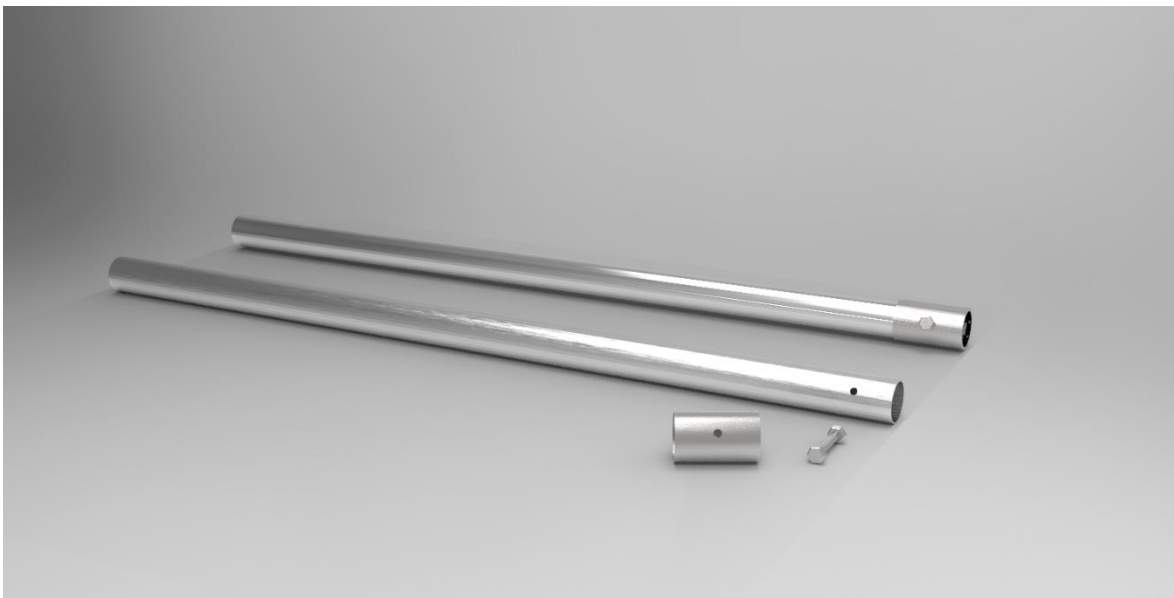


Figure 50. Overview of the behind legs in SolidWorks

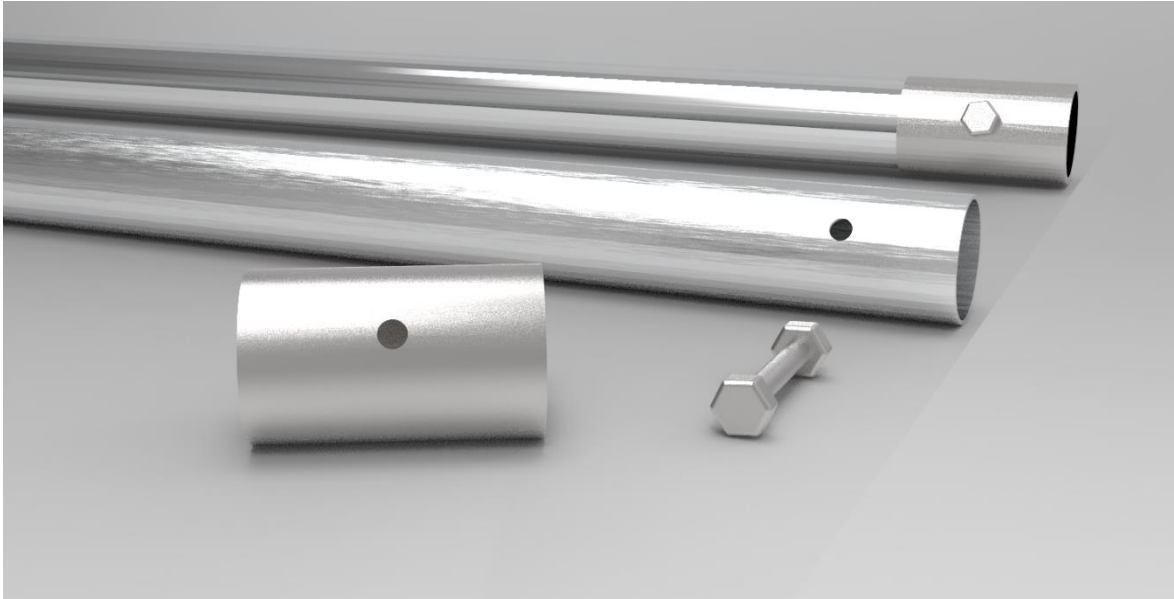


Figure 51. Overview of the behind legs in SolidWorks

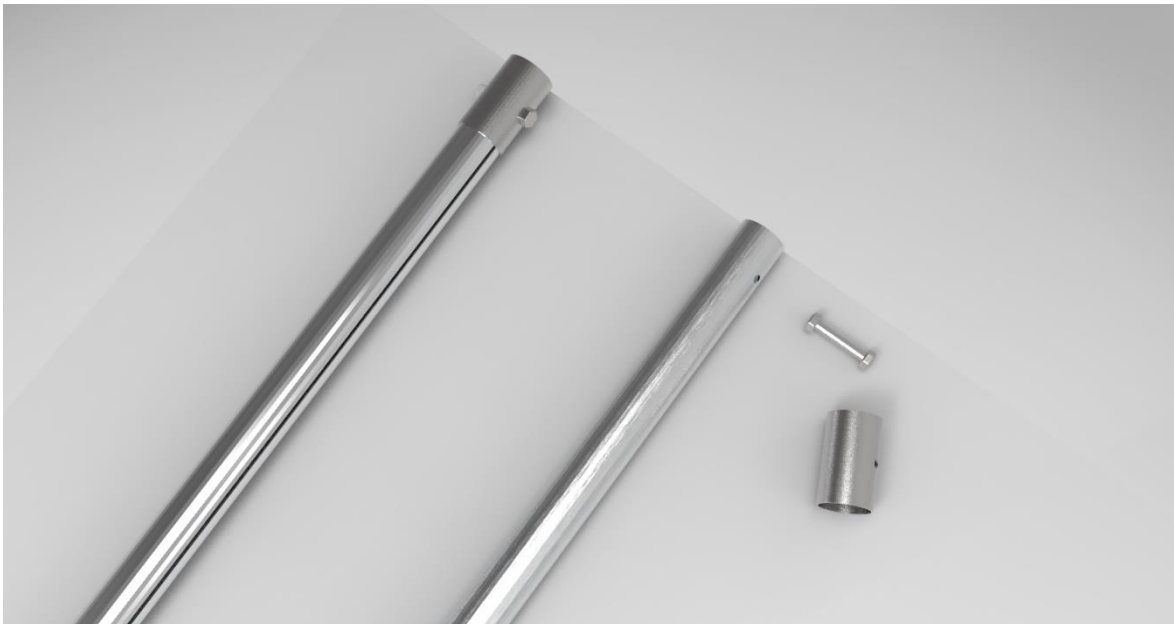


Figure 52. Closer view of the behind legs in SolidWorks

4.11 Front legs

In the pursuit of enhancing the outdoor cooking experience, a novel fire pit/charcoal barbecue design was conceptualized and meticulously crafted. This innovative design features four legs, with the front legs boasting a unique and functional construction. The first design of the bases was made of square aluminium profile, but due to the sharpness of the corners and the incompatibility of the square design with the circular barbecue, it was changed to a round profile.

Comprising two vertical cylinders and one horizontal cylinder, the front legs are crafted from durable aluminium profile, offering both stability and mobility to the fire pit/charcoal barbecue. With a height of 400 mm and a thickness of 280 mm, these front legs are designed to elevate the pit's functionality and aesthetics, making it a standout addition to any outdoor cooking space (Figure 53).

At the core of this fire pit/charcoal barbecue design are the uniquely designed front legs, meticulously engineered to optimize both stability and mobility. The two vertical cylinders, each with a length of 700 mm and a radius of 40 mm, are strategically connected to the pit's body via sturdy connectors, ensuring robust support during use. Furthermore, these vertical cylinders are equipped with bearings on both the right and left sides, allowing for smooth movement and easy transportation of the fire pit/charcoal barbecue.

The integration of connectors between the vertical cylinders and the pit's body enhances structural integrity, ensuring that the fire pit/charcoal barbecue remains sturdy and reliable even under high temperatures and heavy use. Additionally, the welding of the vertical cylinders to the horizontal cylinder further reinforces durability, guaranteeing long-lasting performance throughout countless cooking sessions. This seamless connectivity not only enhances functionality but also contributes to the overall aesthetic appeal of the fire pit/charcoal barbecue.



Figure 53. Overview of the front legs in SolidWorks

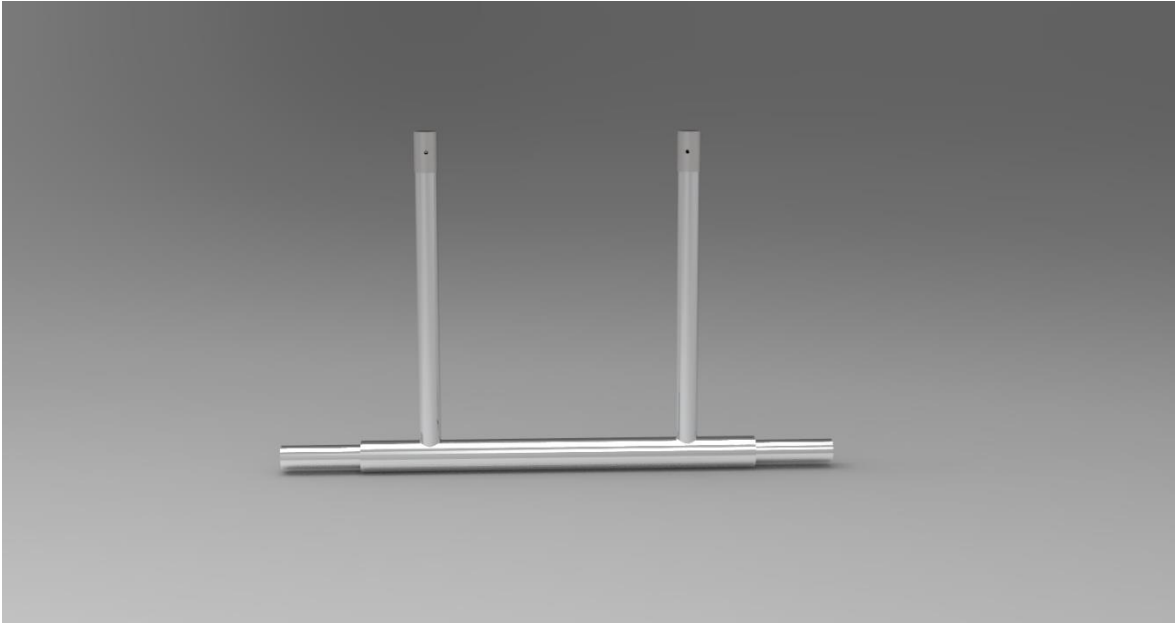


Figure 54. Overview of the front legs in SolidWorks

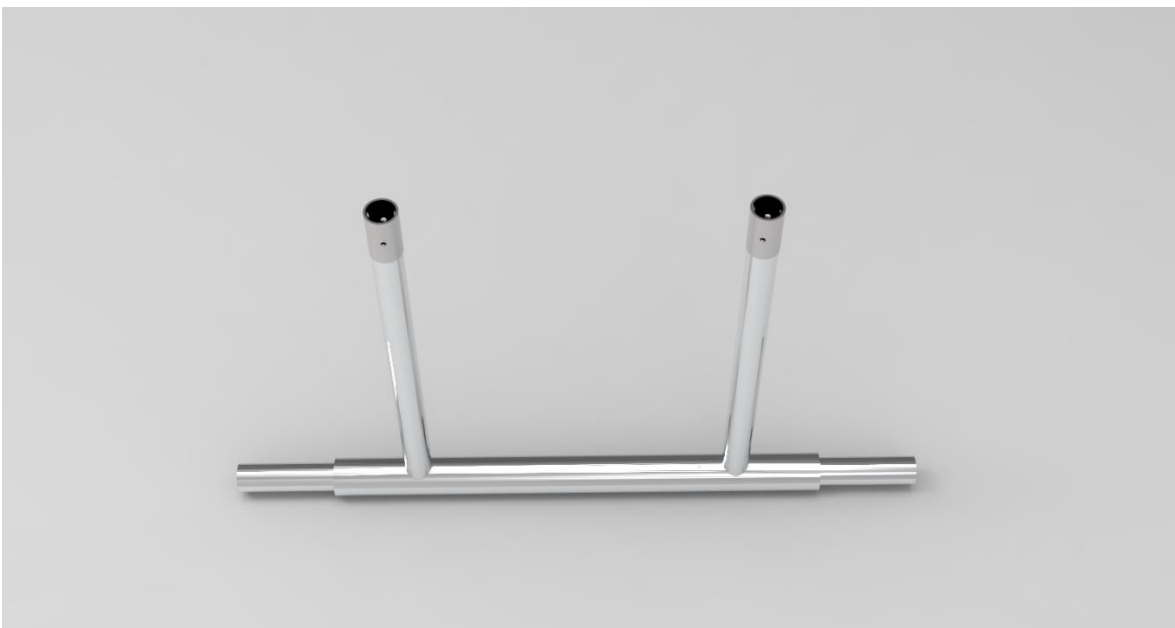


Figure 55. Overview of the front legs in SolidWorks

4.12 Wheels

In the pursuit of enhancing the outdoor cooking experience, a novel fire pit/charcoal barbecue design was conceived and meticulously crafted. This innovative design features a round shape, providing a visually appealing and functional centerpiece for any outdoor gathering. Equipped with two wheels located underneath the front portion of the fire pit/charcoal barbecue, this movable design offers convenience and versatility, allowing users to easily transport the unit to different locations within their outdoor space.

At the core of this fire pit/charcoal barbecue design are the two aluminium wheels, meticulously engineered to facilitate smooth movement and easy transportation. With a diameter of 500 mm and a thickness of 20 mm, these wheels provide stability and durability, ensuring reliable performance throughout countless cooking sessions. The wheels are connected to the front leg's shaft via 30 mm diameter ball bearings, enabling effortless rotation and maneuverability, even on uneven outdoor surfaces (Figure 56).

In conclusion, the development of this innovative fire pit/charcoal barbecue represents a significant advancement in outdoor cooking technology. With its round shape and movable design, equipped with durable aluminium wheels and ball bearings, this fire pit/charcoal barbecue offers unparalleled convenience and functionality for cooking enthusiasts. Whether grilling up a feast for family gatherings or enjoying a quiet evening under the stars, this versatile unit promises to elevate the outdoor cooking experience to new heights, creating lasting memories for years to come.

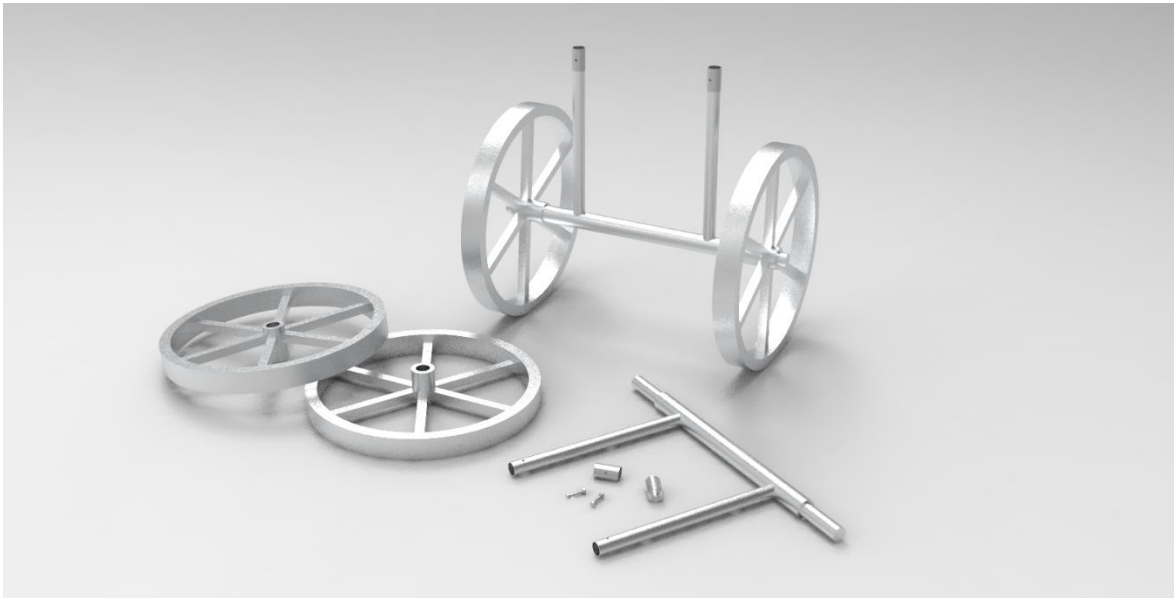


Figure 56. Overview of the wheels and front legs in SolidWorks

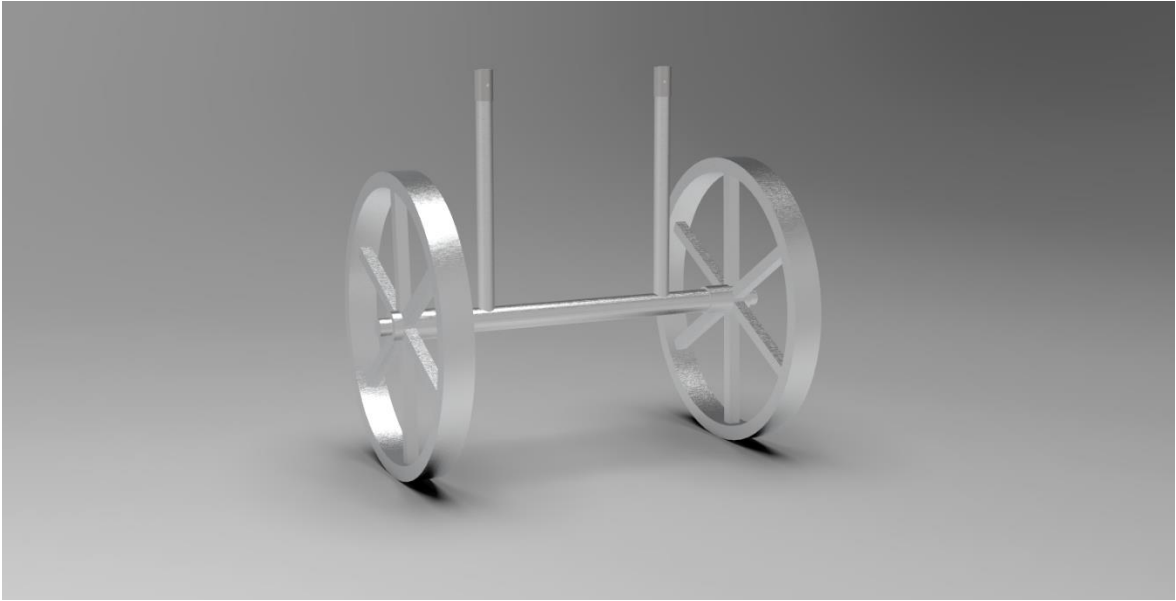


Figure 57. Overview of the wheels and front legs in SolidWorks

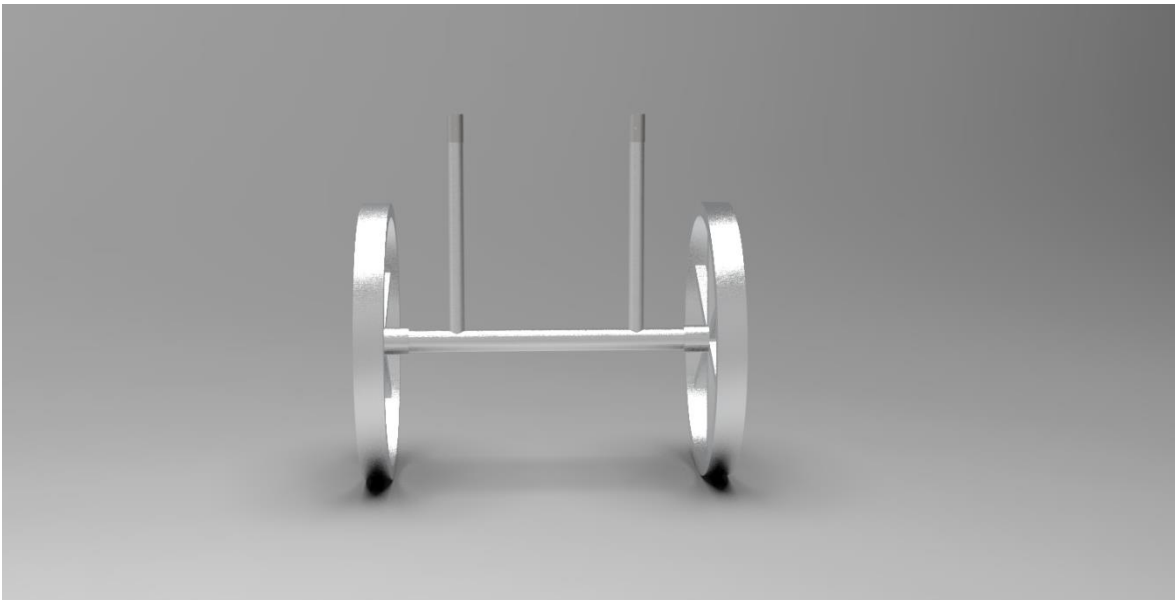


Figure 58. Overview of the wheels and front legs in SolidWorks

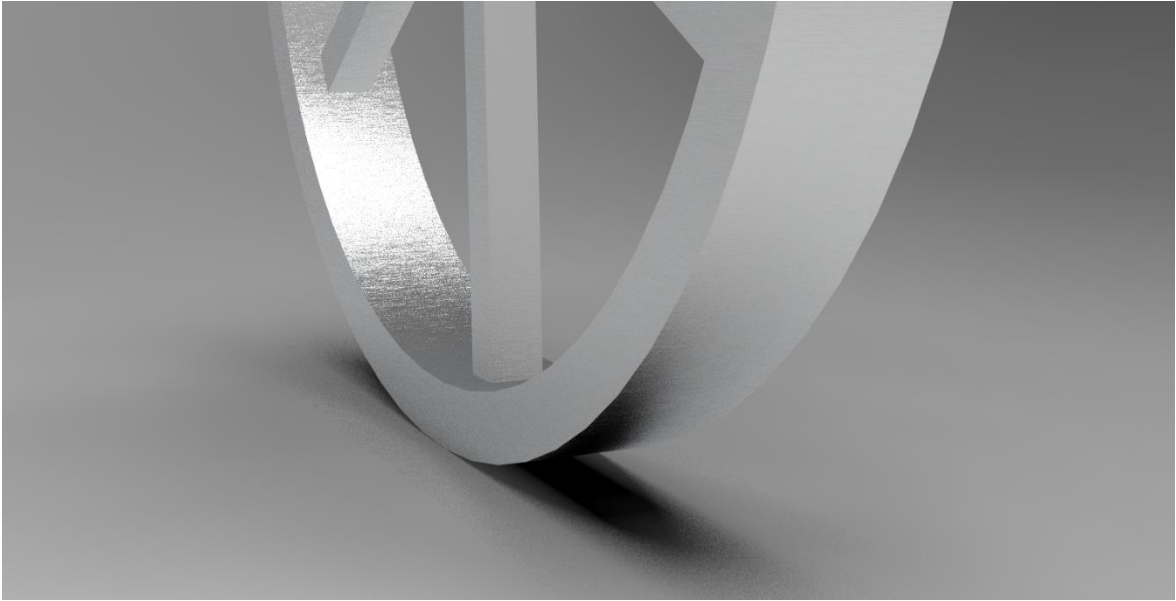


Figure 59. Closer view of the wheels and front legs in SolidWorks

5 Summary

Outdoor grilling surged in popularity among people of all ages and backgrounds. This was attributed to factors like the enjoyment of cooking and dining outdoors, socializing around a grill, and the desire for flavorful meals. Additionally, outdoor grilling allowed individuals to experiment with diverse culinary techniques and savor unique flavors. The convenience and versatility of outdoor grilling made it a preferred choice for various occasions.

In response to the demand for versatile, convenient, and sustainable outdoor cooking, a multifunctional charcoal barbecue/firepit was designed. Crafted with a round shape and spacious diameter, it integrated grilling, frying, and smoking capabilities. The design emphasized mobility, versatility, safety, and ease of storage, with wheels for transportation and disassembly for compact storage. Safety for the environment was also considered, ensuring contained fire usage. The aim was to redefine the outdoor cooking experience by offering functionality, mobility, and ecological mindfulness.

The design process involved creating a round fire pit/charcoal barbecue using stainless steel for durability. The main pit included features like an internal pit, lid, grid and griddle, smoker grid, and smoker mesh, smoker stand, and adapter, all aimed at enhancing cooking performance and safety. Additionally, unique leg configurations and movable features like wheels were incorporated to improve stability and portability.

Overall, the design aimed to meet the needs of modern outdoor cooking enthusiasts, providing them with a convenient, versatile, and eco-friendly cooking solution.

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