BARBEQUE WITH AIR VENTILATION SYSTEM

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WAN NUR AMIRA SHAFIKAH BINTI WAN MOHD FAZLI

Thesis submitted in fulfilment of the requirements
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of degree of Bachelor of Engineering Technology in Electrical.

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ABSTRACT

Nearly half of the world's human population used barbeque for party or gathering with family or friends. This thesis aspires to have a conventional and altenative source of the baqberque with ventilation system.The problem of the thesis was to research about the time of barbeque produce products. Identify good quality charcoal and reduce negative effect towards environment and human health. The main objective was to segment to improve the heat transfer performance of conventional charcoal because if heat directly touch to charcoal Animal testing has shown exposure to high levels of chemicals such as these is linked with cancer, Combusting wood, gas, or charcoal emits chemicals known as Polycyclic Aromatic Hydrocarbons. To design a portable charcoal barbeque set with air ventilation system. The material we use is zinc. stainless steel, blower, battery and hot rack. Designing was started by drawing a few designs using NX10 software. After run an analysis on those design and once a desired design was selected, then fabrication are started. Fabrication flow starts with a material selection were a material used was stainless steel. Then the material was cut into desired measurement. Those pieces are then welded togetger by using MIG welding machine. Machine setting parameter will be0 explained on chapter 3 methodology. The final part of this fabrication was finishing part. The structure painted so that it would be not rusted and in order to have structure with better looks.

ABSTRAK

Hampir separuh daripada populasi manusia dunia menggunakan barbeku untuk pesta atau berkumpul dengan keluarga atau rakan-rakan. Tesis ini bercita-cita untuk mempunyai sumber konvensional dan altenatif baqberque dengan sistem pengalihudaraan. Masalah tesis ini adalah untuk meneliti masa barbeque menghasilkan produk. Kenal pasti arang berkualiti dan mengurangkan kesan negatif terhadap alam sekitar dan kesihatan manusia. Objektif utama adalah untuk segmen meningkatkan prestasi pemindahan haba arang konvensional kerana jika haba secara langsung menyentuh arang ujian haiwan telah menunjukkan pendedahan kepada bahan kimia yang tinggi seperti ini dikaitkan dengan kanser, kayu, gas, atau arang memancarkan bahan kimia yang diketahui sebagai polycyclic aromatic hydrocarbons. Untuk merancang barbeque arang mudah alih yang ditetapkan dengan sistem pengudaraan udara. Bahan yang kami gunakan adalah zink. Keluli tahan karat, peniup udara, bateri dan rak panas. Reka bentuk bermula dengan menarik beberapa rekaan menggunakan perisian nx10. Selepas menjalankan analisis pada reka bentuk tersebut dan sebaik sahaja reka bentuk yang diingini dipilih, maka fabrikasi dimulakan. Aliran fabrikasi bermula dengan pemilihan material adalah bahan yang digunakan adalah keluli tahan karat. Kemudian bahan itu dipotong ke ukuran yang diinginkan. Potongan-potongan tersebut kemudian dikimpal dengan menggunakan mesin kimpalan mig. Parameter penetapan mesin akan dijelaskan pada bab 3 kaedah. Bahagian terakhir dari fabrikasi ini adalah bahagian akhir. Struktur dicat supaya tidak berkarat.

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LIST OF ABBREVIATION

cm	Centimeter
°C	Degree Celsius
g	Gram
kPa	Kilopascal
kV	Kilovolt
L	Liter
MPa	Megapascal
m	Meter
µg	Micro gram
µl	Micro Liter
µm	Micro meter
ml	Milliliter
mm	Millimeter
min	Minute

CHAPTER 1

INTRODUCTION

A barbeque grill is a device that cooks food by applying heat from below. Barbequing over charcoal grills is popular around the world. Every country have their own style of barbequing. It depends on the type of barbeque system. To that end, consumers are able to choose from a various type of charcoal grills that come in all shapes and sizes. Charcoal grills require approximately 30 minutes or more to heat the charcoal to a temperature suitable for safe and effective cooking.

Barbecuing is normally a social occasion and is a safe 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).

The trend in Figure 1.1 shows barbeque products that increased in sales year over year. Charcoal grill still being used for barbequing purpose. On top of Infrared Grills, Kamados, Gas Grills and Pallet Grills. Thus, in 2014 data show that 15% retailers are still using charcoal/smoker as their barbeque system.

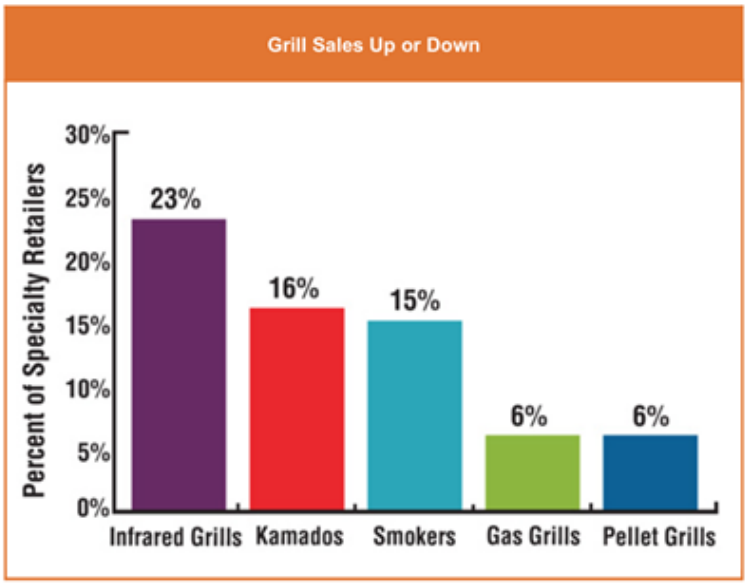

Figure 1.1: The Barbeque Grill Sales in United State 2014 (Wright, 2015)

According to Table 1.1, the amount of shipments for three types of barbeque grills including charcoal, gas and electric from 2010 to 2013. Gas and electric grill shipments were increased while charcoal slightly decreased about 10.3%. People in North US were looking for other method instead of charcoal as they choose not to get expose to the smoke from charcoals. However, charcoal grill cooked meat has better acceptability, tenderness, juiciness, and flavour scores compared to those of gas and electrical grill-cooked. (Choi, 2016).

Table 1.1: Charcoal, Gas and electric Barbeque Grill Shipments (North US)

Year	Charcoal	Gas	Electric
2010	6,232,500	8,553,500	276,600
2011	6,047,000	8,445,000	288,000
2012	5,917,000	8,200,000	280,000
2013	5,590,000	8,053,000	302,000

Therefore, the charcoal grill need to be improvised by providing a simple and easy to use device that generates an airflow that travels through the charcoals, allowing accelerated ignition and heating of the charcoal without creating potential contaminants or blowing ashes into the cooking food.

From the literature and market studies, gas and electric grills are not new after the charcoal grill. However, this study will focus on the improvement of charcoal grill in specific. Thus, the objective of this study is to develop a prototype of Charcoal Barbeque with Air Ventilation System. In the project development, few aspects have to be considered such as the compatibility of the design with semi-auto portable concept, the air ventilation system at which the device is able to be produce and recycle heat, and the quality of barbecuing in aspect of environmental. The proposed barbeque set will enable the users to improve energy, time consumption, environmental friendly and user safety. Lastly, the most important feature will be quality of barbequing with ease of use.

1.1 Problem Statement

Barbecue grills set have gained in popularity in recent years, grill manufacturers are continually striving to develop barbecue grill that will safely and efficiently cook meat or other foods while retaining the natural flavor of the food being cooked. Conventional charcoal barbeque has low energy efficiency and produce smoke emission. It requires longer times to produce heat and low in heat distribution.

The invention of gas and electric barbeque getting more popular over conventional barbecue. However, most gas and electric barbeque are non-flexible for indoor and outdoor usage. Furthermore, gas and electric grills were designed with attached permanent briquettes (Figure 1.2) to replace conventional grills which use combustible charcoal briquettes. Nevertheless, the permanent briquettes associated with current gas and electric grills have a tendency to collect grease from food being cooked and thereby provide a cooking environment very susceptible to unwanted flaming which can burn and dry out meats or other foods being cooked.

Figure 1.2: Ceramic Briquettes inside a Gas Grill

In other hand, another disadvantage associated with conventional charcoal grills is the difficulty in cooking large pieces of meat which often require longer cooking times and have a tendency to lose their natural juices during such prolonged cooking periods. Other than that, grease drippings will directly contact with the heat source and create uneven heat distribution toward the food.

Thus, the proposed portable charcoal barbeque set is portable to be easily carried, moved and flexible for indoor and outdoor usage. It will be installed with regulated air ventilation system that reduce energy and minimize grilling time consumption. The self-fabricated barbeque set prototype also eco-friendly which contribute less pollution towards the environment and safe for user.

1.2 Objectives project

Below are objective of "barbeque of air ventilation system" project:

1. To improve the heat transfer performance of conventional charcoal and reduce cooking times.
2. To identify good quality charcoal and reduce negative effect towards environment and human health.
3. To design a portable charcoal barbeque set with air ventilation system.

1.3 Project Scope

The project covers all aspects in the development of charcoal barbeque set installed with air ventilation system including the design and fabrication stage. This project will be developed based on research from previous studies and several products available in marketing in order to propose more efficient charcoal barbecue set. The main components of this charcoal barbeque set are the cooker, charcoal system and air ventilation with low smoke emission and hot rack. General process involves in the development of this project is:

1. Identifying the ideal equipment that will used for the Charcoal Barbeque with Air Ventilation System by selecting the material based on price, size/dimension and quality.
2. Drawing a 3D Charcoal Barbeque with Air Ventilation System by using NX10 Modelling.
3. Designing and constructing a portable and flexible charcoal barbeque system equipped with cooker, charcoal port, fan to create proper heat distribution and hot rack to maintain food quality.

CHAPTER 2

LITERATURE REVIEW

Barbequing over charcoal grills is enormously popular the world over. To that end, consumers are able to choose from a seemingly endless array of charcoal grills that come in all shapes and sizes. In spite of great availability of charcoal grills these grills universally face one great setback. Charcoal grills require approximately 30 minutes or more to heat the charcoal to a temperature suitable for safe and effective cooking.

Consequently, the transformation of barbecue technique has been improvised from time to time. Many researchers have improved the technology of barbecue in order to ensure the effectiveness of the barbecuing set and preserving quality of food. Gas and electric grills are not new after the charcoal grill. However, this study will focus on the improvement of charcoal grill in specific.

There will be three main components that will be discussed in this review, which are the overview of the barbecue set, revolution and innovation of barbecue set design as well as special features of barbeque set.

2.1 Overview of Barbecue Set

In this section, background study of barbecue is discussed including the barbecuing methods and style of barbecue. Various type of barbecue sets also has been investigated.

2.1.1 Methods and Style of Barbecue

There are numerous methods and styles of barbecuing that break down into two distinct cooking methods; direct and indirect methods. Direct cooking or grilling is where the heat source is directly put under the food to be cooked. The heat source effectively emanates from one direction so food cooked directly is cooked on one side at a time and will need turning to ensure that it is cooked on all sides. Whereby, indirect cooking on a barbecue uses convection heat like in a conventional oven. The primary feature of indirect cooking is that there is separation between the food and the heat source by positioning of food in relation to the heat source or by a physical barrier.

Another usual term is roasting refers to a cooking method that uses dry heat, whether an open flame, oven, or other heat source. Roasting usually causes caramelization or mail lard browning of the surface of the food, which is considered a flavour enhancement. Roasting, as the word implies, is the working mechanism by which the food product material are thermally subjected into irreversible structural changes and reduction of moisture contents purposely to bring about digestible content for human consumption (Oke, 2013).

2.1.2 Typical Barbecue Sets

There are various types of barbecue sets which are put into use worldwide. These include electric barbecue machines, cell barbecue grill, barbecue grill netting, and barbecue machine (Gyansah, 2012). Most conventional barbecue set for an example, in Namibia all run on wood and undergoes the same principle; firewood is placed in a metal container and once the embers are ready for barbecuing the meat is placed on a grill rack above the embers (Lindberg, 2010)

In developing countries like India, barbecue sets mostly use by the local street vendors selling roasted corns operate seasonally, as per the availability of maize crops. Roasting of corn cobs is done by placing the maize on a glowing charcoal and then turning it occasionally to allow even distribution of heat. A hand fan is used by the vendor to blow the air so as to maintain the glowing of charcoal. The rate of heat transfer from the charcoal to the maize depends on how fast the hand fan blows the air current. The process is strenuous as the vendor is tired out with the time before the corn cob is completely roasted (Deepika, 2016)

While in China, Chinese style barbecue is very popular in Chinese charcoal barbeque restaurant. Before put on the table, food is initially baked in the charcoal burner range in kitchen. During the meal, a pot or plate that fueled with charcoal is set on each table to ensure that the food is always hot. Similar to hot pot, when the food is eating up, other dishes can load into the broth for further cook (Zhang, 2017)

Conversely, contemporary barbecues also exist out there such as regular barbecue using charcoal and a steel casing as in Figure 2.1 (a), the heat can fluctuate, which can either be positive or negative. Figure 2.1 (b) depicts the barbecue that uses propane gas that allows for easy temperature control but wood chips should be added in order for the food to taste smoky. Meanwhile, Figure 2.1 (c) shows a ceramic barbecue that stays warm more easily but is expensive and hard to handle. All three can be used with or without a lid and this has a lot of impact on the functionality (Taams, 2016). Most of the barbecues sold in Sweden are run on charcoal or Liquefied Petroleum Gas (LPG) (Lindberg, 2010).

(a) (b) (c)

Figure 2.1: (a) Regular Barbecue Using Charcoal and a Steel Casing (b) Barbecue That Uses Propane Gas (c) Ceramic Barbecue

2.2 The Innovation and Evolution of Barbecue Set

The needs for more energy efficient barbecues is alarming and urged many researchers to innovate and involve in the evolution of barbecue set. In this section, the reviews are composed of various invention from previous researchers. The content is divided into two, improvement of the conventional barbecue and high technology invention in barbecue set.

2.2.1 Basic Improvement of the Conventional Barbecue

One of the study at the open markets in Namibia was initiated since firewood constitutes a large cost for the actors selling food at the market. Therefore, (Lindberg, 2010) had built a prototype called the EzyStove. The project was dedicated for a Creative Entrepreneurs Solution (CES) based in northern Namibia. The barbecue set is as an attempt to reduce the wood consumption, applying a concept of combining cooking and barbecuing. The most important finding during the field study was that it is common to use two or more fires at the same time to be able to both barbecue and cook in pots.

The design in barbecue set was improved further through barbecue stove design with features to minimize the stress on arms, probability of accidents and improving the performance of the stove. The cubical shape stove is insulated to avoid the direct contact of heat to the body and the provisions were made to avoid the contact

of fire with the body part. A blower was attached to the model to reduce the stress produced by constant fanning (Deepika, 2016)

2.2.2 Advance Barbecue Invention with Technology

Moving forward, more sophisticated study devoted to barbecue set was developed by other inventors or researchers. As part of Senior Design Project that took place in the Department of Mechanical Engineering at Ohio University, Team OU BBQ were proposed a mobile grilling system to solve a problem with a mobile food vending service. The problem presented to the group dealt with the customer running out of product because a large enough grill could not be transported on her truck. After researching food and road safety standards, the group designed and analyzed a system that could incorporate a much larger grill and still be transported on her truck with ease of use. The end product used a hydraulic lift system that attached to the back end of the truck and lowered the grilling system to the ground so the grill could be used wherever was convenient (Harris, 2010).

Another invention in barbecue set is a development of portable gas barbecue machine by (Gyansah, 2012). The prototype was proven to be more efficient, serviceability, low cost, and has better heat radiation controllability when manufactured. Besides the primary objective to provide a portable barbecue set, this design also eliminates the health hazards associated with the use of charcoal in substitute of gas cylinder. Whereby, (Oke, 2013) has designed the multipurpose roasting machine made up of roasting chamber, heating chamber, two blowers, and power transmission mechanism. The roasting chamber houses ten food hangers use to hold the food items. The hangers were continuously rotated to perform uniform and smooth roasting.

Additionally, more sophisticated study devoted to barbecue set was developed by (Taams, 2016) and his team by deploying the Internet of Thing (IoT) concept. Pitmaster was created, that is barbecue support toolkit consists of temperature sensors, sensor tongs, timers and a base station. They had redesigned the barbecue experience using modern communication technologies into a smart barbecue toolkit that evolved from an iterative design process. One of the special features is a wireless-connected barbecue system where the user is possible to check the cooking progress from anywhere.

2.3 Special Features of Barbecue Sets

The latter emphasizes distinctive major features of the improved design of barbecue sets. Three major components are reviewed including the cooker, barbecue incorporated with fan and barbecue smoke reduction.

2.3.1 The Cooker

The barbecue cooker is a vital part in barbecue set. A variety of charcoal type cookers are conventionally available, and serve the functions of containing the fuel and generating the heat used for the cooking process.

Among the latest invention that focused in the cooker is by (United States Patent No. 12/776,825, 2010). He designed a convection oven for cooking foods includes a housing having a fire chamber and a cooking chamber disposed generally above the fire chamber. A vessel is receivable in the fire chamber and is adapted to hold combustible material therein to generate heat and smoke for cooking food in the cooking chamber. A blower is mounted on the housing to move air. The oven does not require supplemental heat from a burner or similar heating element. The convection oven is provided in Figure 2.2.

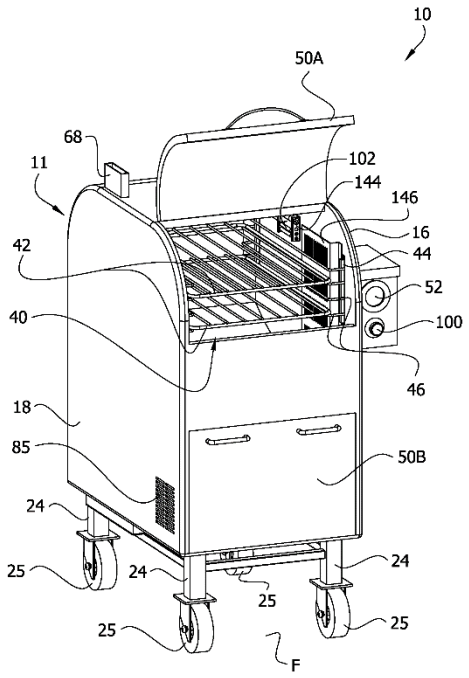

Figure 2.2: convection oven (United States Patent No. 12/776,825, 2010)

2.3.2 Barbecue Incorporated with Fan

People are looking for a good barbecue that are energy efficient, less cooking time and user friendly. Ordinary barbecues require longer time to starts fire manually, however this activity is now taken over by the incorporated fan or blower in most barbecue set. Remarkably, Farid Daud, 2008 has designed a charcoal grill that providing a rapid ignition and heating of the charcoal, by means of an electric fan that is coupled to the body of the grill. The fan as depicted in Figure 2.3 decreases the overall time required to heat the charcoal to proper cooking temperature by increasing the flow of air provided to the charcoal. The increased airflow created by the incorporated fan accelerates the firing-up and heating of the charcoal by channelling air across and through the charcoal.

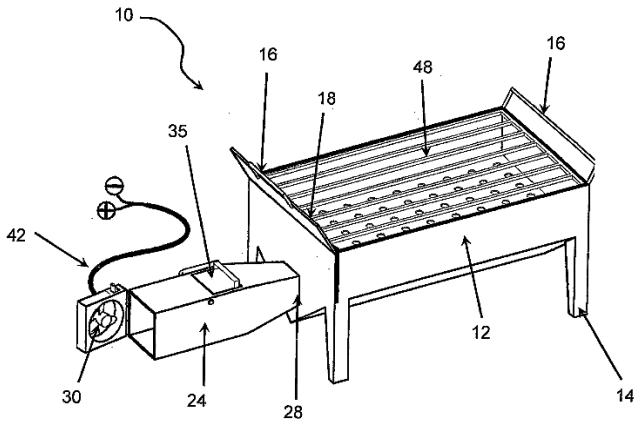

Figure 2.3: Portable Charcoal Grill with Incorporated Fan.

Likewise, forced air grill in Figure 2.4 utilizes a fan to force air through an air duct and into the lower chamber of the firebox, up through the charcoal. This grills temperature is controlled by the use of thermocouple to turn a fan on and off which supplies air to the fuel. The design of the grill makes it easy to add charcoal and clean out ashes. The removable tray gives an option to prevent flare-ups so user no need to constantly monitor the grill.

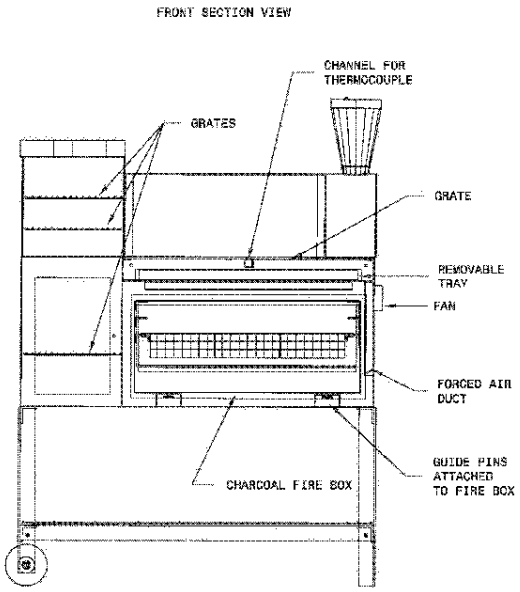

Figure 2.4: Forced Air grill.

2.3.3 Barbecue Smoke Reduction

A by-product of the barbecue grill in a great many occasions is smoke which may result due to the high heat and meat being cooked on the barbecue grill. The direction of the smoke may vary depending on the wind direction and strength. Normally, the smoke is directed towards the cook. According to (Zhang, 2017), barbecue charcoal combustion could be an important source of emissions to the atmosphere with potential health risks. Thus, it would be desirable to be able to control the direction of the smoke in order to provide a more pleasant cooking experience and prevent health risks.

Respectively, (United States Patent No. 13/630,348, 2014)had designed a barbecue grill device attached with a base member to form a base for the barbecue grill device, a burner housing to be positioned on the base member and an airflow diverter to form an airflow between the user of the barbecue grill device and a burner housing. Meanwhile, Figure 2.5 shows a vent created at the back side of the portable gas barbecue to allow circulation of air and flow out the excess smoke (Gyansah, 2012).

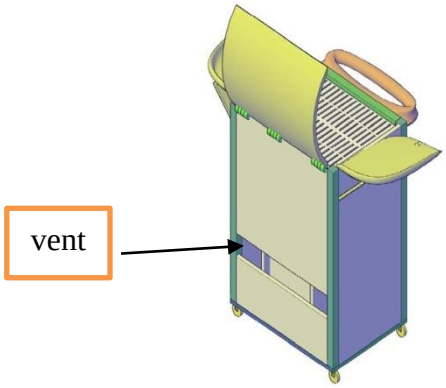

Figure 2.5: A vent at the back of portable gas barbecue

2.4 Overview of Charcoal for Barbeque

Charcoal represents one of man's very first technological achievements; it was in use as early as 200,000 B.C. When wood is burned slowly without oxygen it produces charcoal. The charring removes the water and most of the flavor-producing chemical compounds of the wood, leaving a carbon-rich fuel that burns hot, cleanly, and efficiently. Charcoal also produces a more concentrated fire. No wonder the vast majority of the world's grill masters burn charcoal. But not all charcoals are the same. Common type of charcoals are lump charcoal, Charcoal briquettes, and coconut shell charcoal.

2.4.1 Types of Charcoal

Lump charcoal

Sometimes called char wood or natural lump charcoal, this is the original charcoal, made by burning trees or logs in a kiln, sealed cave, or even underground. Unlike briquettes, lump charcoal is pure wood—free of binders or petroleum-based accelerants. Lump charcoal burns hot, cleanly, and pure. You can refuel a lump charcoal fire with unlit charcoal without producing the acrid smoke associated with freshly lit briquettes. However, natural lump charcoal burns unevenly, hotter at the beginning, cooler at the end, and it burns out more quickly than charcoal briquettes. When you grill with lump charcoal you'll need to refuel the grill more often than with briquettes, usually after 30 to 40 minutes. Avoid "lump" charcoal that comes in straight-edged

rectangular blocks—it's made from lumber scraps, not logs. One excellent widely available brand is Royal Oak. For something a little more exotic.

Charcoal briquettes

These are designed to burn evenly and maintain a steady "broiling" temperature of at least 600 degrees F for 1 hour. Traditional briquettes contain wood scraps, sawdust, coal dust, borax, and petroleum binders, so it's not surprising that they emit an acrid-tasting smoke when first lit. Instant-light charcoal consists of briquettes saturated with lighter fluid. The acrid smoke disappears once the charcoal glows orange and begins to ash over, but you're still grilling over borax, coal dust, and petroleum binders. And, although the petroleum-based accelerants of instant-light charcoal burn off in theory, they can produce an oily taste when less than completely lit. "Natural" briquettes, which contain only wood scraps and starch binders, are meant to eliminate these problems.

Coconut shell charcoal

This sustainable charcoal is made from coconut shells, not wood. It is flavor neutral and generates virtually no smoke or ash. It is quick to light, hot burning, and sold in small pieces, it's the perfect charcoal for the small grills used by Asian street vendors. This charcoal burns up to 978°F, so you will never have issues getting beautiful grate marks on your food.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter is focusing on the methods and procedures that need to be executed in order to achieve the objectives of this project. The chosen methods have been considered in every aspect so as to ensure a satisfying result of the performance of the Charcoal Barbeque with Air Ventilation System. The methodology outline including material selection, methodology flowchart and designing and technical analysis planning.In addition, this chapter also discusses the process flow of the project which is about the designing the structure of the barbeque and the fabrication process to built the part of the air ventilation system. The steps and explaination for software and hardware development with the electric circuit diagram also included in this chapter.

3.2 PLANNING FOR SENIOR DESIGN PROJECT

Each steps starting from designing and fabricating this project are carefully planned and approved by supervisor so that the criteria needed to build a complete air ventilation system can be meet. Figure 3.1 shows the flowchart of the project.

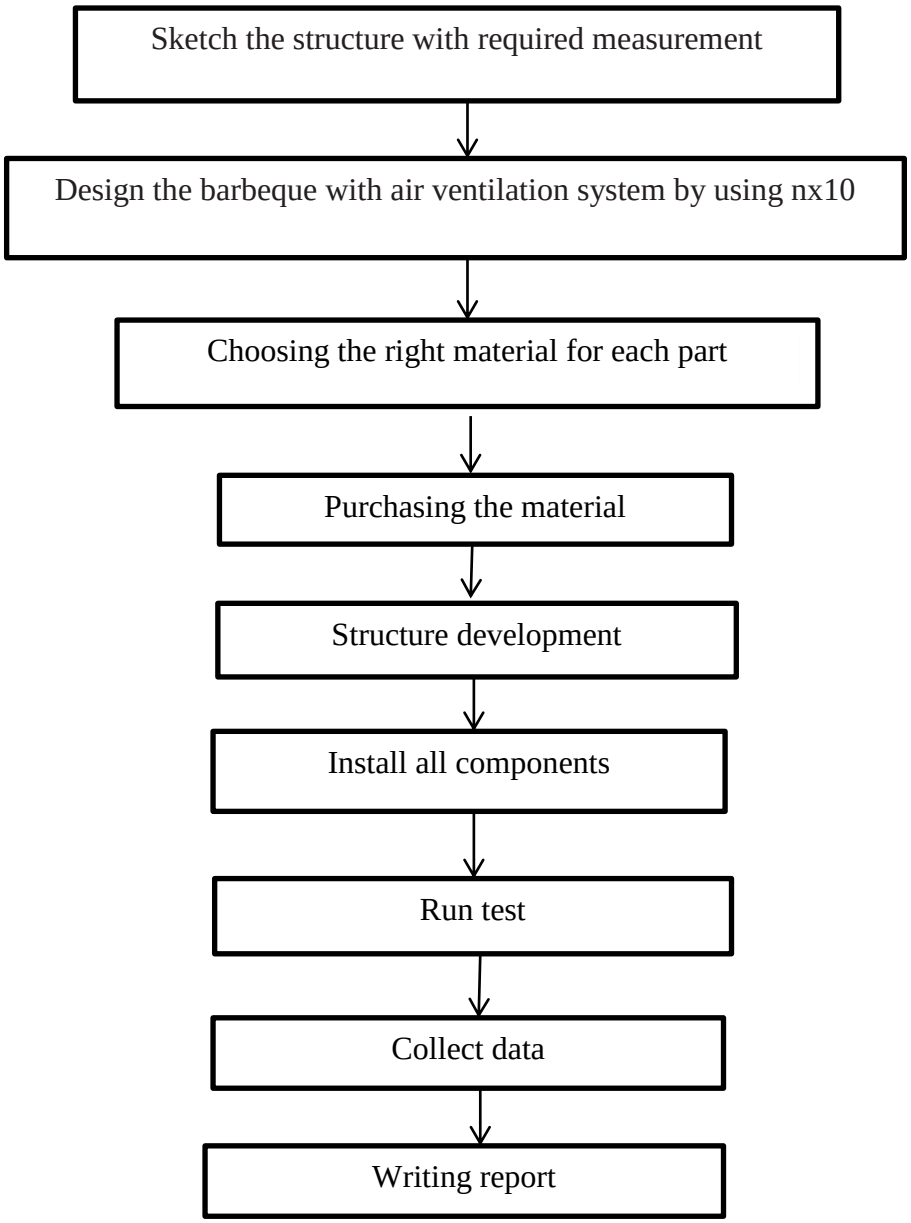

Figure 3.1: Planning For Senior Design Project

The design part is done during last semester and before the last semester end, the material for the structure are decided before the semester ends. Early this semester, the purchasing had been done and the waiting time to receive the materials takes about a month. After that the construction ad chassic development take part. Then, barbeque was mounted to the structure and electrical part such as wiring, electric controller and battery were installed. The barbeque with air ventilation system is then tested after all the components are ready. Finally, we proceed with report writing.

3.3 DESIGNING STRUCTURE OF BARBEQUE WITH AIR VENTILATION SYSTEM

Every product need to have a complete design with exact measurement before it can be fabricated. The design plays a fundamental role in this project. So before starts the design process, a few criteria should be take note. The information is gathered by doing some discussion with supervisor and other team members. Firstly, the information regarding the component needed are decided so that the design can be made to make syre all the components can be installwithit errors. The process continued by inserting on the sketches.

The engineering design process was a methodical series of steps that engineers use in creating fuctional productsand processes. The process highly iterative, part of the process often nee to be repeated many times before another can be entered. The design part of this project is done by using NX10.

3.4 Methodology Framework

The methodology framework for the development of Charcoal Barbeque with Air Ventilation System as shown in Figure 3.2.

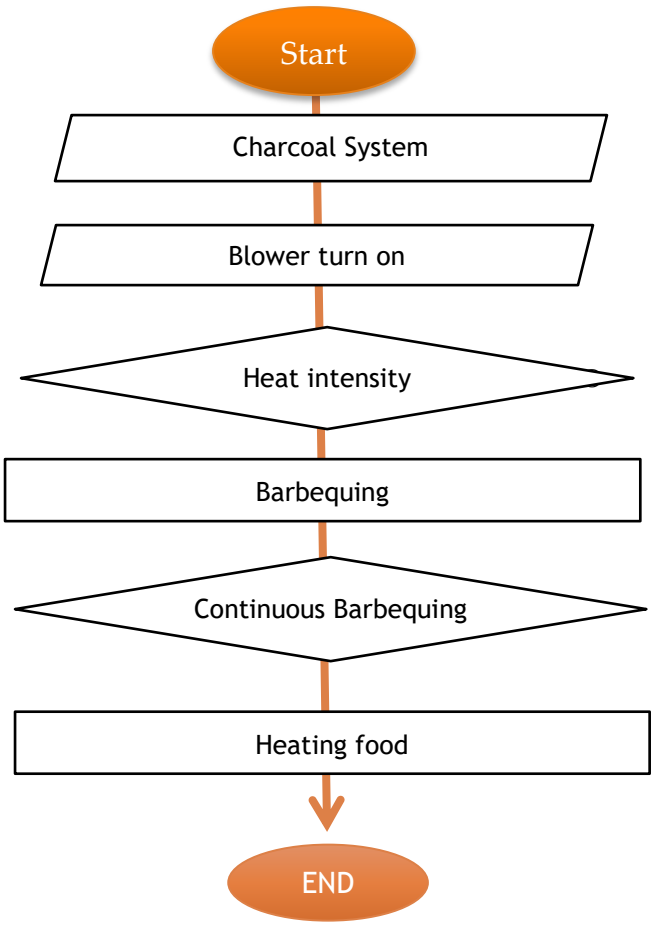

Figure 3.2: Methodology Framework

3.5 The Theory of Charcoal Barbeque with Air Ventilation System

This sub-chapter explained the theory of process behind the proposed Charcoal Barbeque with Air Ventilation System according to two different parts explicitly charcoal system and the cooker with air ventilation system.

The Charcoal System

The charcoal system mechanisms inside the charcoal system will go through these three steps. Firstly, charcoal need to be fired up inside the charcoal port. Secondly, switch on the blower to allow air flow through the charcoal port. Finally, air will interact with the hot charcoal and perform hot air distribution towards the system. Consequently, the hot air will be used as a medium for barbequing in cooker part. All these processes are summarized as a flowchart in Figure 3.3.

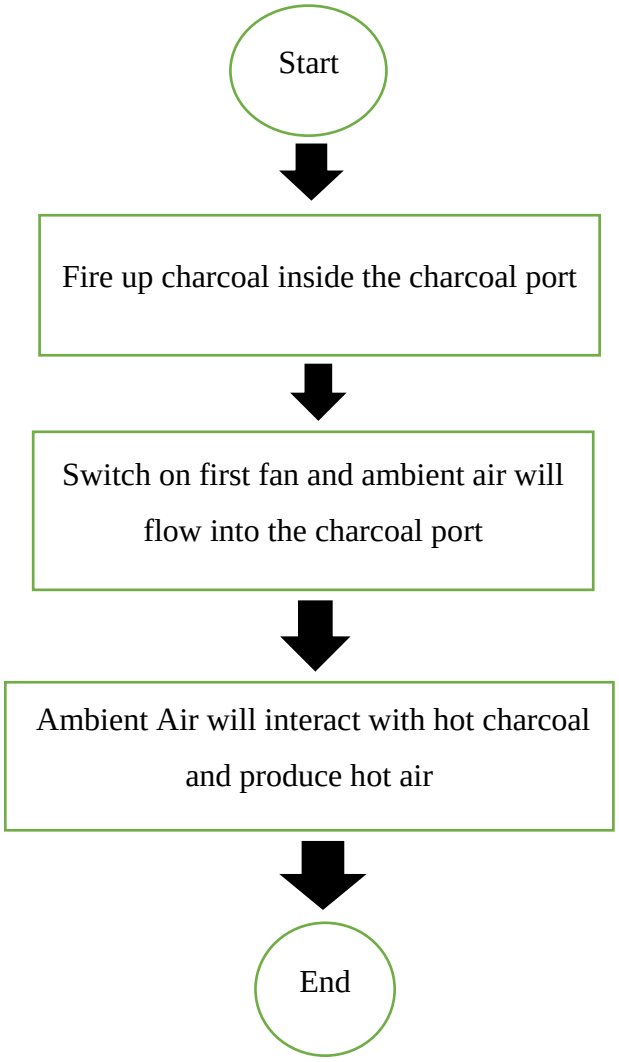

Figure 3.3: The Process for First Part of Barbeque (Charcoal System)

The Cooker and Hot Rack

On the other hand, the process inside of barbeque cooker will follow these three steps. Figure 3.4 illustrated process flow of cooker and hot rack components. Firstly, add grilled barbeque food inside the cooker. Secondly, switch on the second fan to allow hot air from the charcoal flow through damper and spread into cooker. Finally, the hot air will interact with the food and being recycle back to the hot rack inside the cooker to maintain the grilled barbeque food temperature.

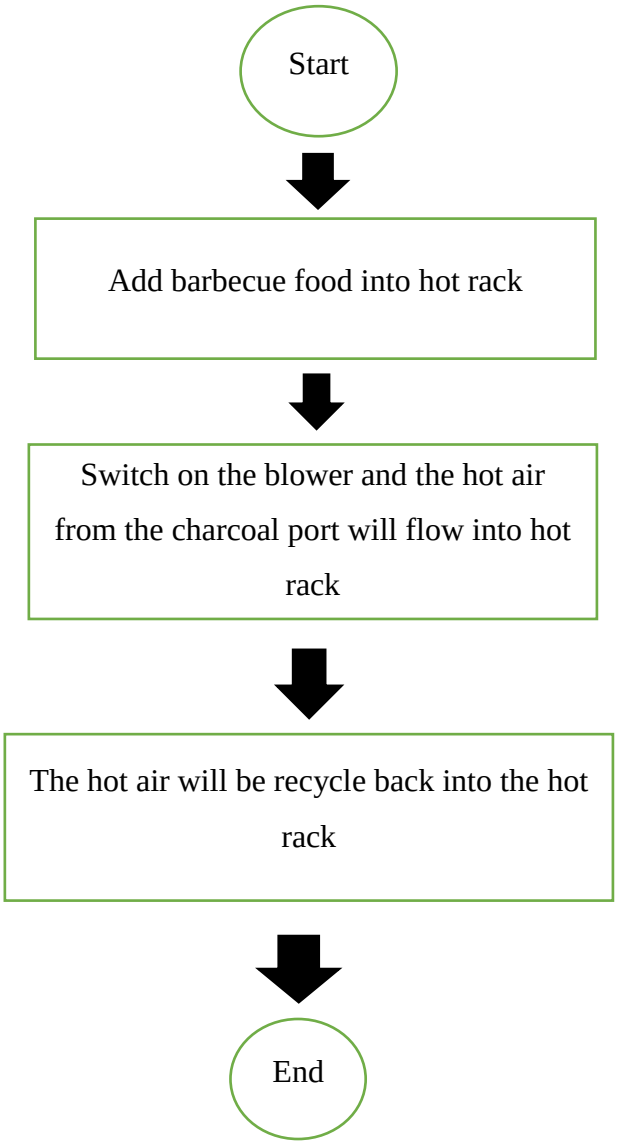

Figure 3.4: The Process for Second Part of Barbeque (Cooker and Hot rack)

3.6 The Design and Features of Charcoal Barbeque with Air Ventilation System

The design of a portable and flexible Charcoal Barbeque with Air Ventilation System comprising of three different parts of this charcoal barbeque set explicitly charcoal system and the cooker with air ventilation. The 3D drawing of the barbeque set was prepared using NX10 Modelling. Figure 3.5 shows front view of the poject system while Figure 3.6-3.8 illustrated right, left and isometric view respectively.

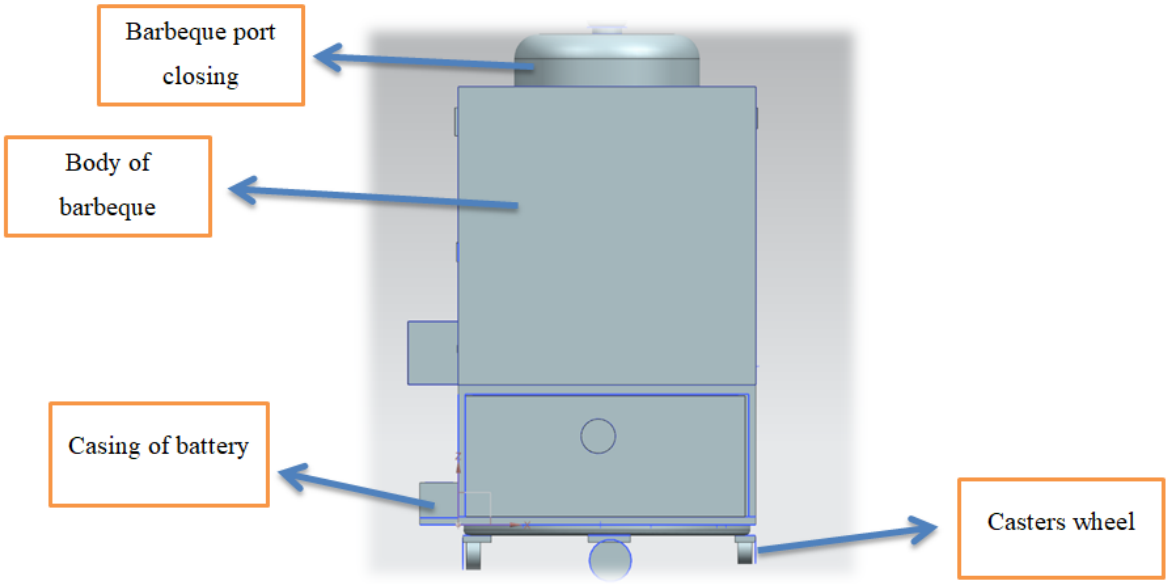

Figure 3.5: Front View of the Proposed System

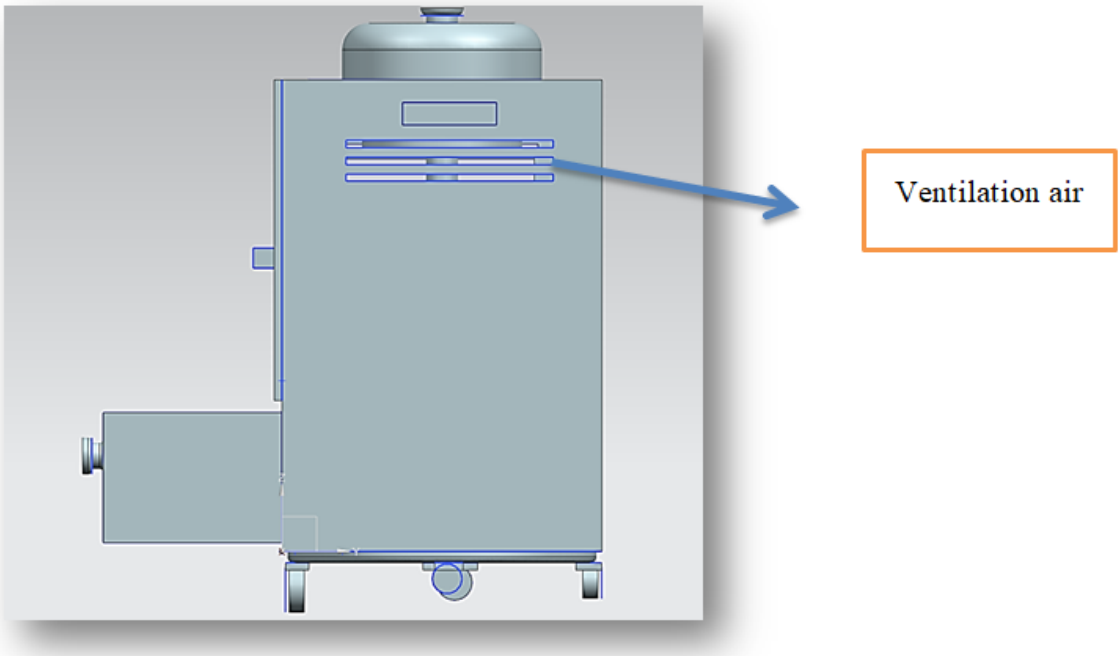

Figure 3.6: Right View of the Proposed System

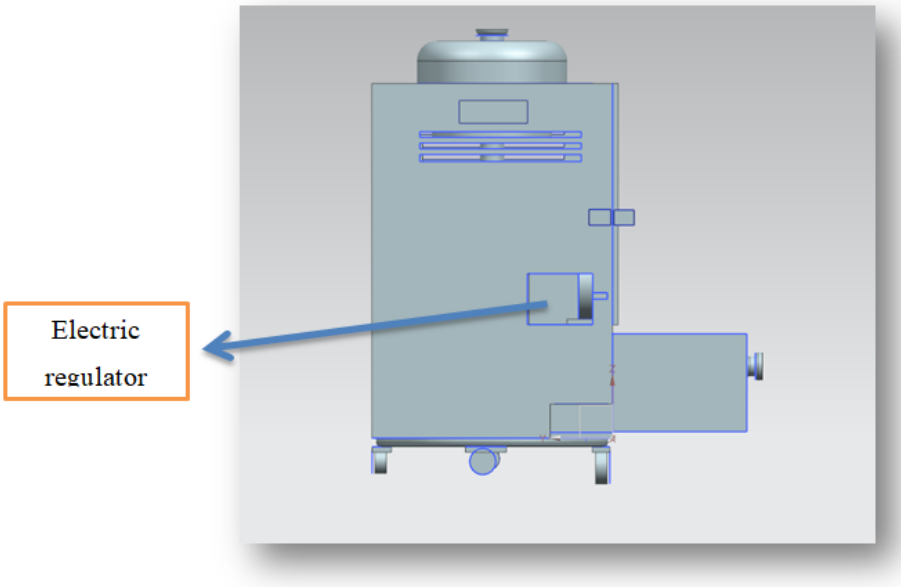

Figure 3.7: left View of the Proposed System

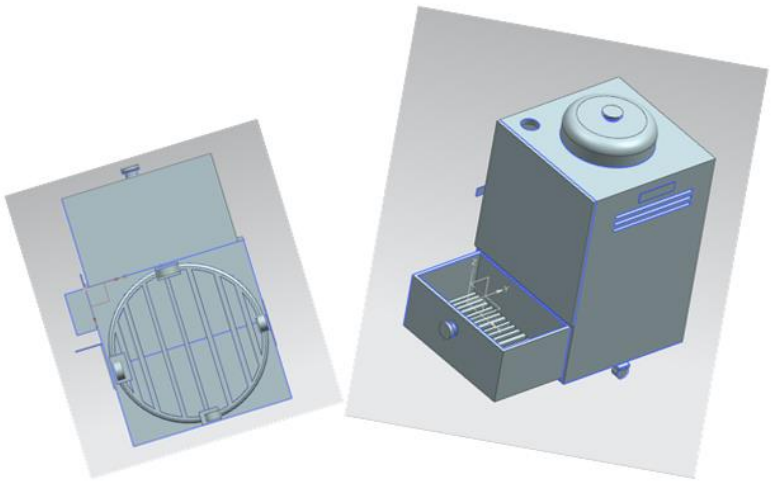

Figure 3.8: Isometric View of the Proposed System

Meanwhile, special features of the proposed Charcoal Barbeque with Air Ventilation System are mentioned as:

- Portable – Compact 85 cm diameter, 85 cm high barbeque.
- Simple to use – No manual fanning required.
- Safe – Exterior double-wall construction. Easy – Easy to assemble and cleaning.
- Healthy – Due to the special design of the charcoal port, excess fat cannot reach the charcoal.
- Environmental Friendly- Use of Coconut Shell Charcoal

3.7 Material Selection

After completing the designing stage of Charcoal Barbeque with Air Ventilation System, material selection was carried out to identify ideal equipment for prototype assembly. Material selection is based on price, size/dimension and quality. List of selected materials are as in Table 3.1.

Table 3.1: Material for Charcoal Barbeque with Air Ventilation System

Material	**Quantity**
Stainless Steel	10kg
Zinc	5kg
Barbeque bowl	1
Barbeque grill	1
Variable Speed Switch Control	1
Blower	1
Coconut Shell Charcoal	3kg
Casters Wheels 2"	3
Battery 9V	1

3.7.1 Cover Set Selection-Stainless Steel

The selection of appropriate material for the cover set is deemed vital to retain heat during barbecuing. According to Table 3.2, stainless steel was chosen over aluminum as a common cooking material based on the thermal diffusivity, α. Thermal diffusivity, α is the combination of the three properties: is the combination of the three properties:

$$\propto = \frac{k}{\rho} . Cp$$

k=Thermal conductivity, ρ=density, *Cp*=Specific heat

A material with high α is characterized by a quick response to the changes in surrounding temperatures. A material with low α characterized takes longer to reach a steady state condition, but is excellent at retaining heat once heated.

Table 3.2: Properties of Common Cooking Materials.

	ρ(kg/m^3)	k (W/mK)	c_p (J/kgK)	α(10^{-6} m^2/s)
Aluminum	2780	170	880	70
Cast iron	7870	70	450	21
Copper	8900	400	385	117
Stainless steel	8000	15	480	3.7
Glass	2600	4	800	1.9

3.7.2 Charcoal Selection

In this project, charcoal is use to fuel the barbecue set. Right selection of charcoal determine its efficiency. Thus, a comparison has been done to decide the best charcoal. According to Table 3.3, the coconut shell charcoal can be considered as the best type of charcoal for grilling because of its cost, efficient, and burning process. However, the natural coconut shell charcoal having size unevenly bring negative effect to grilling quality. Therefore, the Coconut Charcoal Briquettes were then suggested to use on barbeques. This sustainable charcoal is made from coconut shells, not wood. It is flavor neutral and generates virtually no smoke or ash. It is quick to light, hot burning

and can burns up between 500˚C to 600˚C for 3 to 4 hours (Coconut Shell Charcoal in Malaysia, 2012).

Table 3.3: Comparison of Types of Charcoal

		
Lump charcoal	**Charcoal briquettes**	**Coconut shell charcoal**
Expensive	Inexpensive	Inexpensive
Less efficient	More efficient	More efficient
Burn faster (1 hour)	Burn slower (1-2 hour)	Burn slower (3-4 hours)
Burns hottest (≥760°C)	Lower temperature (400˚C to 500˚C)	Lower temperature (500˚C to 600˚C)
Pure natural hardwood	Sawdust of scrap wood	Natural
Size unevenly	Size evenly	Size either evenly or unevenly
Burning with strong flame and smoke	Burning with smoke	Flameless and smokeless

(Source: Jenner, 2017)

3.8 Technical Analysis Planning

This subchapter shall clarified technical analysis planning to be carried out after completion of the Charcoal Barbeque with Air Ventilation System. There are three technical analysis deemed important to assess the efficiency and practicality of the barbeque set.

1. **Time Consumption Analysis for the Barbecuing.**

   The average cooking time consumption for the roasting process of Charcoal Barbeque with Air Ventilation System will be compared with the conventional barbecue.

2. **Performance testing of Heat Distribution Due to Different Air Flowrate.**

   Different air flow will be regulated in order to ensure installed fan running smoothly and capable to provide adequate air to the barbecue set. Simultaneously, the cooking quality of food will be determined. Undercooking meat, poultry and other foods can be very dangerous as it can contain harmful bacteria that can cause food poisoning. Thus, correct cooking temperature also will be determined to destroy these harmful microorganisms.

3. **Environmental Analysis**

   An environmental analysis also will be part of this project to detect any polluted gaseous emission of barbeque smoke by using toxic gas analyzer. The results will be compared with conventional barbecue. However, it is expected to generate less emission due to the application of coconut shell charcoal.

3.9 FABRICATION

3.9.1 Fabrication Structure of Charcoal Barbeque With Air Ventilation System.

Metal fabrication is the building of metal structures by dimentioning , cutting, joining, assembling processes. These value added processes including welding, cutting and machining are done in the workshop. The fabrication starts with shop drawing including precise measurements then move to the fabrication stage and finally to the installation of the final project.

3.9.1.1 **Welding**

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal.

In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized.

Many different energy sources can be used for welding, including a gas flame (chemical), an electric arc (electrical), a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space. Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

3.9.1.2 Piping System

A piping system is a network of pipes, fittings and valves intended to perform a specific job i.e. to carry or transfer fluids from one equipment to another. The plumbing network supplying water at your home is a common example of a piping system. Other more rigorous examples include steam piping in a power plant, milk piping in a dairy, paint piping in a paint manufacturing plant, oil piping in a refinery, so and so forth. Piping system may consist of a variety of materials including mild steel, stainless steel, aluminum, brass, copper, glass or plastic. Usually, pipe fittings and valves are made of the same material as the pipe. The material selection as well as pipe sizing depends upon parameters like nature of fluid, pressure, temperature and flow rate.

The piping system for this project is to flow the heat from charcoal port to the hot rack using the close loop system. This system construct of commonly available in 127mm (5inch), 177.8mm (7 inch), 50.8 (2 inch) and 101.6mm(4 inch). The charcoal port is connected by the pipe 5 inch in bottom of the charcoal port. Pipe was joined by ”5 x “7 stainless steel to reducer fitting was connected by hot rack.

3.9.1.3 Finishing

Surface finishing, a type of mechanical finish, is a traditional but very important technique in textiles. Calendering is the last step which determines the final appearance and handle of the fabric. Both the appearance and handle can be varied per the end user’s requirement by different types of calendering. Even after application of chemical finishes, the final appearance is decided by calendering. After the introduction of synthetics and their blends, calendering has lost its importance to a great extent. The calender gives a paper-like finish which is objectionable in many cases and therefore is substituted by a stenter finish, which gives the fabric fullness and a special type of feel or handle.

The simple thready appearance of a fabric can also be modified to imitate animal skin through sueding or emerising techniques, or it can be given a hairy appearance by napping or raising techniques which enhance the warmth of fabric.

For our project, we had used the spraying method as the finishing.the process need to be carefully handled so that the rust is removed completely. Later, the fabrication process continued with spraying.

3.10 COST ANALYSIS

Cost analysis is based on the simulation of our project and it shows the feasibility of to control the efficiency blower. The average contruction cost for barbeque with air ventilation ranges rm150-rm200 depending materials used. We still used stainless steel in certain part of barbeque but for curtain part we used zinc for save a cost.

The foremost outcome from this study likewise to develop an energy efficient barbeque set at the optimum cost of investment. Therefore, meticulous material selection was prepared through literature review from previous study and product market review. The quotation of materials purchasing were obtained from the local suppliers. Detail breakdown of material and costing for the development of Charcoal Barbeque with Air Ventilation System prototype is tabulated in Table 3.4 below. In overall, total cost involved is RM 367.00.

Table 3.4 : cost for project

NO	ITEM PURCHASED	COST(RM)	PER UNIT	TOTAL COST ITEM (RM)
1	barbeque bowl	25.00	1	25.00
2	barbeque grill	25.00	1	25.00
3	Variable Speed Switch Control	20.00	1	20.00
4	7500 RPM Cooling Fan	18.00	2	36.00
5	Coconut Shell Charcoal	8.00	3	24.00
6	Casters Wheels 2"	10.00	3	10.00
7	Battery 6V	31.00	1	31.00
8	stainless steel	14.00	10	70.00
9	zinc	7.00	5	35.0

3.11 ETHICAL CONSIDERATIONS

In order of us to complete our project there several work ethics should be follow. The priority was safety precaution while doing our project. Safety are the most important for student to be followed to make sure that there will be no accident in workplace. Next ethics consideration is that university rules. In our university there plenty of rules to be followed by student. For example, before get into workshop student should wear PPE (personal protective equipment) so ensure that student are protective for any object that might be harmful. Furthermore, there are also rules for student if their want ot use workshop. We should get the permission from the supervisor first. Next plagiarism is strictly prohibited in proposal writing because it may prevent the student to think out of the box and creatively.

3.12 GANTT CHART

Project activities	Weeks	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Verify the titles	Plan															
	Action															
Verify the supervisor	Plan															
	Action															
Discuss about the tittle with supervisor	Plan															
	Action															
Literature and theoretical study	Plan															
	Action															
Complete the proposal for project	Plan															
	Action															
Verify the panels	Plan															
	Action															
Submission of proposal	Plan															
	Action															
Proposal presentation	Plan															
	Action															
Complete the final report	Plan															
	Action															
Final report submission	Plan															
	Action															

Project activities	Weeks	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Hardware design	Plan															
	Action															
Construction of hardware	Plan															
	Action															
Collection of data by testing	Plan															
	Action															
Modification and evaluation	Plan															
	Action															
Complete the chapter 4	Plan															
	Action															
Complete the chapter 5	Plan															
	Action															

CHAPTER 4

RESULT AND DISCUSSION

4.1 DESIGN ANALYSIS

The design is then analyzed by doing simulation in nx10 software. NX, formely known as NX Unigraphic or usually just UG, is an advanced high-end CAD/CAM/CAE software package originally developed by Unigraphic, but since 2007 by Siemens PLM software. Itcan be used among other tasks, for :

- Design (parametric and direct solid/surface modelling)
- Engineering analysis (static; dynamic; electro-magnetic; thermal, using the finite element method; and fluid, using the finite volume method)
- Manufacturing finished design by using included machining modules.

Simulation is done on the base part which is the main part for the blower. A strong base is an important key to the structure. The base must be widely enough so that the body of barbeque is stable.

4.1.1 LOAD CALCULATION

The load main load that had been count is the charcoal port, hot rack and its holder which is made by ourselves, which are 500g and 800g. so, the total load had been assigned 1.3kg.

Force formula :

F = ma

Where;	F	=	Force
	m	=	Mass
	a	=	Gravitational acceleration

Force = 1.3kg x 9.81

= 12.753N

4.1.2 stress and deformation test

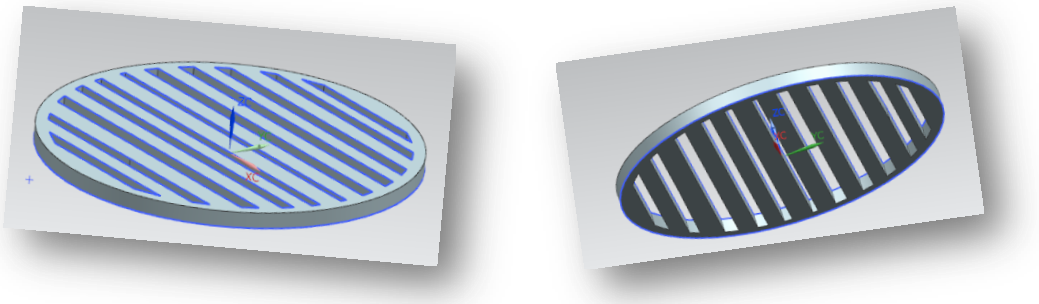

Figure 4.1 : Before run of simulation

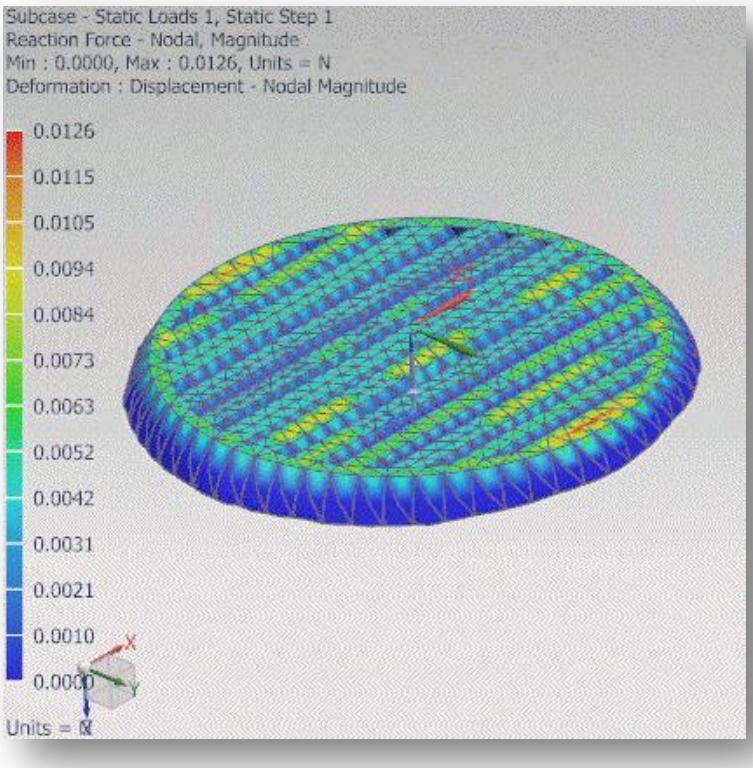

Figure 4.2 : reaction force of barbeque grill

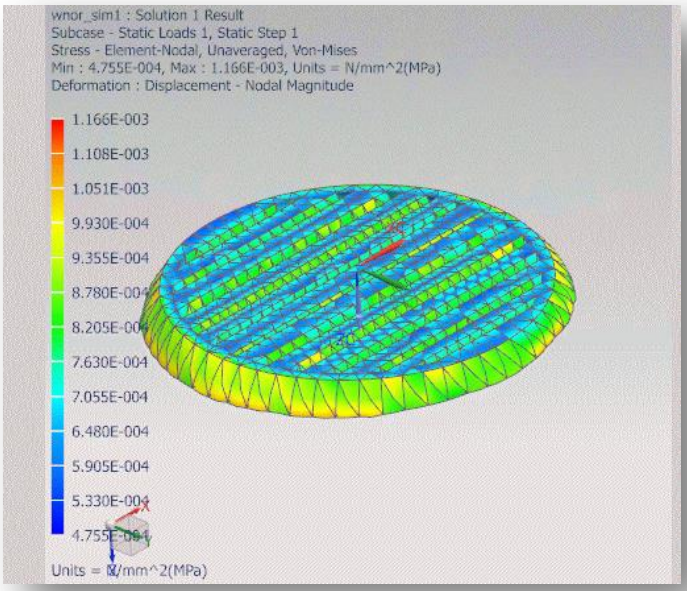

Figure 4.3 : stress – element –nodal, unaveraged, von mises of barbeque grill

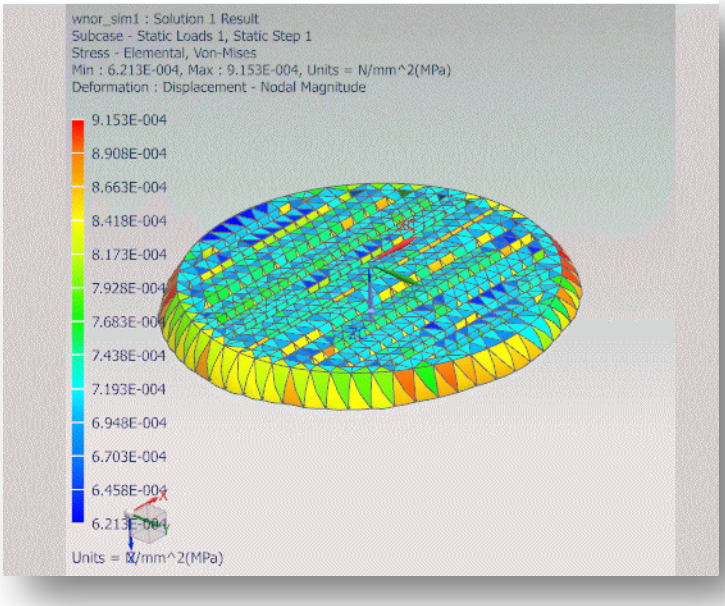

Figure 4.4 : stress – elemt, von mises of barbeque grill

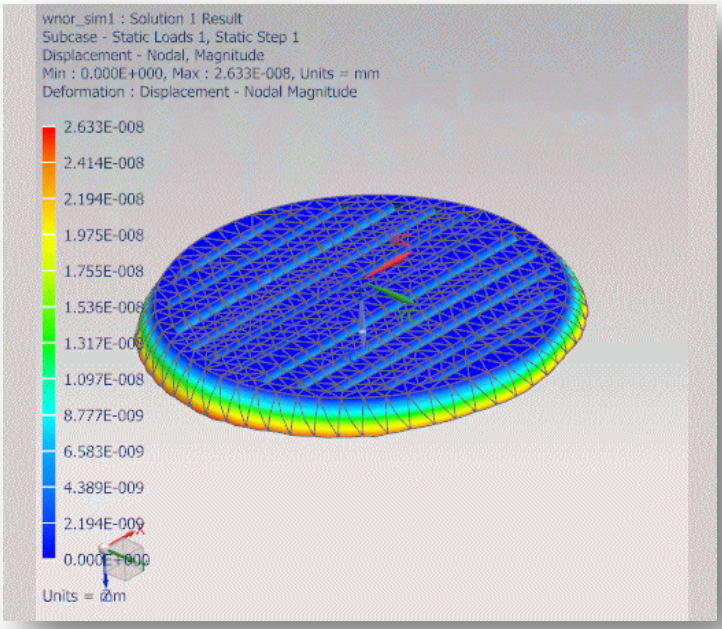

Figure 4.5 : displacement –nodal, magnitude of barbeque grill

Deformation testing evaluates the effect that load has on the shape of a sample. It is the measurement of a sample material to withstand a permanent deformation and/or the ability of the sample to return to its original shape after deforming. Deformation is measured as the percent change in height of a sample, under a specified load, for a specified period of time.

From figure 4.2 until 4.5 it shows that the main support is strong enough toresist the force from the load. The red zone shows the maximum pressure exerted by the main support and the blue zone shows the minimum caused by the load.. it can be concluded that the structure of barbeque grill is very strong and there will not be any deformation occur.

4.2 Efficiency of Barbeque With Ventilation System

The barbeque with ventilation system tested for 2 times and the average of the barbeque temperature of chicken and heat transfer and voltage. At first the data was taken in minimum power of battery and the second times we used the maximum power. The data was taken around 30minutes per test. From the result, the average of temperature of chicken and heat transfer heat time been given in figure 4.6.

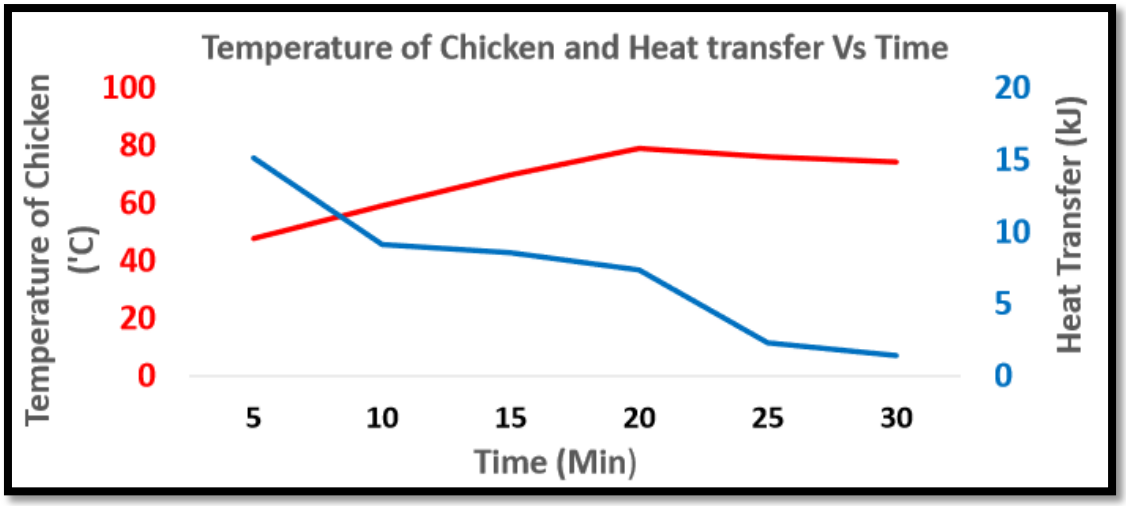

Figure 4.6 the ambient temperature of chicken and heat transfer vs time.

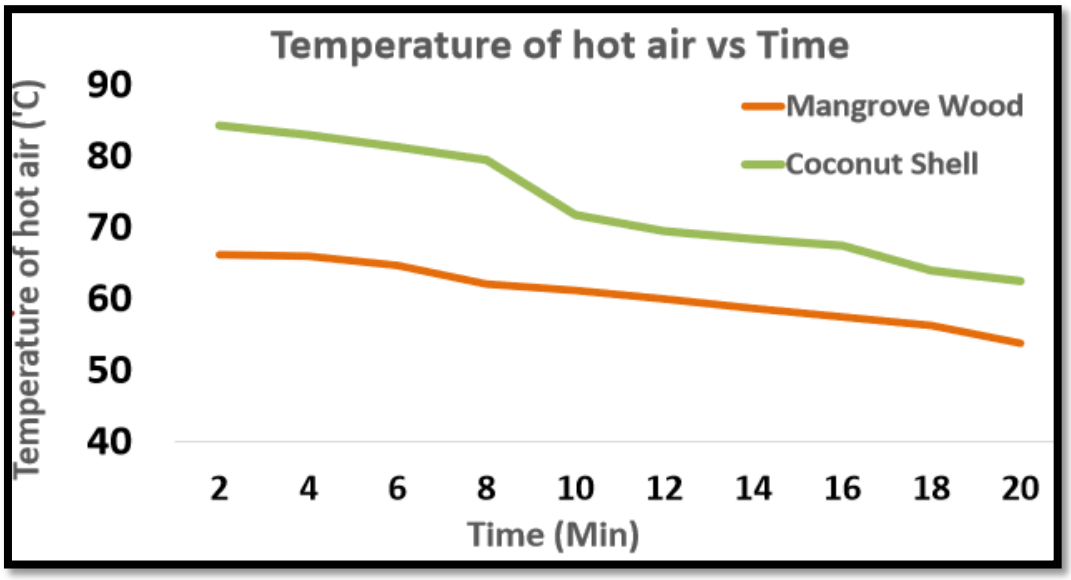

Figure 4.7 : temperature of hot air vs time.

The temperature of barbeque also effect the voltage and velocity of barbeque. The voltage of the barbeque is directly proportional with velocity. Therefore, when the voltage is increase, the velocity also increase. Figure 4.8 show the result.

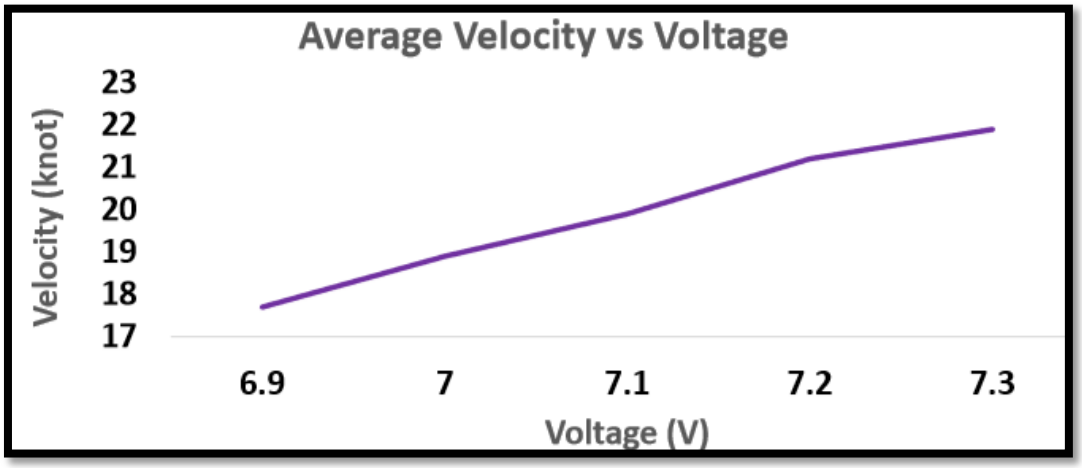

Figure 4.8 average velocity vs voltage.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The analysis of the structure of the barbeque with air ventilation system helps in identifying several factors that that need to be considered to build n effective ventilation system. The team were able to build the barbeque with air ventilation by using suitable material. The main purpose of choosing a correct material is to minimize cost while meeting product performance goals.stainless steel had been choosen as the best material for the body of barberque based on its properties that meet the project requirements. The stainless steel had enough strong to make the structure and stainless steel not to fragile when we start cook the product.

5.2 Recommendation

For this project, they are several recommendation should be taken into account in order to improve its efficiency. The first one is the design is portable charcoal barbeque with air ventilation system. Secondly, this project more efficient and user friendly to conventional barbeque set. This barbeque also is portable with easily and flexible for indoor and outdoor usage.

One of the major problem in building this project is conventional charcoal barbeque has low energy efficiency and produce smoke emission. It requires longer times to produce heat and low in heat distribution. The invention of gas and electric barbeque getting more popular over conventional barbecue. However, most gas and electric barbeque are non-flexible for indoor and outdoor usage.

The next recommendation is it can improve the quality of barbequing through the fitted blower and require no manual fanning like others conventional barbeque. We also have problem during assembly this product because in workshop there have nt enough uqipment so that we have to makeit at others workshop such as FIM workshop. A sensor also should be install instead battery since we don’t have any electric’s groupmate it will be our limitation but using a blower it enough for our project.

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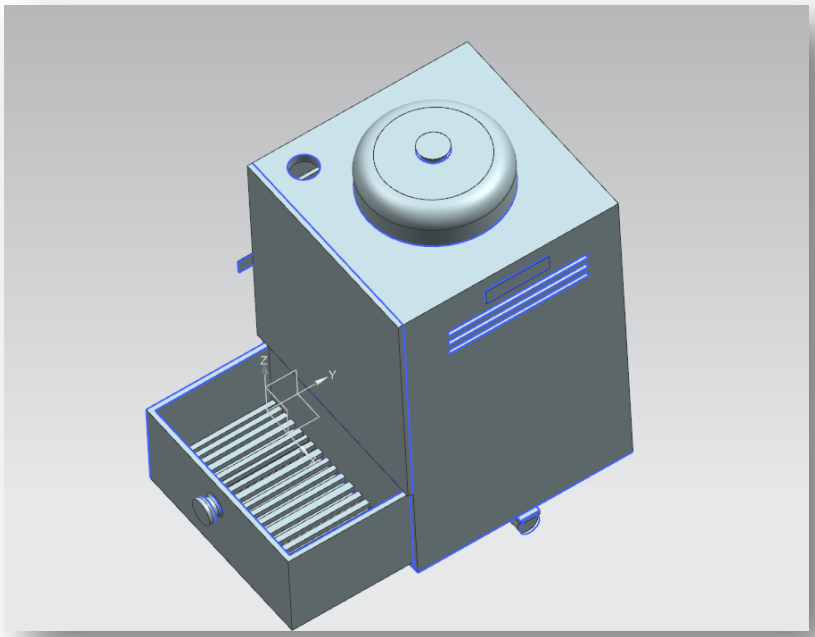
APPENDIX A

NX10 MODELS AND PHOTOS

NX10 Model of barbeque with air ventilation



barbeque Construction

Welding part

Welding part

Cutting the body

Cutting the part of the body using machine

Put the roller at the hot rack

Welding the body

Spraying the charcoal port

Srapying the body