DEVELOPMENT OF MOBILE CLEAN WATER SUPPLY UNITFOR FLOOD DISASTER VICTIMS

MUHAMMAD AMIR DANIAL BIN NAZARI

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY(AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical and Manufacturing EngineeringTechnology

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A thesis submitted
in fulfillment of the requirements for the degree of
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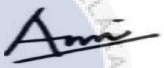
DECLARATION

I declare that this Choose an item. entitled " Development Of Mobile Clean Water Supply Unit For Flood Disaster Victims " is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	Muhammad Amir Danial Bin Nazari
Date	:	18 JANUARY 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature : 

Supervisor Name : Mohd Arizam bin Abdul Wahap

Date : 18 January

DEDICATION

To my father and mother

To Siblings

To Friends

And to Myself

ABSTRACT

In places where flood disasters occur often, a shortage of clean water is a concern. Some of the existing methods of supplying clean water may not be particularly successful as a result of the crisis, as well as location, infrastructure, and other constraints. For flood disaster victims, developing mobile clean water supply units may be an alternative option. The system is intended for raw water sources in flood-prone regions that need 7500 liters per day or 25 people. The design of this water purification system was based on current technology and research. Even if conventional procedures are used, it is critical to design a system that is mobile, easy to assemble and disassemble, and robust enough to transport the unit to disaster areas where it is needed. This design uses a turbo water pump to boost pressure, thus increasing the flowrate of the filter, but the filter was selected at random using a morphological chart based on market availability, assuming the area lacks power and clean water. The filter was being researched by another student, so the investigation is still continuing. After he confirms the filter selection, this design will utilize the chosen filter for this system, which is suitable for sanitation, cooking, and drinking despite utilizing polluted water as an input source. The connection between joints is the focus of this design, which can be easily assembled and disassembled due to the use of robust materials.

ABSTRAK

Di tempat-tempat di mana bencana banjir sering terjadi, kekurangan air bersih menjadi perhatian. Beberapa metode penyediaan air bersih yang ada mungkin tidak terlalu berhasil karena krisis, serta lokasi, infrastruktur, dan kekangan lain. Bagi mangsa bencana banjir, membangun unit bekalan air bersih bergerak boleh menjadi pilihan alternatif. Sistem ini ditujukan untuk sumber air mentah di wilayah yang dilanda banjir yang memerlukan 7500 liter sehari atau 25 orang. Reka bentuk sistem pembersihan air ini berdasarkan teknologi dan penyelidikan terkini. Walaupun prosedur konvensional digunakan, sangat penting untuk merancang sistem yang mudah alih, mudah dipasang dan dibongkar, dan cukup kuat untuk mengangkut unit ke kawasan bencana di mana ia diperlukan. Reka bentuk ini menggunakan pam air turbo untuk meningkatkan tekanan, sehingga meningkatkan kadar aliran saringan, tetapi saringan dipilih secara rawak menggunakan carta morfologi berdasarkan ketersediaan pasar, dengan anggapan kawasan tersebut kekurangan daya dan air bersih. Tapisan sedang diteliti oleh pelajar lain, jadi penyelidikan masih diteruskan. Setelah dia mengesahkan pemilihan filter, reka bentuk ini akan menggunakan filter yang dipilih untuk sistem ini, yang cocok untuk sanitasi, memasak, dan minum walaupun menggunakan air yang tercemar sebagai sumber input. Sambungan antara sendi adalah fokus reka bentuk ini, yang dapat dipasang dan dibongkar dengan mudah kerana penggunaan bahan yang kuat.

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In the Name of Allah, the Most Gracious, the Most Merciful

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
L	-	Litre
LPH	-	Litre per hour
GPD	-	Gallons per day
cm	-	Centimeter
mm	-	Milimeter
kg	-	Kilogram
Psi	-	Pounds per square inch
KW	-	Kilowatt
m^3	-	Cubic meter
m	-	Meter
ml/L	-	Milliliters Per Liter
Hz	-	Hertz
Hp,hp	-	Horsepower
L/min	-	Litre per minute
V,v	-	Volt
l	-	Length
w	-	Width
h	-	Height
QFD	-	Quality Function Deployment
VOC	-	Voice of Customer
HOQ	-	House of Quality
NTU	-	Nephelometric Turbidity Unit
PVC	-	Polyvinyl chloride
UPVC	-	Unplasticized polyvinyl chloride
HDPE	-	High Density Polythylene
	-	

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is physically positioned in the tropics near the Equator and, since it is still surrounded by the sea. Malaysia's east coast states get hit annually by monsoon rains between the end of the year 2020 and the early weeks of the new year. However, keep in mind that tropical rain usually comes in the form of heavy rain or thunderstorms, causing rivers to overflow. This will affect the residents living close to the river.

The flood-hit area in Malaysia is estimated at 29,800 km, or 9% of the country's total geographical area. Heavy rains from Siberia are sometimes brought to the peninsula by seasonal monsoon winds, which trigger seasonal monsoon floods on the east coast of Kelantan, Terengganu, Pahang, and East Johor. This is especially so in the East Coast region of the peninsula where the occurrence of such floods is considered a way of life (Chan, 1995). These are common and widespread, and they often turn into disasters, crippling the economy, communications, and public services, as well as causing property damage and death (Chan, 1996).

Vast capital development in urban area has diminished rain catchment area/ capability due to unstable surfaces, excessive rainfall, and insufficient water channels, the amount of water that can seep into the soil has been reduced, resulting in increased surface. When rivers and drainage systems are unable to deal with a sudden increase in water capacity in the catchment area, flash floods occur. Flash floods in Kuantan, Pahang, on December 25, 2012,

flooded several streets and buildings, causing retail malls to shutter their doors. By the end of 2013, the East Coast had been devastated by the worst flood in Malaysian history, rendering Kuantan almost immobile (See et al., 2017). In addition, there is a lack of drainage infrastructure. Existing infrastructure is often inadequate to handle newly developing regions. When the population grows, the infrastructure becomes insufficient, and floods become more often.

As a consequence of uncontrolled logging in hilly regions and large-scale rural agriculture, deforestation is being managed improperly. Flash floods in rural regions are caused by this. Moreover, trees play a role in the local water cycle by returning water vapor to the sky. Rainwater soaks into the soil and keeps it moist. Many complicated tree root systems help to preserve rich soils. The soil is now exposed to direct sunshine until the tree cover is removed, allowing it to dry. In the lack of trees, erosion happens often, washing the soil surrounding rivers and streams. A forest serves as a natural water purifying plant. Soil erosion exposes contaminants to the soil, which then seep into the water supply, contaminating our drinking water(*Deforestation - Causes, Effects and Solutions To Clearing of Forests - Conserve Energy Future*, n.d.)

According to the article from myMetro, when the river water level reaches a dangerous level, people along the river are usually advised to evacuate to the closest flood evacuation center. Angkatan Pertahanan Awam (APM) is in charge of rescue operations as well as serving as the secretariat for data collection on flood victims who have relocated. According to Mohd Arif, his party also works closely with other security authorities such as the Kelantan Jabatan Saliran (JPS) dan Saliran dan Jabatan Kebajikan Masyarakat (JKM)(*7,000 Mangsa Banjir Dijangka Pindah*, n.d.). However, theirs is a group of family leaders who would examine their homes in their free time with the authorities' approval to verify that they were secure and free of any strange events. No burglary or theft will occur

due to flooding. According to Kerian District Police Chief Superintendent Mazuki Mat, the action is also intended to reduce the crime of property theft while a home is empty(*Mangsa Banjir Tinjau Rumah Elak Diceroboh*, n.d.).

1.2 Problem Statement

According to this article, there are lack of clean water for flood victims, especially those in evacuation center according to Rosmah Sijam, 41. She said that just drinking water was provided, but that the availability of water for other purposes was uncertain, since toilet water was also unavailable. There is also no water accessible for bathing or sanitation(*Mangsa Banjir Di Kota Belud Kecewa Bekalan Air Di Pusat Pemindahan Tidak Mencukupi | Astro Awani*, n.d.). Without drinkable water, the health of the visitors will be gravely harmed, and their capacity to carry out everyday activities may be harmed as well. Because most of the water sources have been polluted by flood water and are unfit for household use, particularlydrinking, lack of access to clean water is a serious concern.

Furthermore, water sources contaminated with high silt and suspended solids will make water treatment procedures more difficult because excessive turbidity makes appropriate treatment impossible. Water with a foul odor and taste is contaminated and contains germs. As a result, proper water treatment is required before use to remove disease-causing chemicals. Extreme flooding events may result in current transportation infrastructure disasters. Flood victims will lose communication with the authorities as a result. Clean water eventually could not reach the flood victims. After a flood, the process of restoring water delivery infrastructures is a problem for water providers. Due to the severe flooding that occurred, the area will be severely impacted. Due to this circumstance, fixing the water treatment plant would take a long time and there will be a delay in distributing water to flood-affected communities. In terms of health, the emphasis on water scarcity has forced

victims to drink water of uncertain hygienic quality, most water sources are filthy. This situation makes the sufferer susceptible to a variety of ailments, and it will increase the number of people who need immediate medical attention during the flood.

1.3 Project Objective

Specifically, the objectives are as follows:

a) To design mobile clean water supply unit for flood disaster victims.

b) To analysis mobile clean water supply unit.

c) To fabricate the prototype.

1.4 Project Scope

The scope of this research are as follows:

- To design mobile clean water supply unit using SOLIDWORKS.
- To optimize strength analysis using SOLIDWORKS.
- To fabricate the prototype using selected material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is focusing on the research and design of a water filtration device for flood victims based on the design parameters. The data gathered was analyzed to determine the methods and systems that will be needed to develop or build a new water supply system design. The aim of this project is to create a clean water delivery system using flood water as a source which the system should be mobility, ease of assemble and disassemble and robust. Furthermore, research was conducted on a previous project titled "mobile water filtration system," which was the source for the system structure and guidelines for designing this system. Journals and academic papers were used to collect knowledge about solutions to apply the latest technology in order to further understand the project's core and findings. Suggestions from a prior project also provided a fresh outlook on approaches and improved the project's design.

2.2 Overview

A flood is one of the most dangerous natural disasters. It occurs when an excessive amount of water is gathered in a certain region. It often occurs as a result of severe rain. River overflows are creating widespread flooding in rural regions, resulting in this natural disaster. Infectious organisms such as E.coli, Salmonella, and Shigella, as well as the Hepatitis A Virus and typhoid, paratyphoid, and tetanus agents, are often found in flood water. The majority of illnesses linked with floods are caused by consuming polluted food or water. Agricultural or industrial chemicals, as well as hazardous agents found at flooded hazardous

waste sites, may pollute floodwaters. After that, the flood victim is moved to one of the flood settlements. The number of personnel stationed there is increasing every day, exacerbating the issue of a shortage of safe drinking water. This initiative was developed to filter flood water and give clean water to those who needed it.

2.3 Water Treatment Process

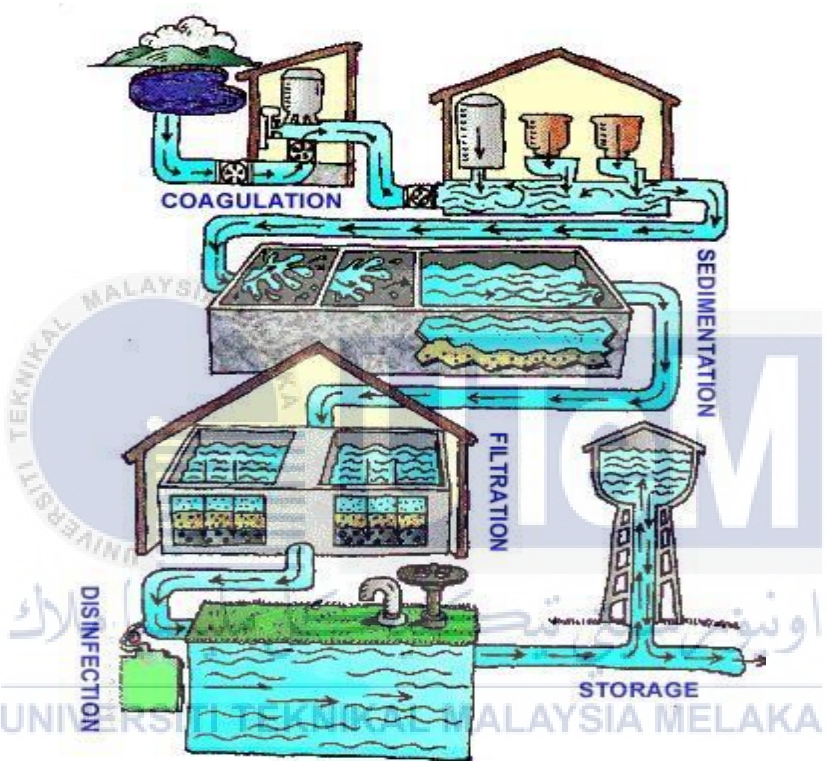


Figure 2.1 Example of water treatment process(Water Treatment | Public Water Systems | Drinking Water | Healthy Water | CDC, n.d.)

This article explains that a typical surface water treatment facility includes procedures such as coagulation, flocculation, sedimentation, filtration, and disinfection. Drinking water sources may be contaminated, and disease-causing chemicals must be removed with proper treatment. To supply safe drinking water to their communities, public drinking water systems use a variety of water treatment techniques.(*Water Treatment | Public Water Systems | Drinking Water | Healthy Water | CDC*, n.d.) The following are the most frequent water

treatment processes employed by community water systems today (mostly surface water treatment):

• Coagulation and Flocculation

The initial stages in water treatment are typically coagulation and flocculation. Positively charged chemicals are introduced to the water. The negative charge of dirt and other dissolved particles in the water is neutralized by the positive charge of these substances. When this happens, the particles bond with the chemicals and produce floc, which are bigger particles.

• Sedimentation

Due to its weight, floc sinks to the bottom of the water supply during sedimentation. Sedimentation is the term for this settling process.

• Filtration

The clear water on top will flow through filters of various compositions (sand, gravel, and charcoal) and pore diameters to remove dissolved particles such as dust, parasites, bacteria, viruses, and chemicals after the floc has fallen to the bottom of the water supply.

• Disinfection

After the water has been filtered, a disinfectant (such as chlorine or chloramine) may be added to kill any residual parasites, bacteria, or viruses, as well as to protect the water from pathogens when piped to homes and businesses.

2.4 Traditional Water Treatment Methods

Rural communities all throughout the globe have developed basic and primitive treatment techniques aimed primarily at removing obvious pollutants from water collected from local sources. Though these traditional approaches are time-saving and may remove some kinds of particles from water, they do not always give water of a quality that is acceptable to these rural populations, and in most situations, a simple disinfection step may produce water free of viruses (*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.). Here, some of the traditional treatment methods are:

i) Filtration through winnowing sieve (used in widely in Mali)

ii) Filtration through cloth (commonly used in villages in India, Mali and the southern part of Niger).

iii) Filtration through clay vessels (used in Egypt)

iv) Clarification and filtration through plant material (commonly used in Tamil Nadu and Kerala, India)

v) Jempeng stone filter method (used in Bali, Indonesia)

2.4.1 Filtration through winnowing sieve

When the water supply is contaminated by wind-borne contaminants such as dried leaves, stalks, and coarse particles, this method of filtration is utilized. The contaminants are cleaned out of the war water using a winnowing sieve. This sort of filter is extensively used in Mali's Bamaka region's communities. Because the sieve cannot filter tiny suspended particles in

raw water, this technique cannot be employed when the raw water is excessively turbid or muddy(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

2.4.2 Filtration through Cloth

The filter medium is a white cotton fabric or a discarded clothing. This filter can remove contaminants including plant debris, insects, dust particles, and coarse mud particles from raw water. Filtration of suspended particles in water can only be accomplished to a small extent. As a result, this method of filtration is ineffective in excessively turbid water. It works well for filtering of well water. Cloth filtration is widely used in communities throughout India, Mali, Niger's southern region, and likely many other parts of the poor world. If the raw water is dirty and smelly in certain Indian areas, wood ash from the Sal tree (shora robuta) is combined with it and then filtered through cloth(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

2.4.3 Filtration through Clay Vessels

Highly turbid water is occasionally filtered using clay containers with an appropriate pore size. Turbid water is collected and allowed to settle in a large clay jar. The water in the jar will then flow out through the permeable clay wall. This trickling water is gathered in a vessel (often a clay pot) by pouring it into the porous clay jar's bottom. In Egypt, this form of water purification is widely used (*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

2.4.4 Clarification and Filtration using Plant Parts

In certain of the southern parts of Tamil Nadu, India, very turbid water with tiny suspended and colloidal particles is first coalesced and settled out using the nuts of a locally accessible plant, and then filtered using cloth filters. Soaking nuts causes them to produce complex

compounds, which is what accomplishes the job, according to studies. Similarly, ramachham (Vetiveria zizanoides) rhizomes' wiry roots are put in a clay jar with small holes on the bottom. This jar is filled with raw water, which is then allowed to filter through the layer of roots. The water then trickles down through the small pores at the jar's bottom. At the bottom of the jar, the filtered water is collected. This filtered water is usually crystal clear and has a lovely aroma. In Kerala and Tamil Nadu, India's southern provinces, this type of water filtering is widely used(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

2.4.5 Jempeng Stone Filter Method

This type of water filtration method is develop in Saringan batu Jempeng, Bali, Indonesia. Here, a small artificial pond or a by-pass channel is cut by the side to an irrigation canal, which carries muddy water (Figure 2.2).

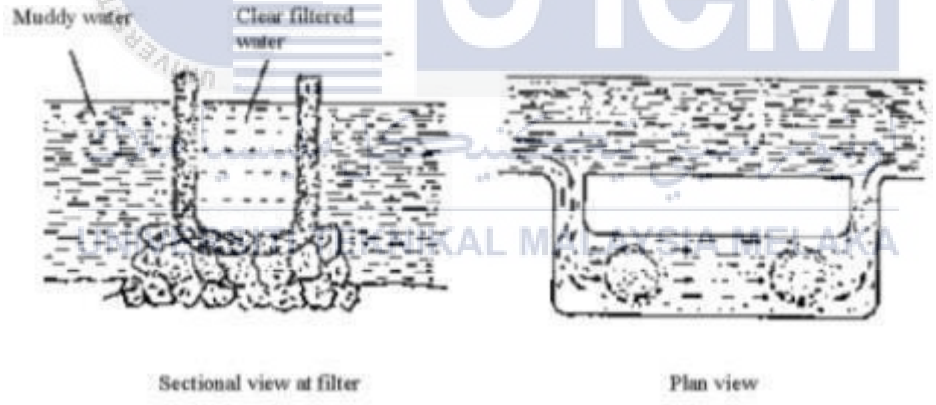


Figure 2.2 Jempeng stone filter(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

In the artificial ponds, Jempeng stone filtration units are installed. The filter unit is made of cadas, which is a porous material. The usual height of this unit is 60cm, with a diameter of 50cm and a wall thickness of 10-20cm. This unit sits upon a gravel bed that is supported by stones. Muddy water filters through the filter unit's porous wall and collects within. This sort of machine may be used to treat the water in a hamlet. It can even handle very murky water.

The key advantage of this unit is that the only expense is the initial investment. Cleaning is not included in the operating or maintenance expenditures(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

2.5 Household Water Treatment Methods

The development of several inexpensive home water purification systems has resulted from a knowledge of the problems faced in delivering water to rural people in poor nations. These approaches generally aim to improve on previous conventional domestic ways for creating microbiologically safe drinking water (*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.). Some of these household techniques include:

vi) Filtration and siphoning technique

vii) Coagulation and sand filtration unit

viii) Water filter canister

ix) Household slow and filtration unit

x) Household defluoridator

Household water treatment units should not be regarded the final answer for rural water supply since most rural people cannot afford them and lack the knowledge to utilize them. At most, the home treatment method may serve as a stop gap measure until community-scalewater treatment facilities are built.

2.5.1 Filtration and Siphoning Technique

A small filter device is inserted in this storage jar below the water level, and raw water is kept in a clay jar with a rigid plastic tube. A thin cloth or a piece of cotton put in such a way that it can filter the water may be used as the filter medium. The hard tube's opposite end is joined to a flexible plastic tube and inserted into a filtered water storage tank (Figure 2.3). The raw water storage jar is positioned below the level of the filtered water tank. Water may be made to flow from the raw water storage jar to the filtered water storage pot by creating a suction at the outlet end of the flexible plastic tube with a tiny rubber bulb. The coarse particles will be sedimented first in the raw water jar throughout the procedure. The filtration mechanism then filters the suspended particles present. This approach may be utilized on waterways with low to medium turbidity. The quantity of household water needed determines the unit's size. The filter unit must be changed if it becomes clogged(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

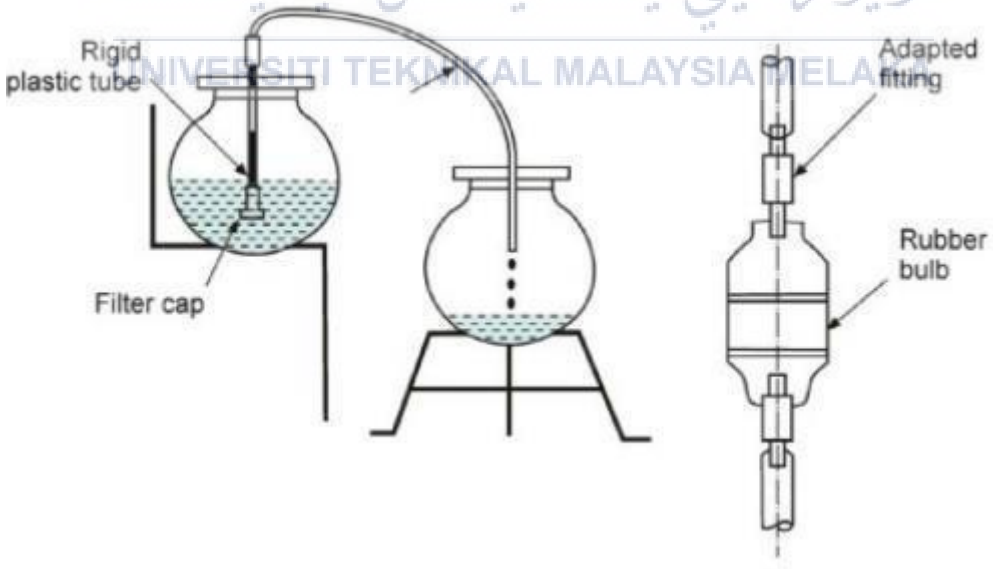


Figure 2.3 Filtration and siphoning arrangement(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

2.5.2 Coagulation and Sand Filtration Unit

A coagulant is added to raw water before it is put into a galvanized iron drum. In this drum, the settling takes place. The settling water is collected and transferred to a meshed sand filter unit through a PVC pipe attached to the drum (Figure 2.4). The filtered water is collected in a clay pot that is submerged in the filter unit. This filtered water storage container is usually equipped with a tap at the bottom for water extraction. The media and cloth are cleaned and reused when the filter unit becomes clogged. This system can filter waters with a medium turbidity, and it may be shared by two or three households of four to five people each. The pure water collected by the machine may be consumed or utilized in the kitchen(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

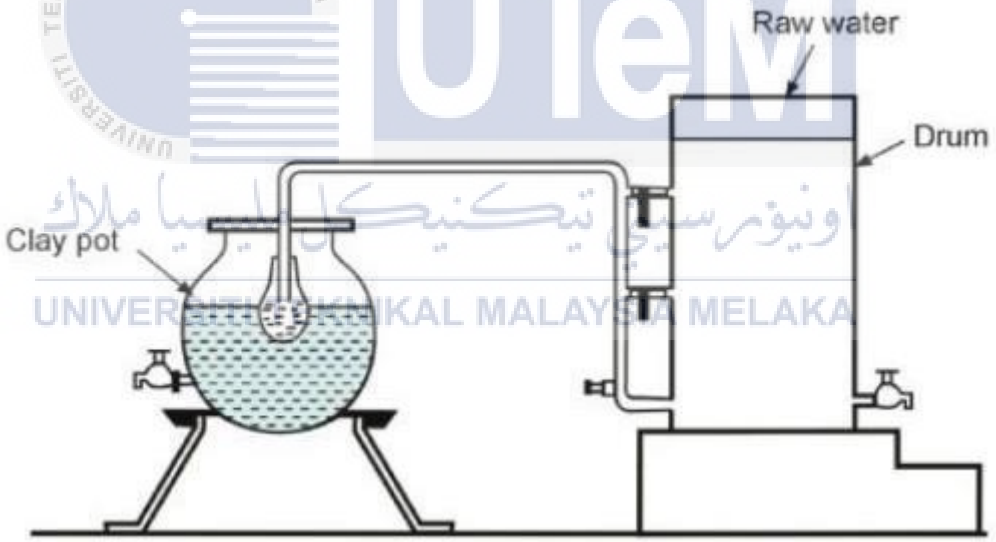


Figure 2.4 Coagulation and filtration unit(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

2.5.3 Water Filter Canister

Figure 2.5 shows a water filter canister that was designed for individual troops in the field, distant from any field water treatment installations. Intermittent usage of canisters generates alternative wet and dry circumstances that aid in the regeneration/recuperation of the media, resulting in consistently good water quality over time. Farmers who must labor in their fields throughout the day, or miners who must work in a mine - groups of workers who are likely to be away from their clean drinking water sources – might use the canister design.

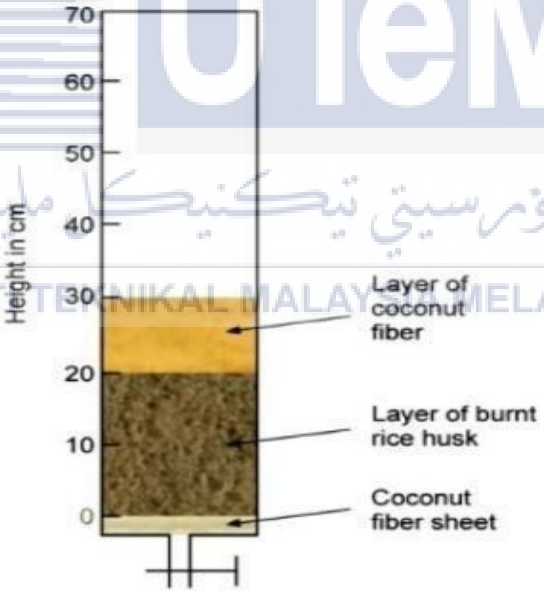


Figure 2.5 Water filtration canister(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

2.5.4 Household Slow Sand Filtration Unit

2.5.4.1 Indian Deign

This sort of water filtration system is intended for a household of four with a daily waterconsumption of 10 liters per person. The main components of this unit are:

- Raw water storage drum
- Filter box with inlet and outlet control valves
- Visual aid
- Collection tank

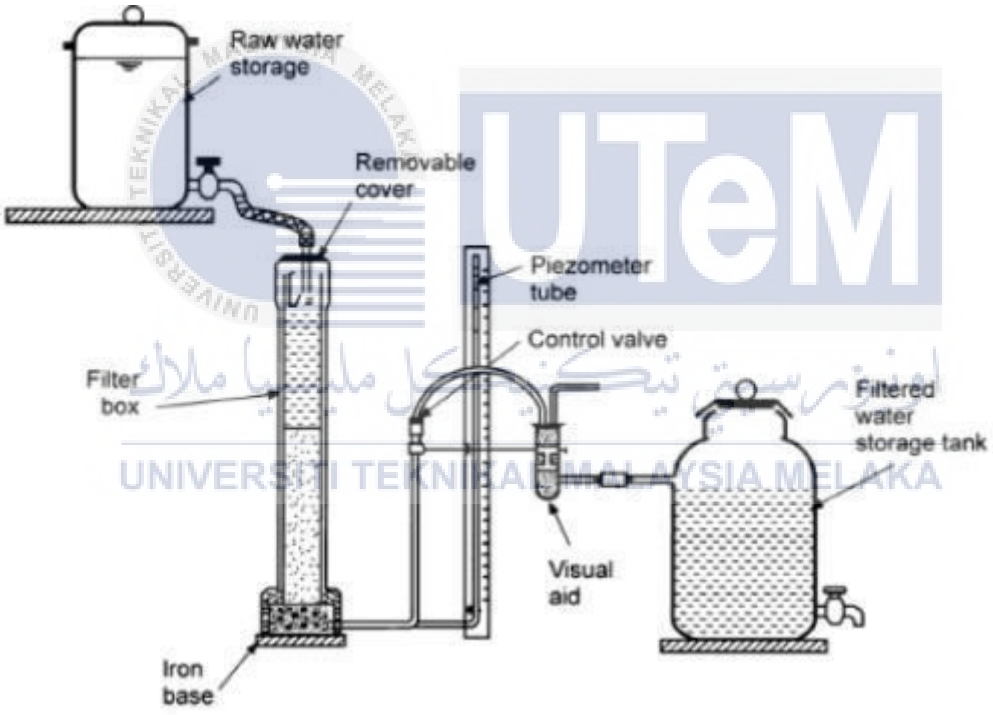


Figure 2.6 household filtration unit – Indian design(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

With the aid of an intake control valve, raw water from the storage drum at an elevated position flows to the top of the filter box. The filter box is built of a circular asbestos-cement or PVC pipe with gravel at the bottom as a supporting medium and sand on top as a filter medium. It works as a traditional slow sand filtration unit with a continuous operating cycle. Water is collected at the bottom of the unit after trickling through the sand bed. The unit's output is attached to a piezometer tube and a visual aid that aids in flow rate management. The flow rate may be simply adjusted by glancing at the visual assistance unit. The functioning of this filter unit is simple enough that it may even be done by non-technical individuals (*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.).

2.5.4.2 Thailand Design

The Thai home filtration unit is separated into two phases, the first of which is coarse sand filtration and the second of which is found sand filtration. The unit is shown in Figure 10 as having two filter compartments, one of which is integrated into the clear water storage.

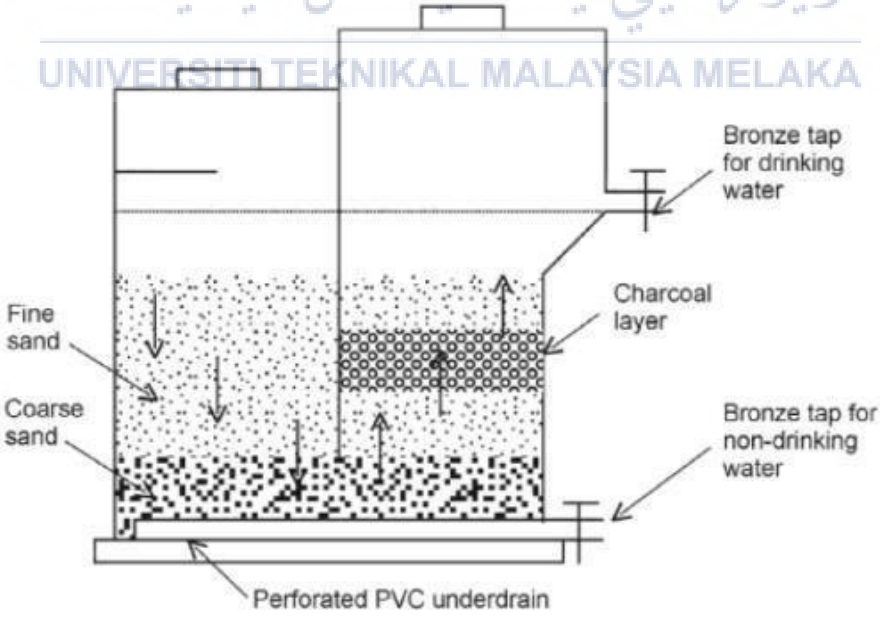


Figure 2.7 Household filtration unit (Thai design)(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

When the raw water includes colorful or odorous components, charcoal is utilized. The filter has a total capacity of 50L and a clean water storage capacity of 15L. The fact that water for non-drinking purposes may be obtained after it has been partly filtered in the first stage of the unit, while drinking water may be obtained after it has been filtered in both stages, is an unusual element of the design of this unit. As a result, the filter's operating time is extended.(*Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books*, n.d.)

2.5.5 Household Defluoridator

Thailand has invented a low-cost, basic defluoridator that decreases fluoride levels and produces water that is pure, colorless, odorless, and has a better flavor. This defluoridator employs charcoal and charred bone meal and is based on filtration and adsorption principles(See Figure 2.8).

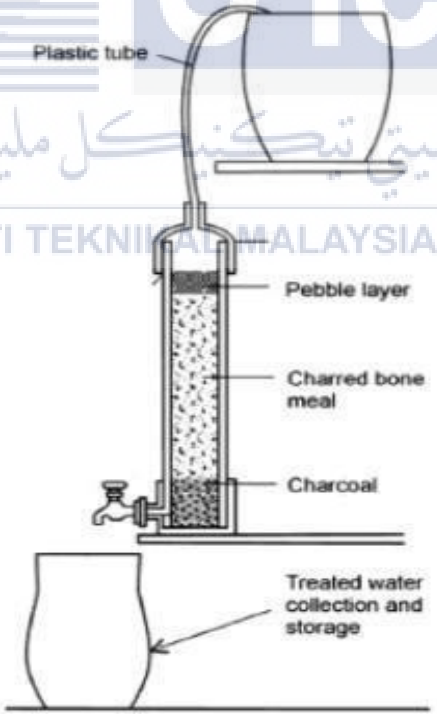


Figure 2.8 Household defluoridator(Wastewater Recycling, Reuse, and Reclamation - Volume II - Google Books, n.d.)

A container plus a filter make up the unit. The container is comprised of a 75cm long, 9 cm diameter PVC pipe with a bottom outlet tap and a top cap with a tiny hole for water input. The filter is made up of three layers: a bottom layer of 300g crushed charcoal for color and odor absorption, a middle layer of 1000 g charred bone meal for fluoride adsorption, and a top layer of around 200g clean pebbles to keep the intermediate layer from floating. A short plastic tube is used to siphon raw water from a clay jar to the top of the defluoridator, resulting in a flow rate of around 4L per hour. The defluoridated water is collected in a separate jar just next to the faucet. Fluoride levels were reduced from 5 mg/L to less than 1 mg/L in laboratory size trials using this flow rate for a total amount of 480L. The first 15 or 20 liters of water are usually dumped, leaving clean, odorless water that may be utilized for drinking or cooking. Depending on the fluoride level in the raw water and the volume of water used, the filter may last up to three months(*Wastewater Recycling, Reuse, andReclamation - Volume II - Google Books*, n.d.).

2.5.6 Concrete bio sand filterwater recovery

In this article, the biosand filter is smaller (approximately 1 m tall, 0.3 m broad on each side) and has been modified so that it does not continually flow, making it appropriate for use in people's homes. A concrete or plastic filtration container may be used. It's layered with sand and gravel that's been carefully chosen and processed. The sand cleans polluted drinking water of germs and suspended particles. The top 2 cm of sand supports a biological ecosystem of bacteria and other microbes. The biolayer is what we call it. Many pathogens in the water are eaten by the microorganisms in the biolayer, making water treatment more effective. At least once a day, contaminated water is put into the top of the biosand filter (but not continuously). Water falls gently through the perforations in the diffuser and down through the sand and gravel when it is poured into the top of the filter. The exit tube

discharges treated water. There is no need for electricity since the filter is powered by gravity. This biosand filter can produce 12 L - 18 L per hour and able to remove 100% of helminths(worms), 100% of protozoa, 98.5% of bacteria and 70-99% of viruses. The cost of BSF was also minimized by using the last form, a sari cloth with a pore size of 20 microns. The bacteria were consumed by the cloth, which had a p pores of 20 microns. It reduced turbidity to 5 NTU with a dosage of 3–24ml/L, according to the findings(Centre for Affordable Water and Sanitation Technology (CAWST), 2009)

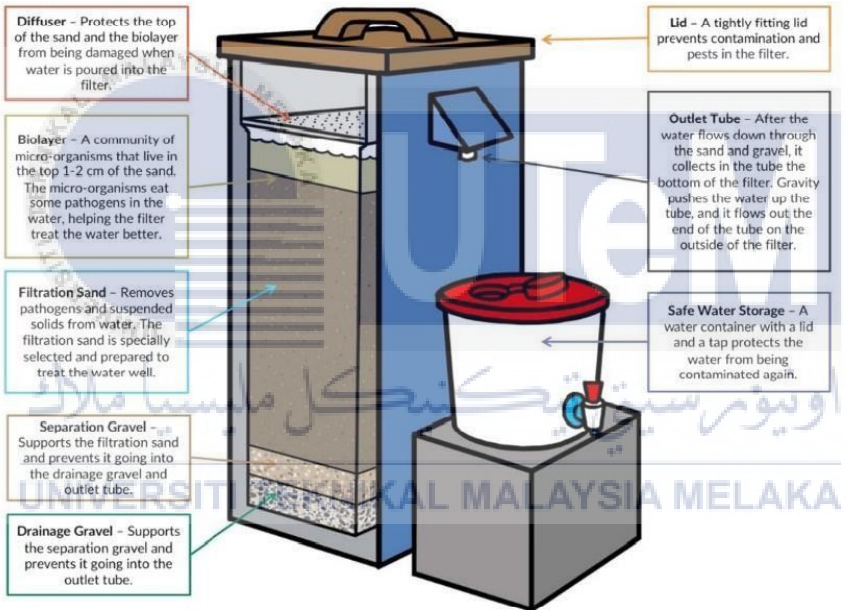


Figure 2.9 Bio-sand filter components(CAWST | Biosand Filter Information, n.d.)

2.6 Latest Technology Water Treatment Method

The system uses a mix of mechanical and electrical components, which helps to improve the production capacity of clean water, according to the most current water treatment

technology. The water quality of drinking water is improved by a high-pressure pump with robust material pipes and a variety of filters that are connected to each other.

2.6.1 MSWT-01 (MOBILE SURFACE WATER TREATMENT)

According to this article, the MSWT-01 (Mobile Surface Water Treatment) Prototype for Disaster Mitigation was produced by a combination of RWT-05 and WWT-01 previous products. It is developed for a river or surface raw water source in a flood region, with a capacity of 1 m^3 per hour or 18-20 m^3 per day, or 100-150 man needs. This product is capable of producing clean water that is suitable for sanitation and cooking/drinking purposes. As part of the cost-cutting purpose, the research has streamlined its system so that the flocculation chamber and turbo mixer, which are both rather costly, will not be employed in MSWT-01. Due to the maintenance component, it is also important to consider appropriated with local parts availability. Combining the mechanical and electrical properties of RWT-05 and WWT-01 might be a viable starting point for building a "new subvariant" prototype for disaster mitigation termed MSWT-01 (Mobile Surface Water Treatment) with (1400x1550x1800) mm size. The research must still demonstrate experimentally that the only new component required is a sieve filter, but due to its unavailability in the local market, another form of screen filter with no automated self-cleaning capabilities will be employed(Ananto et al., 2012). As an alternative to replacing the turbo mixer and

flocculation chamber, a sedimentation tank might be used to make the sand filter performance longer, as shown in Figure 2.10.

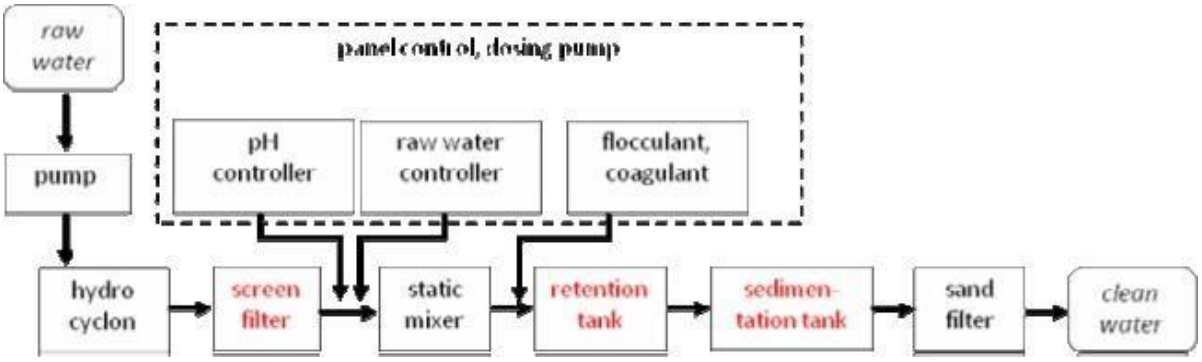


Figure 2.10 MSWT-01 for Disaster Mitigation Block Diagram(Ananto et al., 2012)

In some circumstances, such as an area with a high turbidity flood water supply, a sedimentation tank might be added to the system. In this situation, the sedimentation tank may simply be attached to the main unit as shown in Figure 2.11, making the unit replaceable. It has been proven via a series of prototype-level experiment experiments. In order to get to the next step, more samples that reflect current real-world catastrophe conditions are required. It might be supplemented with a sedimentation tank and a disinfection system if required. All of this has the potential to be much better. In addition to being more efficient than earlier methods, it also contributes to energy conservation in general.(Ananto et al., 2012)

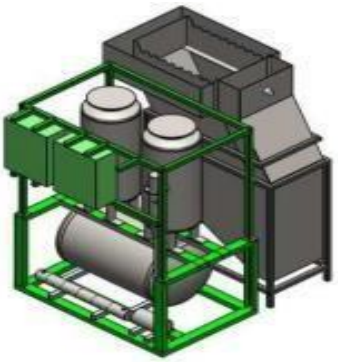


Figure 2.11 MSWT-01with Sedimentation Tank mounted.(Ananto et al., 2012)

2.6.2 Sustainable mobile water maker

According to the article, the need for an easy, low-capacity drinking water treatment system used by local citizens in developing countries to mitigate mortality from water-borne diseases is increasing. A compact portable water treatment device with a processing capacity of approximately 500 L/day was designed to solve this issue. The machine may function without the use of additional power, motors, or turbines, allowing it to be fully self- contained. The solar-powered mobile water treatment device employs tubular ceramic membranes in conjunction with an anodic oxidation mechanism. The main research objective is how to build a suitable stand-alone membrane filtering system that functions without the usage of pumps, power, or chemical cleaning agents for the membranes, allowing the system to function independently of replacement parts and electrical generators. There are several methods available, but the majority of them rely on disposable filters, cartridges, disinfecting, or membrane cleaning chemicals(Groendijk & de Vries, 2009a). Because of the ease with which this membrane may be cleaned and its mechanical robustness, a 40 nm tubular ceramic membrane module (Hyflux Ceparation) was chosen for future investigation. The inner tube diameter is 2.8 m and the membrane module contained 210 tubes with an effective length of 43 cm resulting in a membrane area of 0.8 m^2. A feed water storage tank was installed 3 meters above the membrane filtering unit, resulting in a constant Trans Membrane Pressure (TMP) of 0.3 bar. The feed water for the lab trials came from a 6 m^3 subsurface storage tank located outside the structure. A level controller that could turn on or off a centrifugal pump attached to the storage tank maintained the level in the feed water tank constant. Hands-on operation is required for all valves, including the clean water tap. An air pressure container is attached to the bicycle pump through a fast fit connection. The control box regulates the disinfection level of the filtered water as well as the charging of the battery using the solar power panel powered by a 6V battery. 40 mm hoses were used to

link the membrane unit to the raw water storage tank. Three valves were installed in the unit to allow for backwash and forward flush cleaning of the membranes (see Figure 2.12)(Groendijk & de Vries, 2009b)

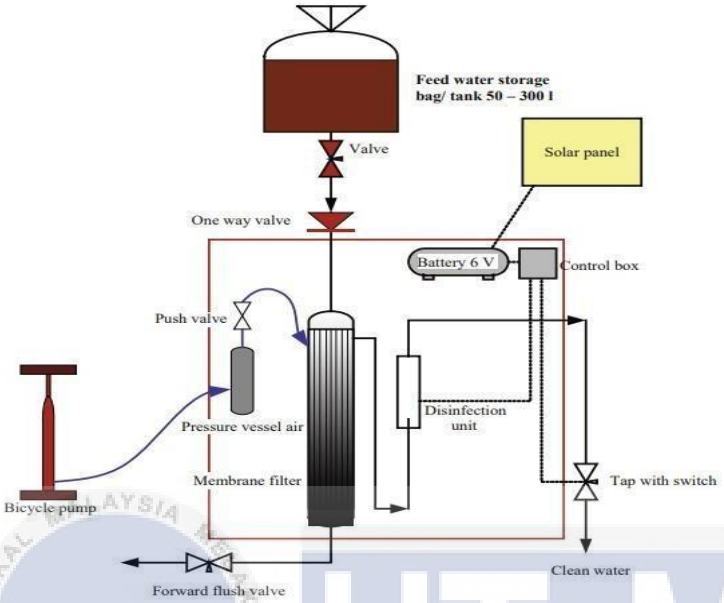


Figure 2.12 Experimental laboratory test set up(Groendijk & de Vries, 2009a)

2.6.3 UTM Portable Water Filter Machine

According to this article, the new technology developed by Universiti Teknologi Malaysia is a portable water filter machine that can provide safe water in the case of natural disasters such as floods (UTM). A team of researchers headed by Prof. Dr. Ahmad Fauzi Ismail of the Advanced Membrane Development Center designed the unit (AMTEC). It was unveiled by the Minister of Science, Technology and Innovation (MOSTI), Datuk Dr. Ewon Ebin, at Sekolah Kebangsaan (SK) Kampung Acheh, Pekan, under the name Ultra filtration Reverse Osmosis Plant. Prof. Fauzi, who was approached after the inauguration, claimed that the research and development for this machine began three years ago with the participation of five PhD students. Without having to heat the water, this generator-powered unit will provide around 5,000 liters of clean water in an hour for 2,000 people a day. Pre-treatment filtration, ultra filtration, reverse osmosis, ultraviolet radiation (UV), and softeners are the five steps

of the water purification phase. UV radiation is used in the water to destroy bacteria and viruses "he said the unit will also process water from a variety of streams, including seawater and brackish murky water, thanks to reverse osmosis technology and ultra filtrate"(*UTM Portable Water Filter Machine Helps Purify Drinking Water in Flooded Areas | UTM NewsHub*, n.d.). A control panel was used to run the system automatically. The UPVC pipe was used to connect to a filter for water delivery to the system, which was assisted by a high-pressure pump. Figure 2.13 shows the whole systems of a UTM portable water filtration machine.

Figure 2.13 UTM Portable Water Filtering Machine(UTM Portable Water Filter Machine Helps Purify Drinking Water in Flooded Areas | UTM NewsHub, n.d.)

2.6.4 Tzu Chi's "Q Water"

From this article, Taiwan's Tzu Chi merits is a well-known charitable organization around the world. The system is simple to put together and provides high-quality drinking water. The foundation requested that the device be 110 cm long, 110 cm wide, and 120 cm tall to fit aboard a Tzu Chi emergency response boat (3.6 x 3.6 x 3.94 ft)(慈濟傳播人文志

業基金會, n.d.). For mechanical transport, the device is mounted in a box. The use of a gasoline- electric generator to supply engine power to pump rainwater for filtration until it is fixed in the disaster region. Activated carbon, UF membrane, UV disinfection and RO membrane systems have been used for the filtration method where water can filter suspended particles in water and disinfect/sand eliminate harmful bacteria, as you can see from Figure 2.13 (Chao & Tseng, 2020). Furthermore, it is compact and weight just 200 kg. It has the capacity to generate roughly 15 tons of water each day, enough to serve 7,500 people. It has super high water efficiency, quick construction, and high mobility, making it ideal for disaster relief deployment(Yesserie, 2015).

Figure 2.14 Tzu Chi designed Q Water(Yesserie, 2015).

Figure 2.14 Tzu Chi designed Q Water – mobile water purification equipment. The concentrate water plant, combined filtration integrated into the container.

2.7 Analysis among the most recent product on the market

2.7.1 Specification Product Analysis

TYPE	MODEL	MAIN PART AND DIMENSION	SPECIFICATION	ADVANTAGES

A	 **YB-SWRO-2000LPD (RM20300.16)** (*Water Filter System Industry 2000lpd Marine Seawater Desalination With Ro System - Buy Seawater Desalination,Seawater Desalination Equipment,Seawater Desalination Plant Product on Alibaba.Com*, n.d.)	**Filter**: 5micron PP filter and 1micron PP filter, bigT33 coconut shell activated carbon, 10W America Hanovia UV sterilizer. **Pump**: Lingxiao pump and SS316L high pressure pump. **Dimension**: (100x50x55) cm	**Productivity**: 125L/Hour **Control**: Manual/Auto running switchable **Power**: 1.9KW **Weight**: 60-80kg **Recovery rate**: 15% **Capacity**: 2000L/Day **Flow Rate**: 1.5TPH	-Easy to move and assemble -Low failure rate, stable and anti-corrosion -Can be connected with common household AC power, gasoline/diesel generator, solar and wind -Auto running system. -Online monitoring output

B	 Youber Small Hand-push portable RO (RM 12145.78) (*Youber Newest Design Ro Reverse Osmosis Desalination Water Refill Station Filtration For Well Water,River Water Etc - Buy Ro Plant,Ro Machine,Ro System Product on Alibaba.Com*, n.d.)	**Filter**: Multi-stage cartridge filter housing and international famous RO membrane **Pump**: SS304 centrifugal pump **Dimension**: (58x53x131) cm	**Productivity**: 100LPH **Control**: Automatic **Power**: 220V,50Hz **Weight**: 55kg **Recovery rate**: 15-20% **Flowrate**: 300LPH	-Portable, compact, safe and reliable, easy to use, stable performance. -High quality stainless steel pump, durable. -Customize all stainless steel Frame, safe and firm, beautiful and generous.

C	**RO**  **Filtration System Sewage Water Treatment Purifier Plant (RM6273.93)** (*Ro Filtration System Sewage Water Treatment Purifier Plant - Buy Ro Filtration System,Sewage Water Purifier Plant,Ro Purifier Plant Product on Alibaba.Com*, n.d.)	**Filter**: Quartz sand filter, cartridge filter, RO membrane. **Pump**: Nanfang vertical centrifugal pump. **Pipe**: PVC type **Dimension**: (80x78x168) cm	**Weight**: 120kg **Power**: 50/60Hz **Flowrate**: 250LPH **Capacity**: 1500GPD **Motor**: 1.0HP **Inlet pipe**: ¾” **Control**: Automatic	-Lower energy consumption -No pollution -Simple technique -High water quality -Easy to operate and maintenance -Wooden case packaging

D	 **Commercial 1500GPD Water Reverse Osmosis Purification RO Machine (RM3453.12)** (Commercial 1500gpd Water Reverse Osmosis Purification Ro Machine - Buy Commercial 1500gpd Water Reverse Osmosis Purification Ro Machine,Small Water Treatment Plant With 3000gpd,205lph Water Purification System Product on Alibaba.Com, n.d.)	**Filter**: Multi-medium filter(sand), active carbon filter, softener(optional), security micron filter. **Pump**: Centrifugal and vertical multi-stage pump **Pipe**: UPVC **Dimension**: (64x50x158) cm **Control Valve**: Auto/Manual optional	**Weight**: 80kg **Power**: 1.1KW **Productivity**: 250LPH **Capacity**: 1500GPD **Control Valve**: Auto/Manual Optional **Application**: Direct drinking water	-Provide clients who need different water treatment (eg: spare parts for assembling and system maintenance) -Wide range product line for clients -Provide professional suggestion -Plastic film + wooden case packaging

E	 **Ultrafiltration water filtration system (RM8664.20)** (*Santai Factory Direct Cheap Wholesale Ultrafiltration Water Filtration System - Buy Uf Water Filter Purifier Uf Water Filtering Machine Uf Water Filters,Uf Water Filtration System Uf Water Machine Uf Water Purification Machine,Uf Water Purifier Uf Water System Uf Water Treatment Product on Alibaba.Com*, n.d.)	**Filter**: ultrafiltration, precision filter, quartz sand filter, carbon filter, soften filter **Pump**: Centrifugal pump **Pipe**: UPVC **Dimension**: (120x50x50) cm	**Weight**: 180kg **Power**: 1.5KW **Productivity**: 500LPH, 7500LPH **Usage**: Pure water process **Original water**: Tap-water or river water **Control**: PLC microcomputer monitoring **Capacity**: Customized	-High recovery rate -Small equipment size -Strong applicability -Wide application range -No environmental pollution -advanced technology, cheaper prices, better product quality, higher performance, lower maintenance costs and perfect after-sales service.

F	 **Hand-held Portable UF Water Purifier** **(MYR 1,977.06)** (*Portable Manual Uf Water Purifier,Uf Water Filtration System - Buy Drinking Water Treatment Plant,Water Purifier Machine,Water Purification Systems Product on Alibaba.Com*, n.d.)	**Filter**: UF280-H-100KC filter **Pump**: Iron cylinder liner hand pump **Pipe**: PVC **Dimension**: (45x35x54) cm	**Weight:** 20kg **Productivity**: 250L/Hour **Water source**: Surface water, underground water, raining water, tap water, non-chemical polluting water **Application**: Drinking water system **Usage**: Turn surface water into drinking water **Flow rate**: can be adjusted	-have wheel and handle for easy to move and carry around -the assembly is convenient -the flow rate can be adjusted, it can flush, backwash, powerful functions -no need electricity -small size -easy operation and less maintenance

2.8 Benchmark using axiomatic design

According to this article, several criterion requirements must be considered at the early stages of process design development in order to get the product specification. The questionnaire method is one of the customer requirement data findings. However, this method is not suitable for products that have a limited relationship with the public. Thusly, the benchmarking method has been introduced. This approach may also be used to determine client requirements for products with restricted guidelines, such as a novel product that no one has ever done before. Benchmarking gives design specs data to help determine product features for quantitative, long-term evaluations. Three techniques are used in the creation of sustainable products: axiomatic design, benchmarking, and detail analysis in figure 15. By defining design demands in functional requirements and sustainable criteria, axiomatic design combines sustainable requirements and customer needs into functional requirements and subsequently design parameters using QFD. In QFD, the HoQ is enlarged to encompass both functional and long-term needs. Benchmark products are disassembled into subassemblies and components so that they may be compared to uncover nuances that contribute to long-term sustainability. The ideal form of components for design objectives is discovered by analyzing benchmark information. Details of sustainable elements, such as materials and component specifications, may then be determined to match the sustainable and functional criteria (Hosseinpour et al., 2015).

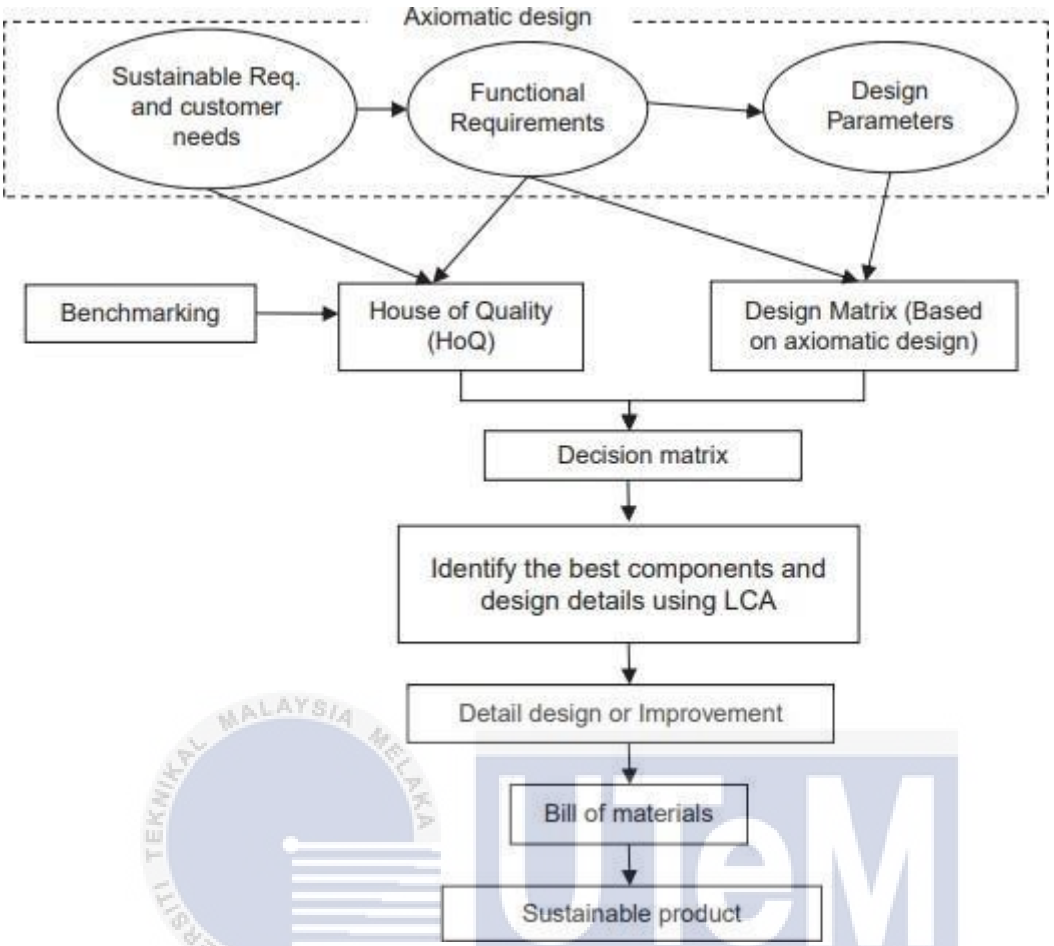


Figure 2.15 Axiomatic design (Hosseinpour et al., 2015)

2.9 Quality Function Deployment (QFD)

Quality function deployment (QFD) is a planning process that helps the organization plan to implement various technical support tools effectively. It is a preparation mechanism that assists an organization in deciding how to efficiently execute different technical support resources that complement each other in order to prioritize each problem. It is a strategy for improving the quality of goods and services by first identifying the needs of customers and then connecting those needs to technological characteristics in order to produce products or services at each stage of the manufacturing process (Ginting et al., 2020).

Function of “QFD” can be described as a process of defining customer desires and needs, and then translating those needs into technological characteristics so that every functional area and organizational level can understand and develop in order to meet objectives. Furthermore, the use of the QFD will ensure that knowledge about customer needs and preferences is obtained as soon as possible. The phases of the planning process are used at any point of the product or service life cycle. The use of QFD can assist in gaining a competitive advantage through the production process, and customer loyalty can be improved through product and service quality attributes (Ginting et al., 2020).

The House of Quality (HOQ) is a QFD tool that is used to evaluate design boundaries, demonstrate the relationship between respondent needs and the matrix to fulfil those needs, and explain the design team's emphasis on delivering quality goods. The technical characteristics of the products with the highest score show that technical characteristics are the company's primary priority for development, while the assembly process' attribute has the highest rating suggests that the products must be corrected to prevent common issues. Process quality planning is a critical strategy for controlling product quality during the product production process, with the aim of developing processes with useful process capabilities to manufacture products (Ginting et al., 2020).

Overall figure for House of Quality

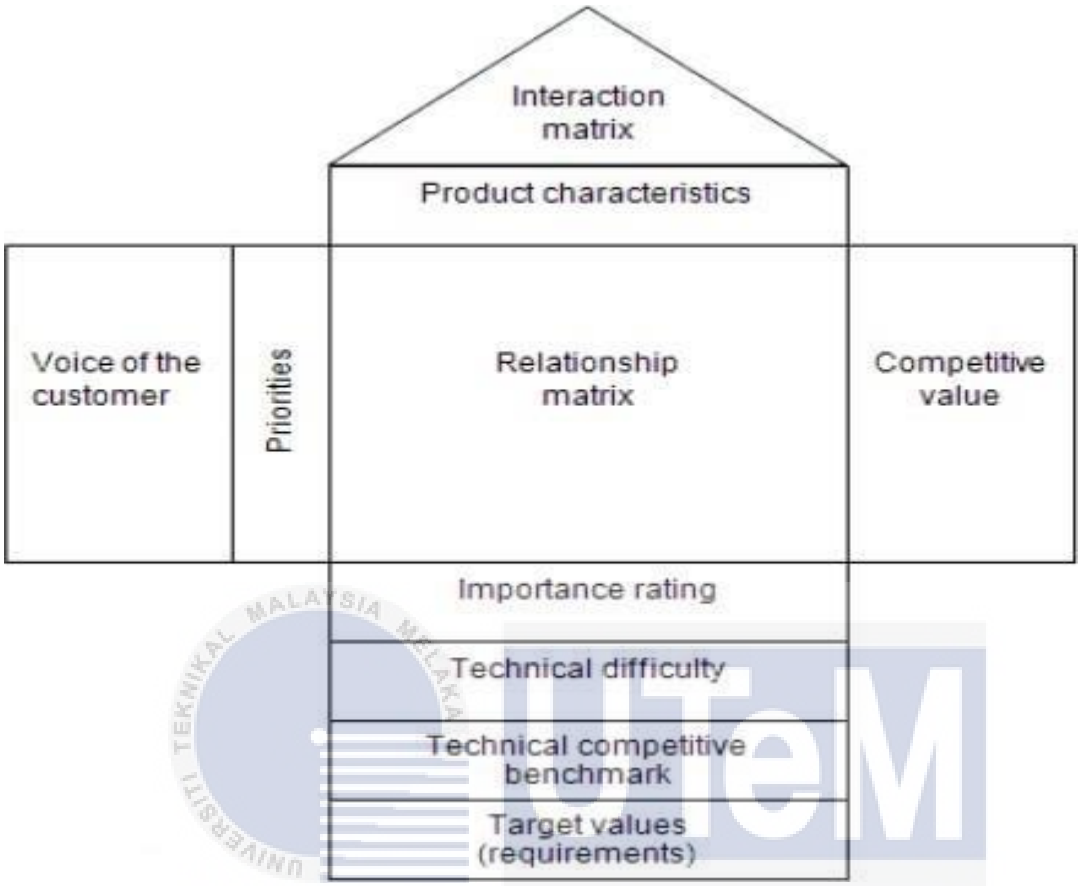


Figure 2.16 House of quality template(What Is Quality Function Deployment (QFD)? | ASQ, n.d.)

2.9.1 Voice of Customer (VOC)

The term voice of the customer is mentioned in different fields of literature including lean six sigma, total quality management (TQM) and quality function deployment (QFD). There is no single best method to perform an adequate VOC analysis. VOC is a process for capturing customers' requirements. It produces a detailed set of customer wants and needs which are organized into a hierarchical structure, and then prioritized in terms of relative importance and satisfaction with current alternatives(Gaskin et al., 1993).VOC can be captured by several tools including customer surveys, focus groups, in-depth interviews,

mystery shopping and complaints. All three concepts focus on the understanding of the customers perception of value. It is hard to establish specifics of product components using QFD just in sustainable design. Adoption of sustainable criteria from current products is utilized to develop sustainable solutions for a product. Three methods are used in the development of sustainable products: axiomatic design, benchmarking, and detail analysis. Through recognizing design needs in functional requirements and sustainable criteria, axiomatic design transfers sustainable requirements and customer needs into functional requirements and subsequently design parameters using QFD. In QFD, the HOQ has been enlarged to encompass both functional and long-term needs (Hosseinpour et al., 2015).The main objective for organizations is improving their performance by minimizing waste and resources while improving customer satisfaction and financial results(Provider, 2015).

2.9.2 Relation Matrix

A relationship matrix was created after the customer implications and technical requirements were established. Using a standard 9-3-1 scale, the matrix rates the correlations between customer and technological attributes as weak, moderate, or solid. The notations used for this scale are as follows: Small (S) = 1, Strong (H) = 9, Moderate (M) = 3, and Strong (H) = 9.

Each technological criteria was matched to each customer consequence. The relationship between them was then calculated and entered into the HOQ's relationship matrix, which is located in the middle. This matrix defines the functional criteria that meet the majority of customer outcomes and determines the required resource allocation for each. To ensure a customer-approved product, the technical specifications that addressed the most customer implications should be dealt with during the design phase. In a QFD analysis, no

more than half of the relationship matrix should be filled, and the result should be a random pattern (Fisher and Schutta, 2003).(Uppalanchi, 2010).

Table 2.1 Symbol in relationship matrix(Erdil & Arani, 2019)

Symbol	Relationship	Score
●	Strong relationship	9
o	Medium relationship	3
△	Weak relationship	1

2.9.3 Importance Rating

Importance ratings are used to quantify customer requirements and are rated on a scale of 1 to 5 in importance. At a later time, this rating will be used in the relationship matrix. Add all of the engineering parameter values in each column and write the total at the bottom of the table. This represents the overall significance of each engineering parameter. The percentage of importance is then calculated as follows:

To calculate the percentages, add them together and divide each individual importance value by the total. This will assist you in determining which parameters should be prioritized in order to meet public expectations. It will also illuminate the relative significance of each parameter in the design process. You can also use as many designs and options as you like. Everything is in your hands! It all depends on the data you have access to, the level of detail you want to go into, and how much time and money you're willing to put into this project. However, due to the numerous decisions that must be made, this is a time-consuming process if done manually. As a result, you must decide which factors are important to take into account and which are not (*Quality Function Deployment (QFD) and House of Quality (HOQ)*, n.d.).

Table 2.2 Example of importance ratings calculation(*6 Steps to Build a House of Quality - Six Sigma Approach*, n.d.)

Pizza color	3 x 1	3
App. Weight, size, etc.	6 x 6 + 3 x 3	45
Low fatty eatables	6 x 4 + 3 x 2	30
Optional eatables	5 x 1 + 3 x 2	11
Delicious and Fresh toppings	3 x 1 + 3 x 3	12
Density of toppings	1 x 6 + 3 x 2	12

2.9.4 Planning Matrix/Competitive Value

The second portion of the HOQ is the planning matrix. This part is where product goals/objectives are developed, depending on the team's interpretation of market research findings. Market research is a key step in designing a product. Market research data is derived through a mix of the company's business objectives with the priorities of consumer demands. After identifying what priority items are most essential to the consumer, the organization must decide each part of the item required. Companies may utilize data obtained from such market research to assess the relative position of items to rivals' goods. First, competing items were ranked (1-5) by their ability to satisfy consumer criteria. Products meeting the scope of the research could not be discovered thus equivalent technologies were reviewed instead. Target ratings (1-5) for the project were created based on competition ratings and client need relevance. Sales points - an indicator of how reaching a customer demand objective will boost the attractiveness of the system to prospective purchasers - were determined (1.00: weak, 1.25: moderate, 1.5: strong) (1.00: weak, 1.25: moderate, 1.5: strong) The weighting of each client was derived using the formula : weighting = relative importance x target rating x sales point. The ultimate significance of each client requirement was estimated as its proportion of the total weighting. In QFD technique, if the company has

an existing technology, it will be appraised and an improvement factor (IF) determined. (IF = target rating - current product rating)(Abello, n.d.)

Table 2.3 Example of planning matrix(Abello,n.d.)

Planning Matrix						
Rating (1-5)				1.00 - 1.25 - 1.50		
GPS Watch	Lark Silent Alarm	Parksafe Sensors	Target Rating	Sales Point	Weighting	Importance
0	0	4	5	1.50	1.0417	16.6%
5	3	3	5	1.50	0.9375	14.9%
5	3	3	5	1.50	0.9375	14.9%
1	0	2	4	1.25	0.4861	7.7%
5	5	5	5	1.50	0.8333	13.3%
5	5	3	5	1.25	0.5208	8.3%
2	5	3	4	1.25	0.4167	6.6%
1	3	2	3	1.25	0.2083	3.3%
1	5	1	3	1.00	0.1667	2.7%
3	4	1	3	1.25	0.1563	2.5%
5	4	3	4	1.00	0.0556	0.9%
5	4	3	5	1.50	0.5208	8.3%

2.9.1 HOWs Correlation (The Roof)

Functional similarities were calculated after the planning matrix was completed. The HOQ's roof is made up of these. The roof depicts the interdependencies and relationships between the technological specifications. The results of which are used to guide the development process by exposing the presence and purpose of design bottlenecks. The relationships between technical requirements were plotted and a value was assigned to them. The roof of the HOQ was completed using previous experience and test results. Symbols are allocated by the researcher to show the strength of the relationship between the technical requirements (Uppalanchi, 2010).

The first row is referred to as either up or down. In this column, you can indicate whether a high or low value is preferable for the following parameter. For example, having a low weight, high engine power and life, low manufacturing costs, high dimensions, and acceleration is often preferable. Similarly, you must now assess the impact of changing one choice on the others. ++ denotes a highly positive effect, + denotes a positive effect, 0 or leave it blank, denotes no effect, – denotes a negative effect, and – – denotes a strongly negative effect.

Table 2.4 Correlation of the roof(Quality Function Deployment (QFD) and House of Quality (HOQ), n.d.)

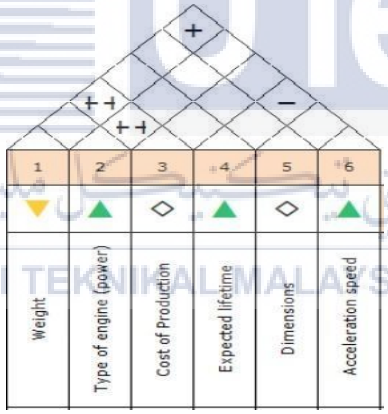


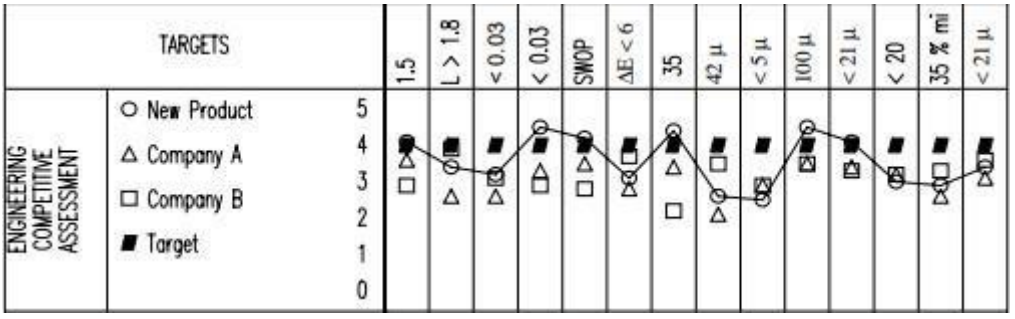
Table 2.5 Example symbols used in correlation matrix(Quality Function Deployment (QFD) and House of Quality (HOQ), n.d.)

Correlations	
Strong Positive	++
Positive	+
No Correlation	
Negative	–
Strong Negative	--

2.9.2 Competitive Assessment or Benchmarking

Competitive assessments are used to equate the design of the competition to the design of the team. The “benchmarking” region where the product or service delivered by the company is compared with products or services of competitors in terms of how much, the own product or service can perform against the competitors regarding the customer needs. Print quality improvements sometimes involves benchmarking competing products. Engineering and marketing teams often create performance objectives for goods in development by studying the performance of competitors' goods. QFD allows you to connect competitive benchmarking data to client needs and objective criteria. Customer evaluation and technical evaluation are two forms of competitive evaluation outcomes that may be included in the house of quality. Customer evaluation is a metric for determining how effectively competing items are viewed in relation to each customer demand. Technical evaluation determines how well competing items perform on each objective criterion. Table 6 shows the house of quality together with the findings of the competitive examination(Yuasa, 1998).

Table 2.6 Example of finding competitive examination(Yuasa, 1998)



2.10 Morphological Chart

In this article, it was explained about the study of shape and form is known as morphology. Morphological study is required for the creation of new forms. Morphological analysis is a technique used in engineering design to investigate all of a system's interactions. Because there are so many possible sets of solutions for a certain product, many engineers have trouble establishing ideas around a certain set of answers. Designers may decide a collection of solutions in a straightforward, structured manner using morphological approaches. A morphological chart (Figure 2.17) is a table that is based on a function analysis. Designers must have a deep understanding of a range of engineering functions and how they are employed in order to develop a good chart. This diagram will explain how each function has a few, if not many, mechanisms in place to carry it out. The morphological chart's last phase is idea generation. The ideas may be formed after the sub-problems have been addressed by combining different combinations of answers from each function. The whole first column following the functions may be considered one concept. A list of engineering roles must be created before the morphological chart for biomimicry can begin. Hundreds of common engineering functions have been recognized and cataloged(Jawaharlal et al., 2017).

Engineering Functions	Solution 1	Solution 2	Solution 3	Solution 4
Function 1				
Function 2				
Function 3				
.				
.				

Figure 2.17 example morphological chart(Jawaharlal et al., 2017)

Figure 2.18 shows several additional functional possibilities that have been added to the conventional approaches. According to this figure, it shows a variety of trash collection strategies for rivers and canals. Of fact, some of them are unworkable or suggest incompatible possibilities. For example, a garbage collection system for rivers and canals would be unfeasible if it used a robotic system to lift gathered material since it would be prohibitively costly. Furthermore, some of the solutions combine many features to provide a multifunctional function(Kader et al., 2015).

Feature	Means					
Collecting system	Multipurpose drop-in-pod system	Quick release system	Turbine pull system	Conveyor system	Oil recovery skimmer	Hydrocarbon separator unit
Storing system	Litter Collection basket	Skipper barge	Hydraulic powered basket	Storage conveyor	Storage tank	Floating bladder
Discharging system	via crane	via conveyor	via pump			
Propulsion system	Fix propeller	Adjustable elevation screw propeller	Water jet	Screw propeller	Hydraulic motor	
Powering system	25-40 HP high thrust, 4 stroke outboard diesel engine	185 HP inboard diesel engine	75 HP inboard diesel engine	Cumin diesel engine, liquid cooled		
Hull form	Catamaran	V-shape hull	Barge	Trimaran		
Operator	Seated at forward	Seated at amidships	Seated at aft	Standing		
Lifting	Hydraulic	Robotic	Crane			

Figure 2.18 Morphological chart for comparison of rubbish collecting system for rivers and canals(Kader et al., 2015)

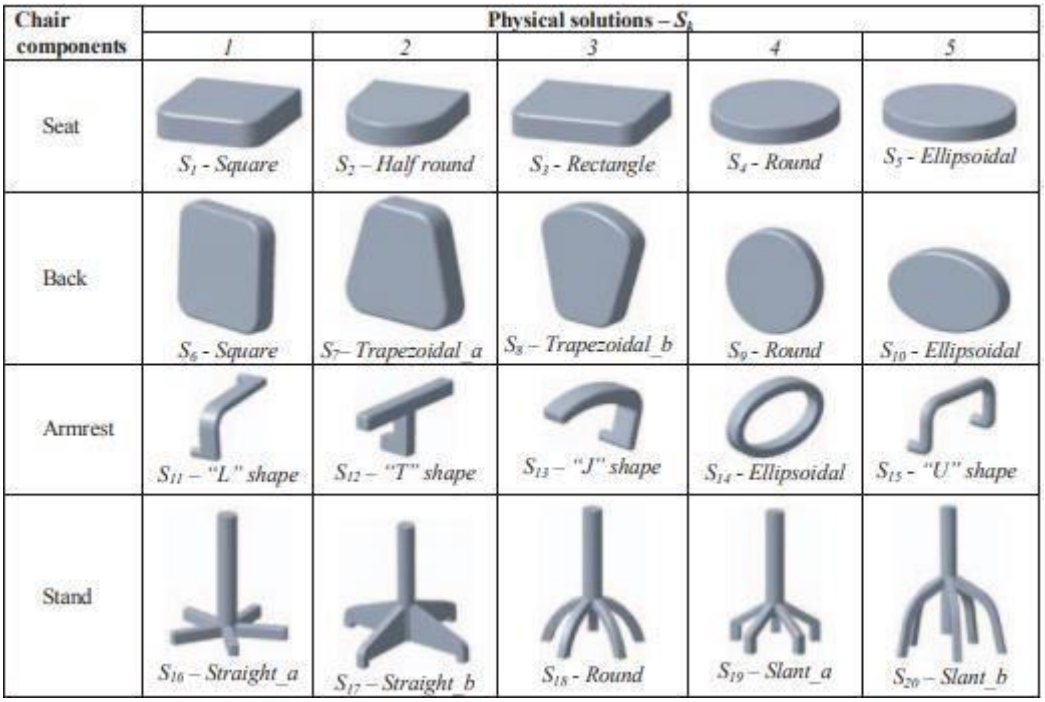


Figure 2.19 Morphological chart of chair (Fougères & Ostrosi, 2011)

Figure 2.19 indicates that this article utilized components as the concepts to construct the solution. After the component has been examined, the concepts may be generated by mixing various combinations of replies from each function. The whole first column after the functions might be regarded a single concept. The designer may pick which method is suitable for their project.

2.11 Pugh Metrix

The Pugh matrix is a method for selecting the best possible choice from a set of options. It is a fundamental tool for selecting the best idea throughout the product development process' idea selection phase. Pugh came up with the idea in 1990. Concepts should be listed in columns, and criteria should be listed in rows, according to the Pugh Matrix technique. The steps of Pugh Matrix Techniques are listed below(Joshi et al., 2019).

1) Select a Datum :- Set a basic standard for evaluating the notion. This minimal level should be compared to the criteria you've put in the rows. When comparing the criterion to the datum level, write + or – or s. Mark the +1 symbol if your criterion goes above your datum level. If your requirements are lower than the datum level, use the − symbol. If it's the same as your datum, put down "s".

2) Ranking& Assessment :- Count how many positive and negative signs are in each column. Count the number of "s" as well. Then add the -ve and +ve signs together. Finally, make a choice based on the results. If the results are favorable, the concept should be given greater weight. If the result is + and -, the concept with the + sign should be chosen. In the situation of – and –, the idea with the closest number to zero should be chosen. However, in such situation, it is preferable to repeat the activity. We may also use++ or- to fine-tune the practice.

Table 2.7 Illustration of Pugh Matrix Techniques of telecom services (Joshi et al.,2019)

Concept / Criteria	Relience-Jio	Idea	Vodafone	BSNL	AIRTL
Network	+	+	-	+	-
Datapack	++	+	+	-	-
Talk Time	++	++	++	+	+
Validity	+++	++	+	-	+
Costing	++	++	+	-	-
	∑+ signs+∑- signs	∑+ signs+∑- signs	∑+ signs+∑- signs	∑+ signs+∑- signs	∑+ signs+∑- signs
	10	8	4	-1	-1

Table 2.7 shows that the example of illustration of Pugh Matrix techniques of telecom services. Consider a company that wants to introduce a new sim card onto the market. It must first hear what customers have to say about the current giants based on specific criteria. The information provided is from a survey that an organization did based on five criteria (Network, Data pack, Talk time, Validity, and Costing). JIO has the most + signs plus -signs. As a result, it can be stated that JIO may be a major rival for companies looking to join the mobile-sim industry.

CHAPTER 3

METHODOLOGY

3.1 Introduction

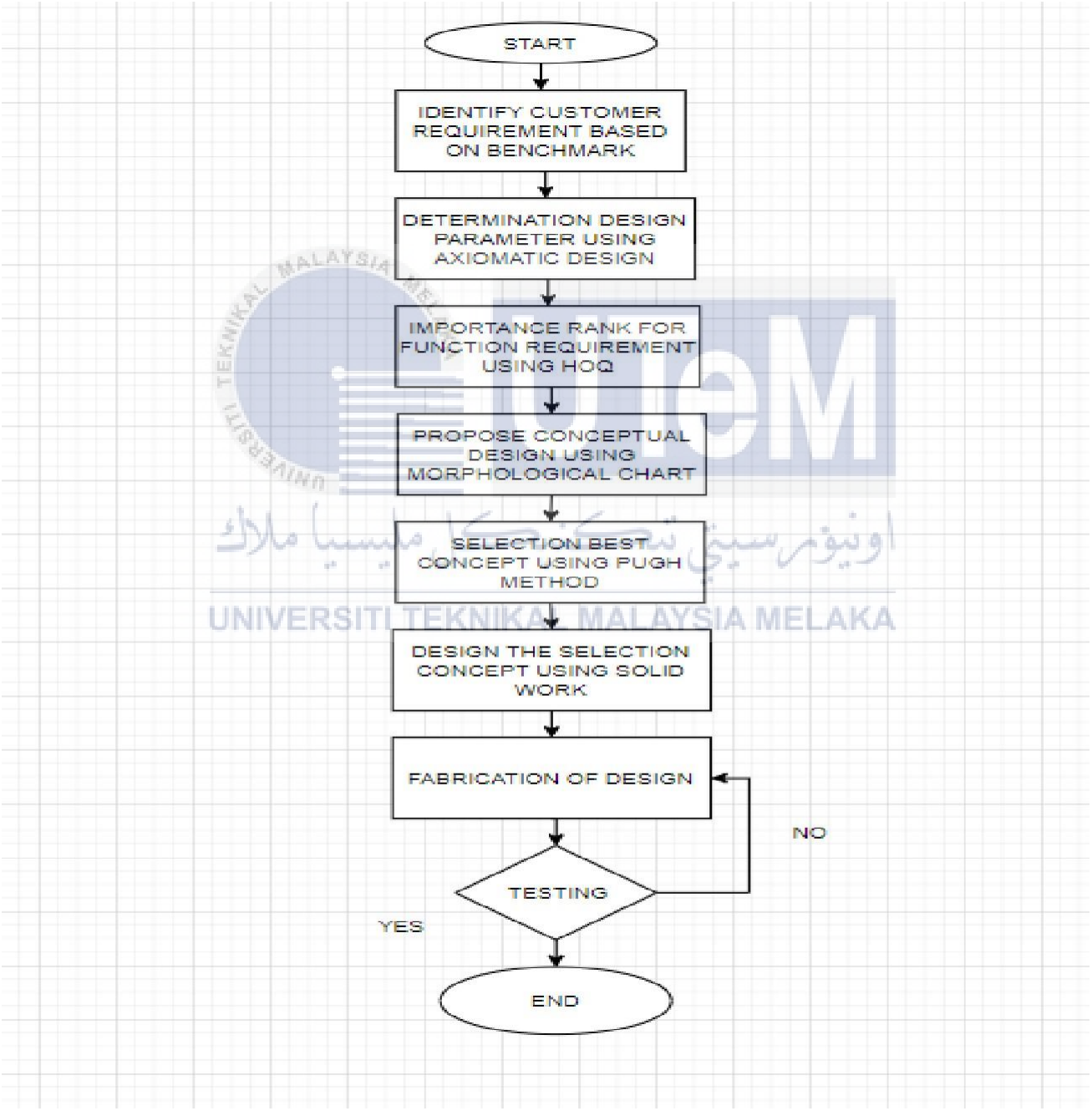
In this chapter, the process of designing and developing mobile clean water supply for flood victim will be explained clearly. The whole process and method discussed herein, all the method that will be used for this project are project schedule, overall project flowchart, project planning and identifying customer needs using benchmark, House of Quality (HOQ), and Morphological Chart. In the project planning and customer needs stage, product development, market research and comparisons stage will be discussed. Besides that, the implement processes, hardware or components to built up the project prototype will be covered.

3.2 Project Schedule

In this part, schedule to complete this bachelor's final year project has been developed for both semester. A Gantt chart is used as a guideline and project planning timeline. This was use as a framework and it should be realistic view of all expectation. This stage is very important to ensure that the project will be complete within stipulated duration. This Gantt chart preparation is allocated into two stages, which is FYP I and FYP II. Phase 1 is focused on the identification of projects and problem statement, review of previous and current projects and the development of process flow. Meanwhile, phase II is more on the methods to implement the project, equipment used, the findings of the project analysis and scheduling as well as discussions of what have been produced

3.3 Overall Project Flow Chart

The overall project flow chart was created to ensure that the project followed thesystematic schedule and ran smoothly.



3.4 Product Planning and Identifying Customer Needs

Product Planning is the ongoing process of distinguishing and articulating market necessities that characterize the feature set of a product. It is the process of coming up with a business idea for a manufactured good, preparing the good for production and then introducing it to the market. Product planning includes managing the manufacture and development of the product by selecting marketing and distribution approaches, making modifications, setting, and changing prices, and offering promotions.

3.4.1 Product Development

From the product development process, the requirements of features and characteristics from customers have been developed into the product, mobile water purification system. Firstly, idea validation has been ensured. Thus, mission statement has been identified and information searching has been done to find the market's potential of mobile water filtration system. Furthermore, survey questionnaires must be administered during this stage to focus on customer needs; however, in this project, to avoid the questionnaire process, a benchmark-based method was used with the assistance of an axiomatic design guide to determine the sustainable product design. Details of sustainable elements, such as materials and component specifications, may then be determined to match the sustainable and functional criteria. From the product analysis, several criteria has been adopt to fulfil the features and characteristics of the product which are:

- ✓ Mobility
- ✓ Easy to assemble and disassemble
- ✓ Robustness of material
- ✓ Service and maintenance
- ✓ Rate of filtration L/H
- ✓ Safe to use
- ✓ Easy to operate
- ✓ Affordable

Based on these features and characteristics, quality function deployment and morphological chart have been conducted to further the continuous process in structure, whole system usedand conceptual sketching.

3.4.2 Determination design parameter using axiomatic design

At this stage, several design parameters from the existing product were adopted for this project, indirectly meeting the customer's requirements. So, based on the latest product there are several requirements for designing this water purification system, which are molibilty, easy to assemble and disassemble, robustness of material, service and maintenance, rate of filtration (litre per hour), safe to use, easy to operate and affordable. The flow of matching customer requirements with function requirements forms a suitable design parameter, as show in the table below.

Table 3.1 Determination design parameter using axiomatic design method

Customer Requirement (CR)	Function Requirement (FR)	Design parameter (DP)
Mobility	Reduce the size and weight	Material properties Size of component Type of packaging
Easy to assemble and disassemble	Have sequence of assembly part	Assembly instruction
	Use detachable joint	Type of joint
	One type and size of component	Standardization component
	Reduce number of components	Number of components Number of accessories
Robustness	Non-rusting material	Material selection
	Durability of pipe	Pipe selection
Service and maintenance	Consumable replacement cycle	Components' service cycle
	Easy to repair and replace	Availability spare-part on market
Rate of filtration L/H	Have enough pressure	Type of filter
	Add more filter	Ramp pump
	Increase the area of filtration	
Safe to use	Safe for user	Material and joint type
	Safe for equipment	Ergonomic design Signage
Easy to operate	Minimum operating system	Variable valve control
Affordable	Reduce cost of design and manufacturing assembly	Cost of product components

3.4.3 Specification of benchmark product

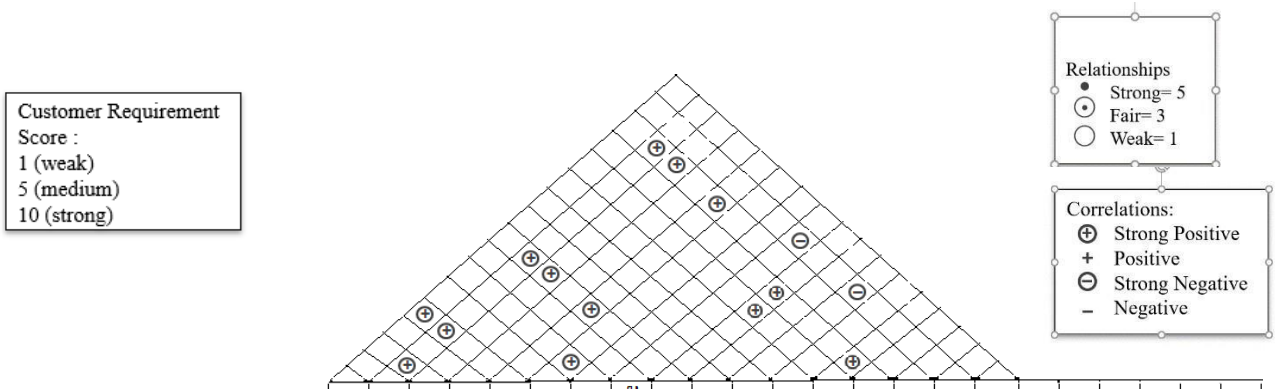
Table 3.2 Specification of six benchmarks

Product Specification	A	B	C	D	E	F
Cost	RM20300.16	RM12145.78	RM6273.93	RM3453.12	RM8664.20	RM1977.06
Weight	60-80kg	55kg	120kg	80kg	180kg	20kg
Flowrate	125LPH	300LPH	250LPH	250LPH	500LPH	250LPH
Control	Manual/Automatic	Automatic	Automatic	Manual/Automatic	Automatic	Manual
Power	1.9KW	220V,50Hz	50/60Hz	1.1KW	1.5KW	No current use

3.5 QFD

Quality function deployment (QFD) one of the capable instruments for improving client fulfilment by means of progressing item quality and diminishing generation time and taken a toll. It moreover an organized approach to characterizing client needs and deciphering them into plans to deliver items to meet those needs. This strategy empowers producers to distinguish customers' needs and wants and make them clear in item plan prerequisites. By using this method, customer needs have been summarized into “house of quality”. And following is the “house of quality” after summarized:

Table 3.3 House of Quality



Criteria	Function Requirement	Weight and size reduction	Sequence of assembly part	Detachable joint	Same type of component	Reduce number of component	Non-rusting material	Durability of pipe	Consumable replacement cycle	Easy to repair and replace	Enough pressure	Add more filter	Increase area of filtration	Safety for user	Safety for equipment	Minimum operating system	Reduce cost	Total	A	B	C	D	E	F
Mobility	4	•				•													3	4	3	4	2	5
Easy to assemble & disassemble	5		•	•	⊙	•				⊙									3	3	2	3	2	3
Robust	4						•	•											4	4	4	4	3	4
Service and maintenance	3									•									3	4	3	4	3	5
Rate of filtration (L/H)	4								⊙		•	⊙	⊙						3	2	4	4	5	4
Safe to use	4													•	•				4	4	4	4	4	4
Easy to operate	5															•			4	4	4	4	3	3
Affordable	3																⊙		2	2	3	3	3	4
Absolute score		20	25	25	15	45	20	20	9	30	20	12	12	20	20	25	9	327						
Relative score		6	8	8	5	14	6	6	3	12	6	4	4	6	6	8	3	100						

Table 3.4 HOQ analysis score description

Level	Score	Description
High	10>15	Very important
Medium	5>10	Quite Important
Low	0<5	Important

Table 3.5 Additional product design specification of water supply unit system

Criteria	Sub-criteria
Mobility	Weight
	Size/Volume
	Numbert of item to carry
	Type of packaging
Easy assemble/disassemble	Type of joint
	No of tools required
	Number of component
	Number of process
Robust	Material of pipe
	Properties pipe material
	Working Pressure
	Burst Pressure
	Type of casing
	Material of casing
	Properties material casing
	Yield strength
	Strain at fracture
	Thermal conductivity
	No of critical point analysis
Service and maintenance	Component service (duration)
	Cost
	Availability spare part
	Lifespan water filter
Rate of filtration L/H	Pressure source
	Flowrate of filter
Safe to use	Quality of clean water
	Ergonomic design

Definition of each customer needs

Mobility

- This project highly depends on mobility, which refers to the ability to move or be moved freely and easily. Many characteristics of the product, such as size and weight, may be considered, but the infrastructure present in developing nations emphasizes the significance of system transit convenience. As a result, the unit must be small and light, as well as capable of being carried on foot if required.

Easy to assemble and disassemble

- The simplicity with which the customer can assemble the item together after getting it, as well as if it is packed in a satisfying way. Instructions for assembling parts and the use of detachable joints will be provided, as well as suggestions for decreasing the number of components.

Robustness

- A robust system is one whose performance is insensitive to changes in source water and changing operating circumstances, and therefore continues to meet the target water quality. Because water is such a fundamental need, reliability and robustness are crucial when developing a filtration system in which the material chosen is a major consideration. For the lifetime of the filter, the suggested technique must be able to provide clean water of constant quality every time it is activated. Because replacement components are difficult to come by in the remote places where the system will be used, the designed assembly must be able to endure the rigors of international and rural travel without compromising filter integrity or mechanical and electrical robustness. As a result, the system should be built to provide water for 30 people per day (about 7.5 L/person) for 30 days with just filter or other disposable and consumable system components changing.

Service and maintenance

- A partial or complete replenishment of an object is referred to as maintenance. Maintenance may help to decrease an item's physical age or even "zero time" it by renewing any or all of its components. Service is something that we must perform

operationally if we are to accomplish the item's inherent dependability, which for this project, the filter is a kind of component that must be serviced according to the product's consumable cycle time.

Rate of filtration liter per hour

- Filtration is the last step in the water treatment process for eliminating particles. Sand, gravel, anthracite coal, garnet, or a number of materials stacked to trap the residual suspended particles in the water may all be used as filter medium. The filtration rate is the amount of water that goes through a particular sized filter in a given amount of time. It is the flow of water across a filter's surface area.

Safe to use

- In and out of the presence of water, the system must contain safeguards to protect both the user and the equipment against damage caused by mechanical or electrical components. In every kind of engineering design or development, this protection must be considered. This specific product will be utilized by unskilled personnel in distant areas. This protection covers the shape of the joint or connection to be placed in terms of mechanisms. Such protection for electronics must offer electrical insulation from shock risks, particularly because water will almost certainly be present in most usage situations. It is necessary to consider the user's safety, whether the user is a victim or not, when drinking clean water that satisfies safety standards.

Easy to operate

- Part-time missionaries with little or no expertise in water purifying methods are anticipated to use the created system. As a consequence, as an ease of use criteria,

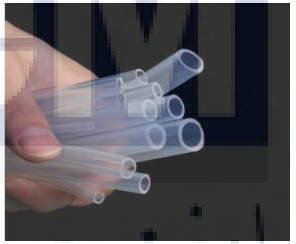
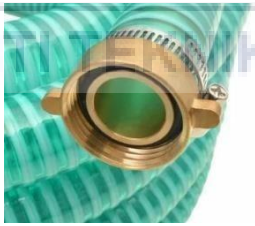
the created product should be able to be unpacked, set up, and operated in 5 minutes. Second, it must combine the filtration system's components in such a way that the user's replacement of used components (filters, tablets, lights, etc.) is simplified, reducing the complexity of any maintenance tasks.

Affordable

- Any design must be able to be mass-produced and sold at a price that is competitive with existing mobile water filtration systems designed for comparable purposes. Furthermore, money are scarce in the short-term missionary market. However, these requirements are not prioritized in this project, not because they are unimportant, but the scope of this project more focusing on mobility, ease of assembly and disassembly, and robustness.

3.5.1.1 Morphological chart

The purpose of morphological chart is to identify varieties of options that can be used to generate design concept. After narrowing down the customer needs from house of quality, Morphological Chart method is used in the design and development method. A Morphological Chart is a diagrammatic technique to catalogue and help evaluate combinations of alternative system elements. It includes independent design characteristics in a chart, and different engineering solutions are proposed for each solution. It catalogues the conceivable combinations of embodiments to find the combination that will result in the "best" design concept.

Component/Part	Variant number	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5
RAW WATER TANK	a	 Collapsible tank	 Drum tank	 PVC plastic water	 IBC water tank	 Polyethylene tank
TYPE OF PIPE	b	 HDPE POLY	 UPVC	 PVC	 PVC Clear Hose	 Spring Hose
TYPE OF JOINT/ CONNECTOR	c	 SCREW TYPE	 Spring hose brass connector	 Quick Connect Solid Brass 3/4 Inch	 UPVC threaded fitting type	

PUMP	d	 Water pump diaphragm (116psi)(12v/24v)(10L/min)	 APACHE TurboPUMP 2-Stroke Gasoline Water Pump Petrol RON95(200L/min)			

ADD ON	e	 12V 7AH Battery - Rechargeable Seal Lead Acid	 XZY Solar 15W 6V Poly Crystalline Silicon			
TYFE OF FILTER	f	 PVDF FILTER	 UF FILTER	 CERAMIC		
CLEAN WATER TANK	g	 Collapsible tank				

3.6 Conceptual sketch

Figure 3.1 Concept 1-a1+b5+c3+d2+f3+g1

Based on the figure above, Conceptual 1 is the concept which used is two-wheel trolley shape casing design. It used two collapsible tanks with 1000L capacity with 6 PVC support rods including drainage valve and ¾ faucet with switch. The tank is used for storing each raw water and clean water. The dimension of this tank is 88cm (h) x 120cm (D) with weight of 7 kg which can be stored away when not used. The design includes the piping channel that connected with raw water tank that placed on the top area. Plus, this design use water pump generator which connected with spring hose thus supply the raw water through the Ceramic filter. After filtration process, the clean water will store into the clean water tank.

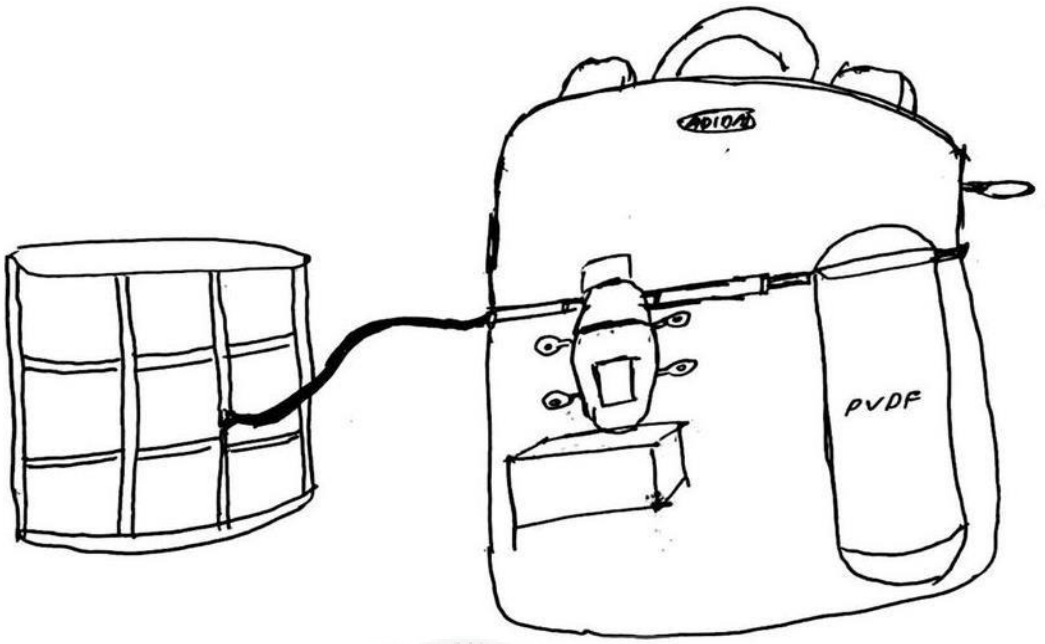


Figure 3.2 Concept 2-a1+b4+c4+d1+e1+e2+f1+g1

For conceptual Sketch 2, the concept used is backpack shape casing design. It used two collapsible tanks with 500L capacity with 6 PVC support rods including drainage valve and ¾ faucet with switch. The tank is used for storing each raw water and clean water. The dimension of this tank is 98cm (h) x 80cm (D) with weight of 5 kg which can be stored away when not used. The design includes the piping channel that connected with raw water tank. Plus, this design use diaphragm pump which connected with battery 12 V then connect with clear hose aquarium. Thus supply the raw water through the PVDF filter. Solar panel has added to generate power for battery charging purpose. After filtration process, the clean water will store into the clean water tank.

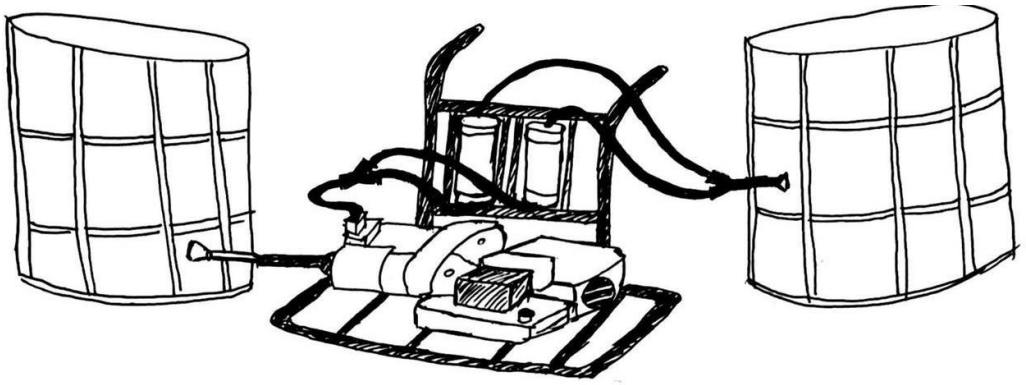


Figure 3.3 Concept 3-a1+b5+c3+d2+f+g1

For conceptual Sketch 3, the concept used is two-wheel trolley shape casing design. It used two collapsible tanks with 1000L capacity with 6 PVC support rods including drainage valve and ¾ faucet with switch. The tank is used for storing each raw water and clean water. The dimension of this tank is 88cm (h) x 120cm (D) with weight of 7 kg which can be stored away when not used. The design includes the piping channel that connected with raw water tank that placed on the top area. Plus, this design use water pump generator which connected with spring hose thus supply the raw water through the Ceramic filter. After filtration process, the clean water will store into the clean water tank.

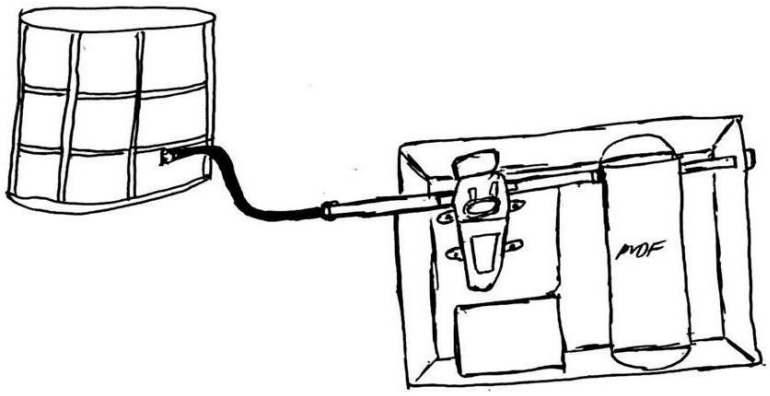


Figure 3.4 Concept 3-a1+b4+c4+d1+e1+e2+f1+g1

For conceptual Sketch 4, the concept used is briefcase shape casing design. It used two collapsible tanks with 500L capacity with 6 PVC support rods including drainage valve and ¾ faucet with switch. The tank is used for storing each raw water and clean water. The dimension of this tank is 98cm (h) x 80cm (D) with weight of 5 kg which can be stored away when not used. The design includes the piping channel that connected with raw water tank. Plus, this design use diaphragm pump which connected with battery 12 V then connect with clear hose aquarium. Thus supply the raw water through the PVDF filter. Solar panel has added to generate power for battery charging purpose. After filtration process, the clean water will store into the clean water tank.

3.7 Pugh method

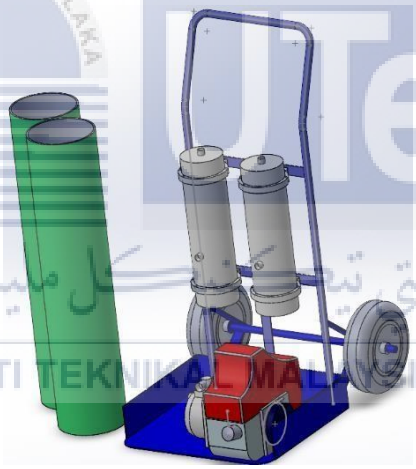
Table 3.6 Pugh Matrix

			DATUM		Concept 1		Concept 2		Concept 3		Concept 4	
	Criteria	Weight	Rate	Score	Rate	Score	Rate	Score	Rate	Score	Rate	Score
	Mobility	4										
	Weight	5	2	10	4	20	4	20	4	20	4	20
	Size/volume	4	4	16	2	8	4	16	2	8	5	20
	Number of item to carry	3	5	15	4	12	5	15	5	15	5	15
	Type of packaging	3	5	15	5	15	5	15	5	15	5	15
				224		220		264		232		280
	Easy assemble/disassemble	5										
	Type of joint	4	4	16	4	16	4	16	4	16	4	16
	No of tools required	3	4	12	5	15	4	12	4	12	4	12
	Number of component	5	2	10	4	20	3	15	4	20	3	15
	Number of process	4	4	8	5	20	5	20	5	20	5	20
				230		355		315		340		315
	Robust	4										
Pipe	Type of pipe	4	3	12	3	12	4	16	3	12	4	16
	Material of pipe	5	4	20	4	20	3	15	4	20	3	15
	Properties pipe material											
Casing	Working Pressure	4	4	16	5	20	4	16	5	20	4	16
	Burst Pressure	5	4	20	5	25	3	15	5	25	3	15
	Type of casing	4	3	12	5	20	4	16	5	20	4	16
	Material of casing	5	5	25	5	25	4	20	5	25	4	20
	Properties material casing											
	Yield strength	4	4	16	5	20	4	16	5	20	5	20
	Strain at fracture	4	5	20	4	16	5	20	4	16	4	16
	Thermal conductivity	3	4	12	5	15	4	12	5	15	5	25
	No of critical point analysis	4	5	20	4	16	5	20	4	16	5	20
				692		756		664		756		716
	Service and maintenance	3										
	Component service (duration)	4	2	8	5	20	5	20	5	20	5	20
	Cost	5	1	5	5	25	4	20	4	20	4	20
	Availability spare part	4	2	8	5	20	5	20	5	20	5	20
	Lifespan water filter	3	2	6	4	12	4	12	4	12	4	12
				81		231		216		216		216
	Rate of filtration L/H	4										
	Flowrate of filter	5	4	20	3	15	5	25	5	25	5	25
				80		60		100		100		100
	Safe to use	4										
	Quality of clean water	3	4	12	4	12	5	15	5	15	5	15
	Ergonomic design	3	4	12	5	15	5	15	5	15	4	12
				96		108		120		120		108
	Total score			1403		1730		1679		1764		1735
				5		3		4		1		2

3.8 Selection of conceptual design

Following the completion of various conceptual ideas, the next step is to choose the optimum design for the mobile clean water supply system. The Pugh Matrix table is used to determine which design is better for comparing the criteria. As the result Concept 3 is chosen because of firstly this concept meets all the criteria and gained the highest total score after concept scoring and concept screening are performed. By comparing to the others, this concept is the most preferable design because it has high score for all the criteria.

3.9 Final design



After selected conceptual sketch 3 using Pugh Method as the final conceptual design, Solidwork has been applied to draw the design of the mobile water supply for flood victim. Before drawing the actual design, it is important have a sketch that consisted with detail design sketch with dimension, whole assembly sketch and sub-system sketch, which will reflect the variety of model. After obtaining the best sketches, then just it will be transfer to Solidworks software.

3.10 Finite Element Method Setup

3.10.1 Load Applied in Rigidity Test

In this test, a constant load of 200 N will be applied to the trolley's designated base plate. The constant load is being used so that the structural change throughout the test may be easily analyzed and compared. The number of items that will be put on the trolley's base determines the constant load applied to that base. The trolley will be carrying a weight of 200 N. By comparing the different materials utilized by other trolleys,

3.11 Summary

To summarize this chapter, in order to select the best conceptual design, Pugh method are used due to its criteria and subcriteria for this project. The selected conceptual design is chosen based on highest score from the Pugh method. After select the conceptual design, it will then be design using Solidwork software for 3D modeling. Thus, the static analysis was run with applying the load which include the weight of the item to be carry on the design. Before applying the load, the design need to apply material which can sustain the load applied. The results of the von Mises stress, displacement stress and strain stress will be compared with different materials chosen in order to analyze and compare the gained data.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overview

In this chapter, the result of testing a prototype of a mobile clean water supply unit for flood victims and discussion of the result will be clearly described. This chapter is divided into several stages, and they are: the analysis result, which is based on observation and several measurements; the BOM and cost analysis; and project evaluation.

4.2 Prototype CAD Model Development

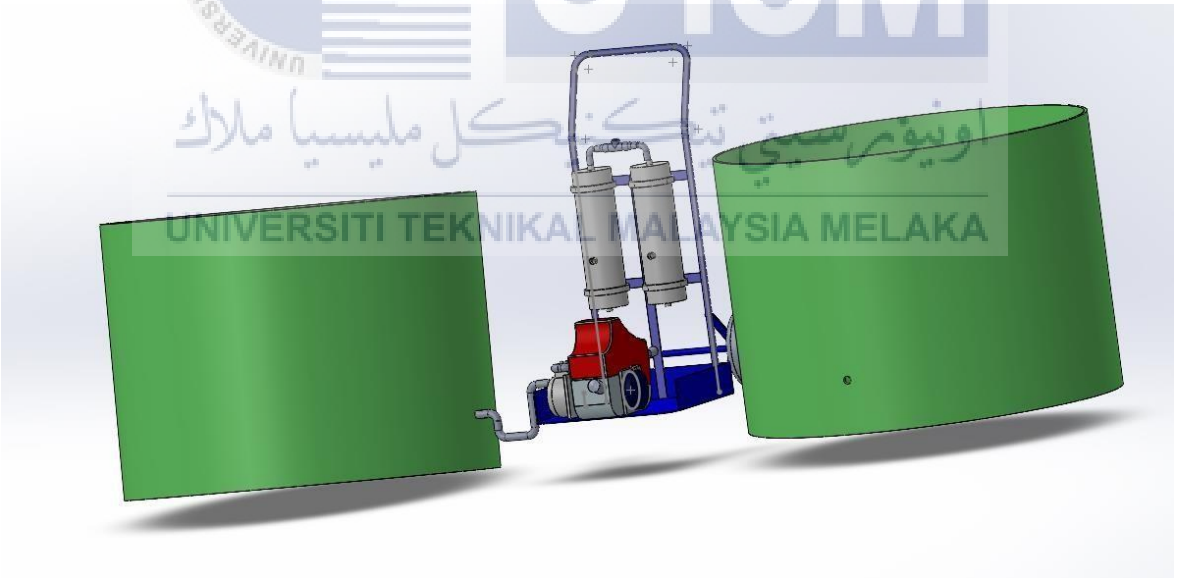


Figure 4.1 Isometric view

Figure 4.1 shows the final design of the mobile clean water supply unit system. This system consists of three main parts, which are the water tank, filter, and pump. All the drawing processes are performed by using Solid Works software with suitable material

selection for the trolley to support the load of the component. Conceptual sketch 3 are depicted in the conceptual Sketch. It used six collapsible tanks with a 1000L capacity, with 10 PVC support rods, including a drainage valve and a ¾ faucet with switch. Inside the raw water tank, there is a strainer for filtering large particles before they enter the hose. This is to protect the water pump from harmful external influences. Next, the output of the tank will then connect with a 25mm diameter hose with hose bands to tighten it. Then, the hose will now connect to the inlet water pump, secured with hose bands. For the outlet water pump, it will transfer the raw water through the selected filter, which is a PVDF type of filter. This project needs two filters to supply enough water to 50 people. After the filtration process, the clean water will be stored in the clean water tank.

4.3 Project Photos

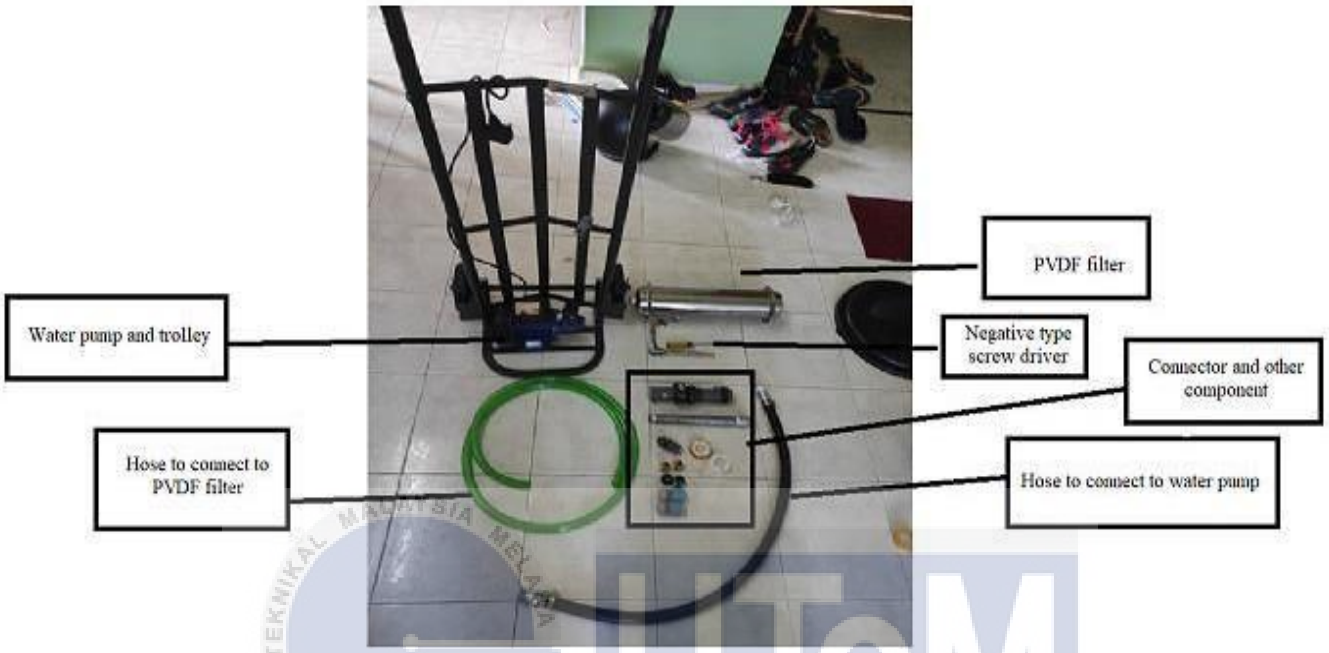


Figure 4.2 Item for build prototype

Figure 4.3 Complete prototype assembly prototype assembly

4.4 Bill of Material (BOM)

A BOM is a list of raw materials and components that are required for use in fabricating a prototype. In this project, the BOM is included with mechanical and electrical part components.

Table 4.1 Bill of Material

NO	ITEM	PRICE(RM)	QUANTITY	TOTAL(RM)
1	APACHE TurboPUMP	339.99	1	339.99
2	Strainer		1	
3	Hose Bands		2	
4	Coupling		2	
5	WP10 (filter hose)		1	
6	Suction Hose (25mm diameter) (1M)	12	3	36
7	Collapsible Water Tank (1000L)	471.45	6	2828.7
8	PVC support rod		60	
9	Drain valve		6	
10	3/4 Faucet with switch		6	
11	Overflow valve		6	
12	PVDF filter	278.88	2	557.76
13	Hose with screw type connector			
14	12MMX0.08MM SEALING TAPE	0.3	2	0.6
15	22-30MM ORBIT HOSE CLIP	1.2	2	2.4
16	1/2" PVC TANK CONNECTOR	1.8	1	1.8
17	1" LD TAIWAN PVC UNION S/E	10	1	10
18	3/4"X1/2" POLY REDUCING BUSH	0.6	2	1.2
19	HL014 3/4" NEKEN BRASS TAP NOZZLE	6	6	36
20	PBGB03 1" K.C NIPPLE	3	2	6
21	1" PCV TANK CONNECTOR	3.3	1	3.3
22	1" P/T SOCKET	1.3	1	1.3
23	3/4"X1/2" GI REDUCING SOCKET	2.5	1	2.5
24	10" X3/4" GI PIPE WITH THREAD CLASS B	9	1	9
25	BARANG HARDWARE	4.5	2	9
26	8010 A-CLASS PVC INLET HOSE CONNECTOR	7	2	14
27	1" PVC PIPE CLASS 6	2	1	2
28	BARANG HARDWARE	0.3	4	1.2
	TOTAL			3862.75

The hardware and components utilized in the prototype of this project cost a total of RM3862.75. In comparison to other items, the pricing is still fair and acceptable. The filter and waterpump are included in the price of RM897.75 without the tank. When compared to similar items that cost twice as much.

4.5 Project Evaluation

An evaluation of how well this mobile clean water supply unit can function or supply enough clean water for 50 people per day, which is equivalent to 8000 litres, is required.This is important and essential to ensure the quality and utility of the prototype. There are four categories have to evaluated in this project and the categories are as following:

1) Number of activity for install and uninstall project
2) Time taken to finish the installation
3) Flowrate for 50 people per day
4) FEA analysis

4.5.1 Number of activity for install and uninstall the project.

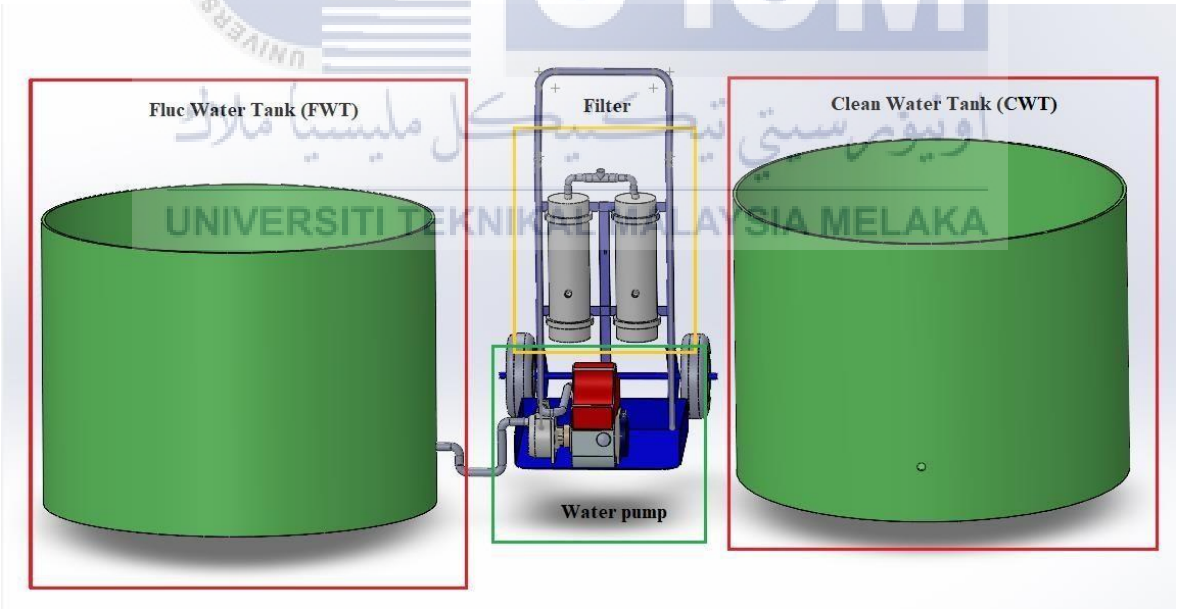


Figure 4.4 Full design detail

Figure 4.2 shows the prototype model, including the name of the item. The selection pipe and connection for the Mobile Clean Water Supply Unit are decided in order to accomplish a simple to assemble and disassemble criteria. Calculating the number of steps for each component will be used to determine the overall level of activity in the system. The sum for the assembly activity is 14, as shown in Table 16, showing that 14 actions are required for assemble and disassemble.

Table 4.2 Number of activity

	Item	Activitity
FWT	Water tank erection	• Enlarge the surface of the tank. • Install 10 PVC support rods to the tank. • Connect tank with union connector. • Fill with fluc water.
	Water Pump	• Connect the hose to the water tank using a union connector.
CWT	Filter A	• Install PVC inlet hose connector to hose. • Connect the inlet hose to filter, • Connect the outlet hose to clean water tank.
	Filter B	• Install PVC inlet hose connector to hose. • Connect the inlet hose to filter, • Connect the outlet hose to clean water tank.
	Water tank erection	• Enlarge the surface of the tank. • Install 10 PVC support rods to the tank. • Ready to store clean water from the filter after the filtering process.

4.5.2 Time taken to finish the installation.

Table 4.3 Time taken to finish the installation

	Item	Activitity	Time
FWT	Water tank erection	• Enlarge the surface of the tank. • Install 10 PVC support rods to the tank. • Connect tank with union connector. • Fill with fluc water.	5min
	Water Pump	• Connect the hose to the water tank using a union connector.	8sec
CWT	Filter A	• Install PVC inlet hose connector to hose. • Connect the inlet hose to filter, • Connect the outlet hose to clean water tank.	30sec
	Filter B	• Install PVC inlet hose connector to hose. • Connect the inlet hose to filter, • Connect the outlet hose to clean water tank.	30sec
	Water tank erection	• Enlarge the surface of the tank. • Install 10 PVC support rods to the tank. • Ready to store clean water from the filter after the filtering process.	5min x (5 tank)

The time it took to complete this project's assembly is shown in Table 17. The time it took to construct was 31.8 minutes, and it took twice as much time to dismantle. It literally took the smallest time to construct it, which was less than 1 minute, according to the connection used. The quickest time demonstrates how simple this project is to assemble and disassemble.

4.5.3 Flowrate for 50 people per day

Table 4.4 Flowrate of PVDF filter

Pressure (kPa)	Flow rate (l/min)
206.843	*3.524*
172.369	*3.226*
137.895	*2.758*
103.421	*2.220*
68.948	*1.468*

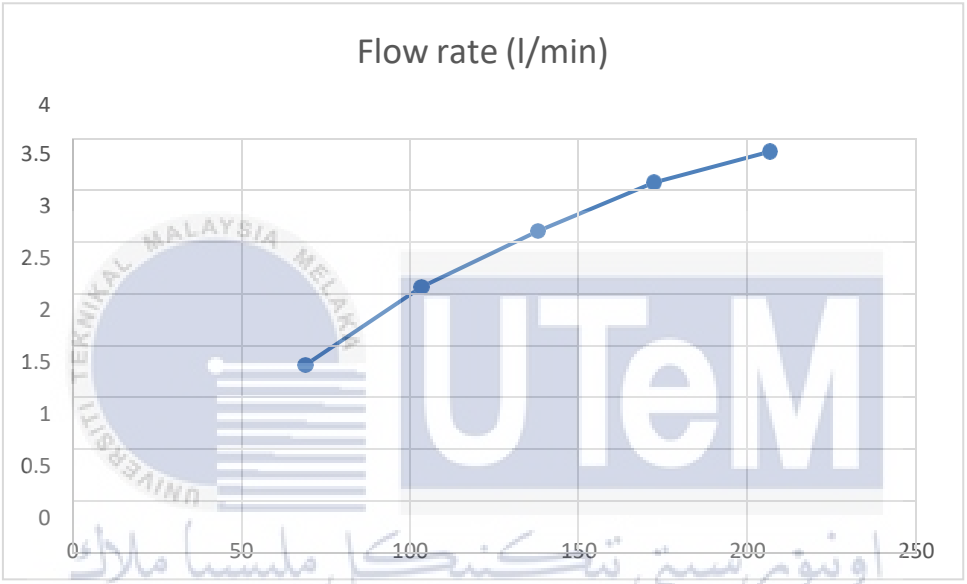


Figure 4.5 Graph Flowrate of PDVF filter

This topic is necessary in order to measure the flowrate of the selected filter in order to supply 50 people per day. The flowrate with the highest value is 3.524 l/min, or 211.44 L/H. In typical circumstances, a person need 300 litres of water every day. If the situation worsens to the point of flooding, austerity is the only option. If each person consumes 100 liters of water per day, this equals to 5000 liters every hour for 50 individuals. Water pumps may work continuously for six to 24 hours, depending on the amount of water and the pump's condition. Assume the waterpump runs for 13 hours nonstop or stage by stage, resulting in 5200 litres per day. It is more than enough to meet the clean water demands of 50 individuals, based on the quantity.

4.5.4 Strength Analysis on CAD Model

During the product benchmarking process, feedback or suggestions were gathered in order to identify the best material for developing a functioning prototype. To keep costs down, it's also crucial to use the right materials for prototype development. Cast Carbon Steel, Plain Carbon Steel, and 201 Anneal Stainless Steel were selected as the materials. As a result, we may deduce that constructional steel is a possible material for this project. Steel is a cost- effective and easily available material that may be acquired at local hardware shops. Before beginning the design process, you must first choose your materials. This is due to the fact that the prototype measurements are taken into account during CAD creation. Furthermore, the project's appropriate materials make the CAD model considerably more viable throughout the design phase. The Engineering Attributes Table is used to assign the properties of various materials. The placement of the load on the trolley's base plate is the major focus of this examination. The entire amount of weight that the trolley was going to carry was used to calculate the load value. The average weight regarded as the load applied to the trolley's base is 20 kg, provided a force of 200 N is applied.

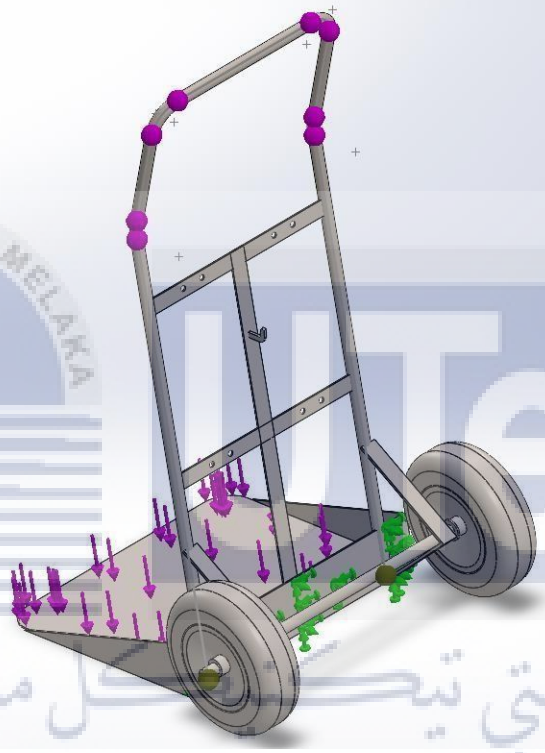
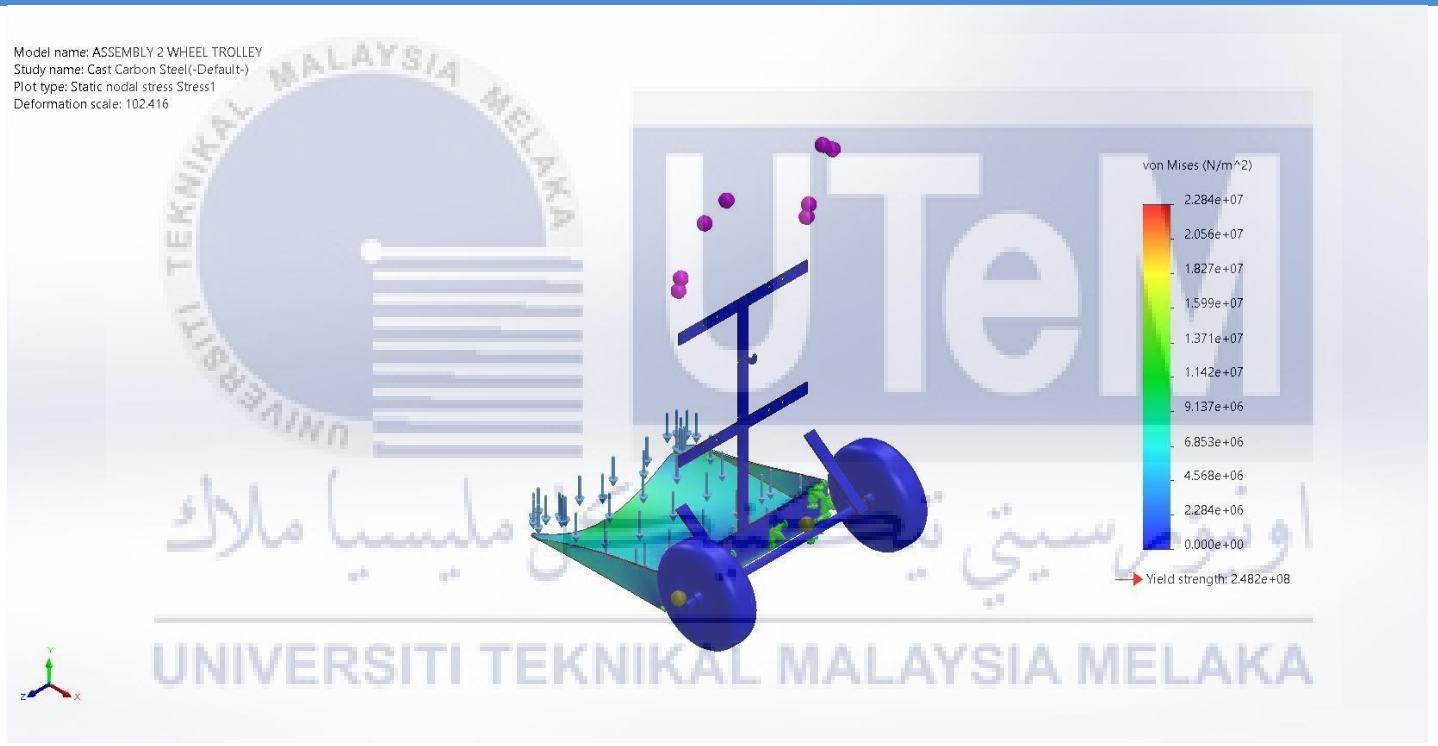


Figure 4.6 Location for force applied and fixed geometry

4.5.4.1 Static Analysis Result

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 9387	2.284e+07N/m^2 Node: 1547



ASSEMBLY 2 WHEEL TROLLEY-Cast Carbon Steel-Stress-Stress1

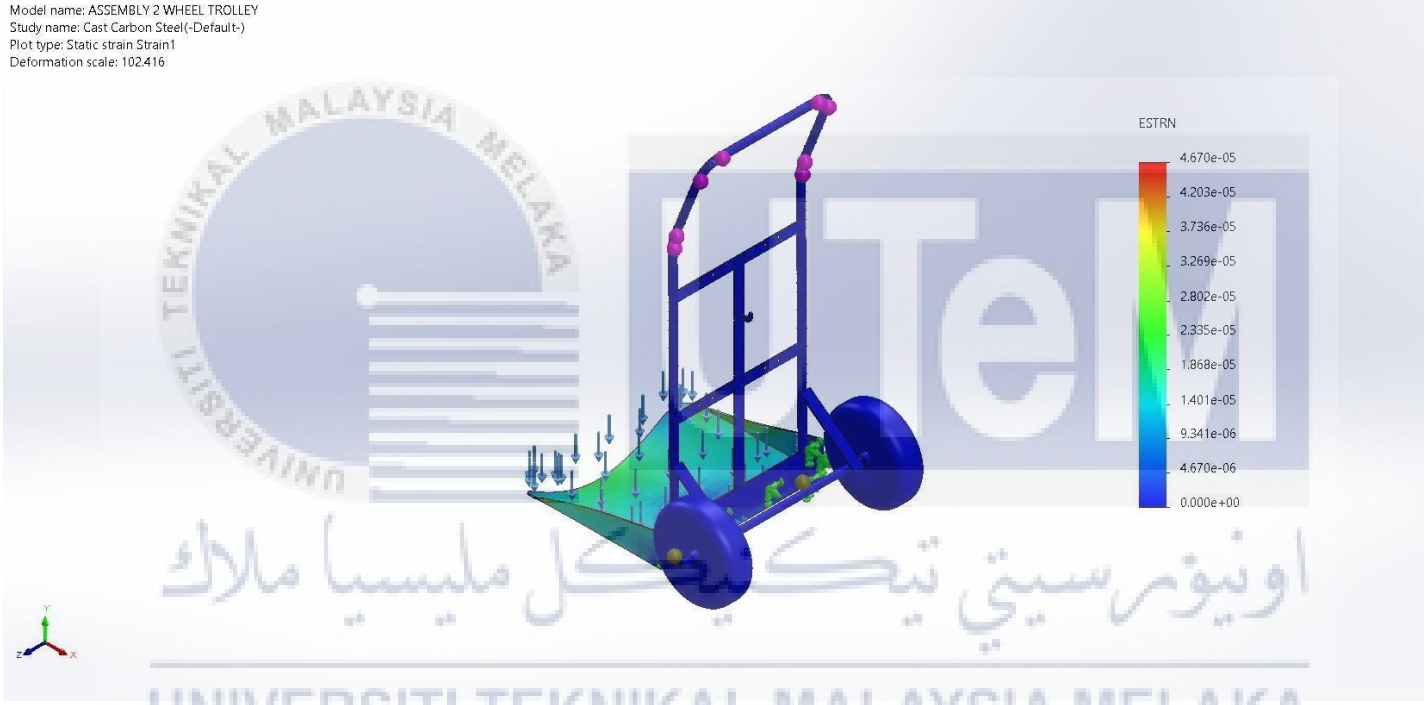
Figure 4.7 von Mises Stress for Cast Carbon Steel

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 631	1.096e+00mm Node: 8826

ASSEMBLY 2 WHEEL TROLLEY-Cast Carbon Steel-Displacement-Displacement1

Figure 4.8 Displacement for Cast Carbon Steel

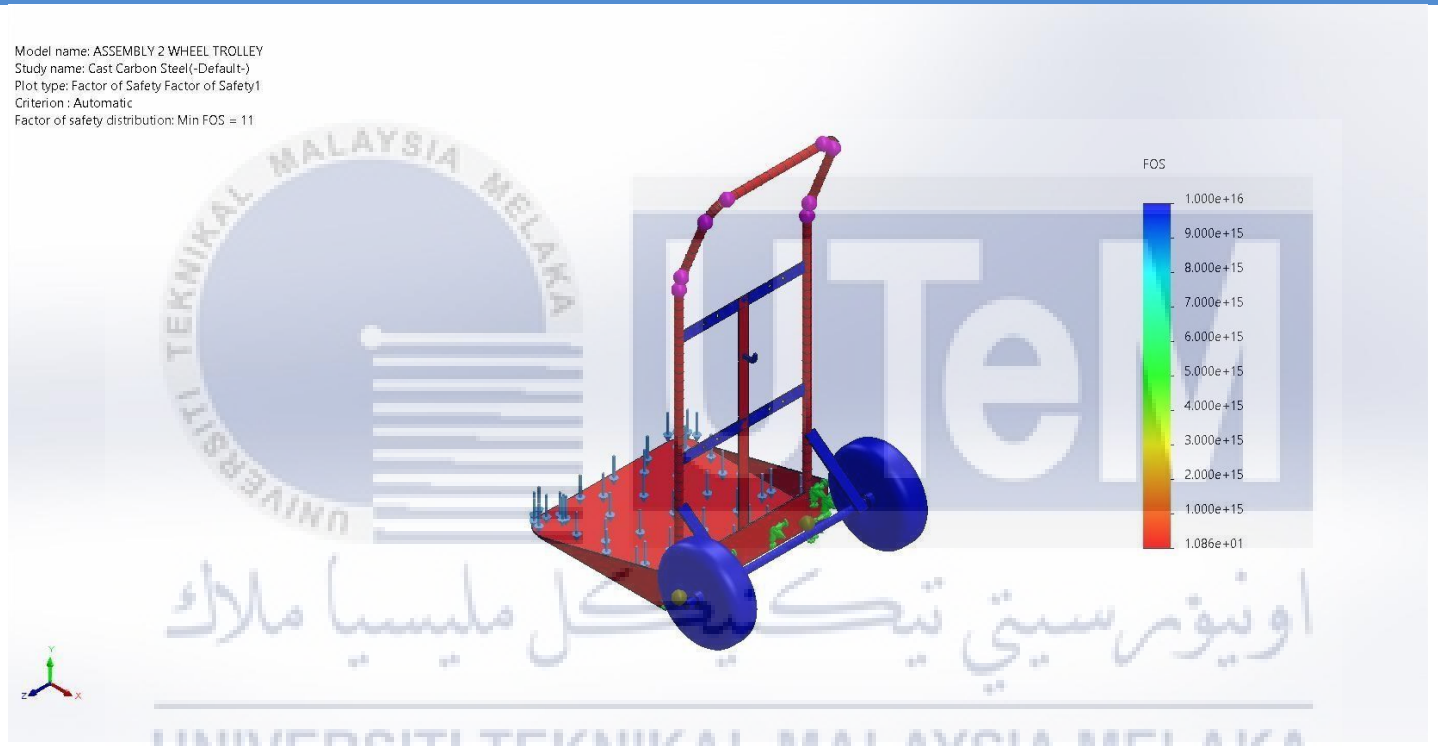
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0.000e+00 Element: 4547	4.670e-05 Element: 4315



ASSEMBLY 2 WHEEL TROLLEY-Cast Carbon Steel-Strain-Strain1

Figure 4.9 Strain for Cast Carbon Steel

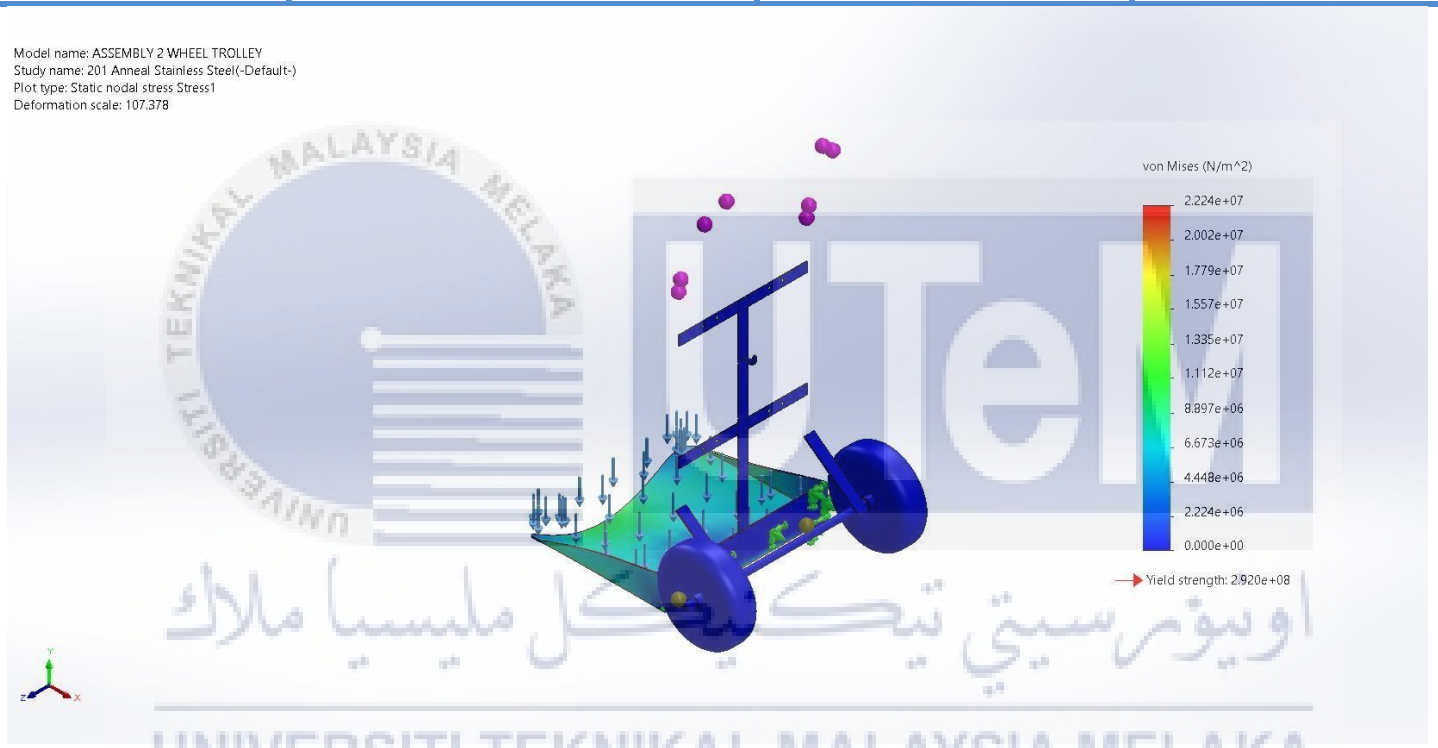
Name	Type	Min	Max
Factor of Safety1	Automatic	1.086e+01 Node: 1547	1.000e+16 Node: 9387



ASSEMBLY 2 WHEEL TROLLEY-Cast Carbon Steel-Factor of Safety-Factor of Safety1

Figure 4.10 Factor-of-Safety for Cast Carbon Steel

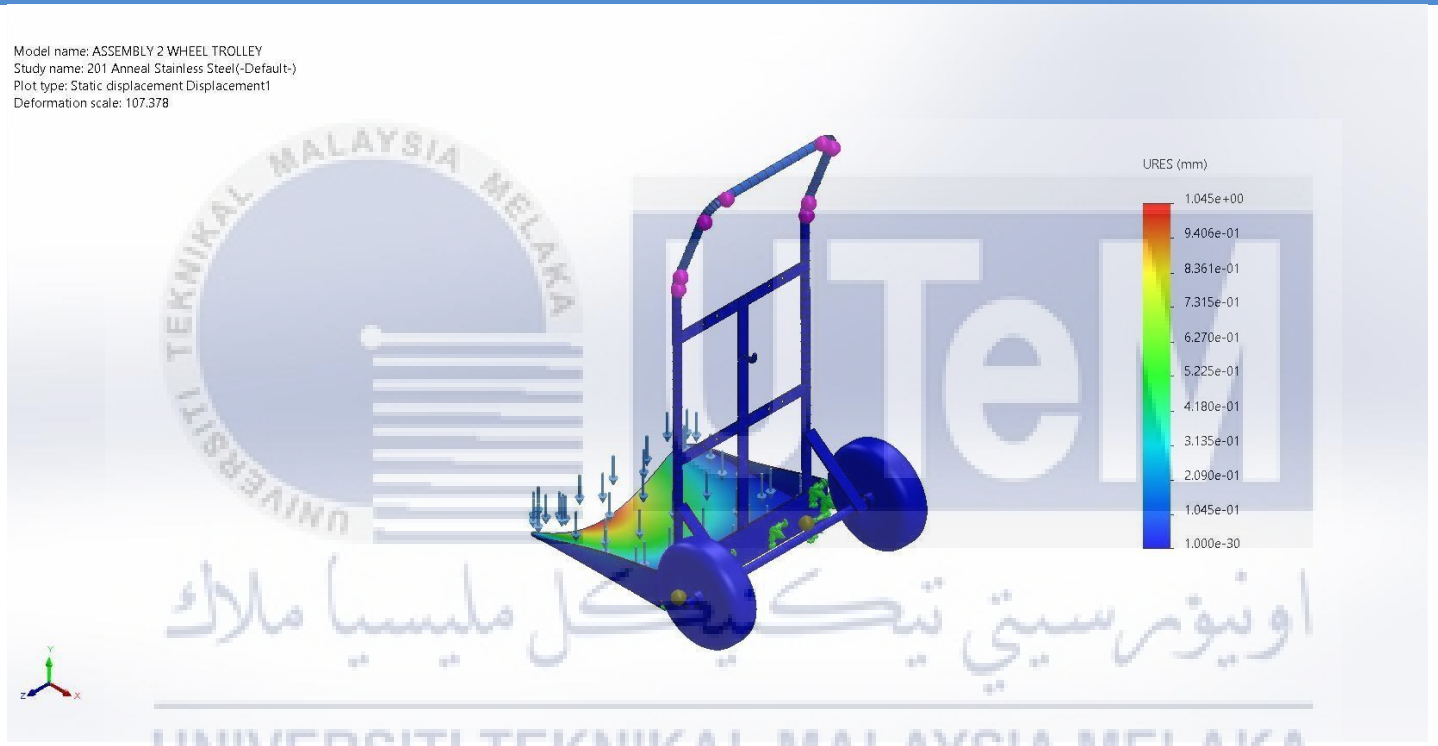
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 9387	2.224e+07N/m^2 Node: 1547



ASSEMBLY 2 WHEEL TROLLEY-201 Anneal Stainless Steel-Stress-Stress1

Figure 4.11 von Mises Stress for 201 Anneal Stainless Steel

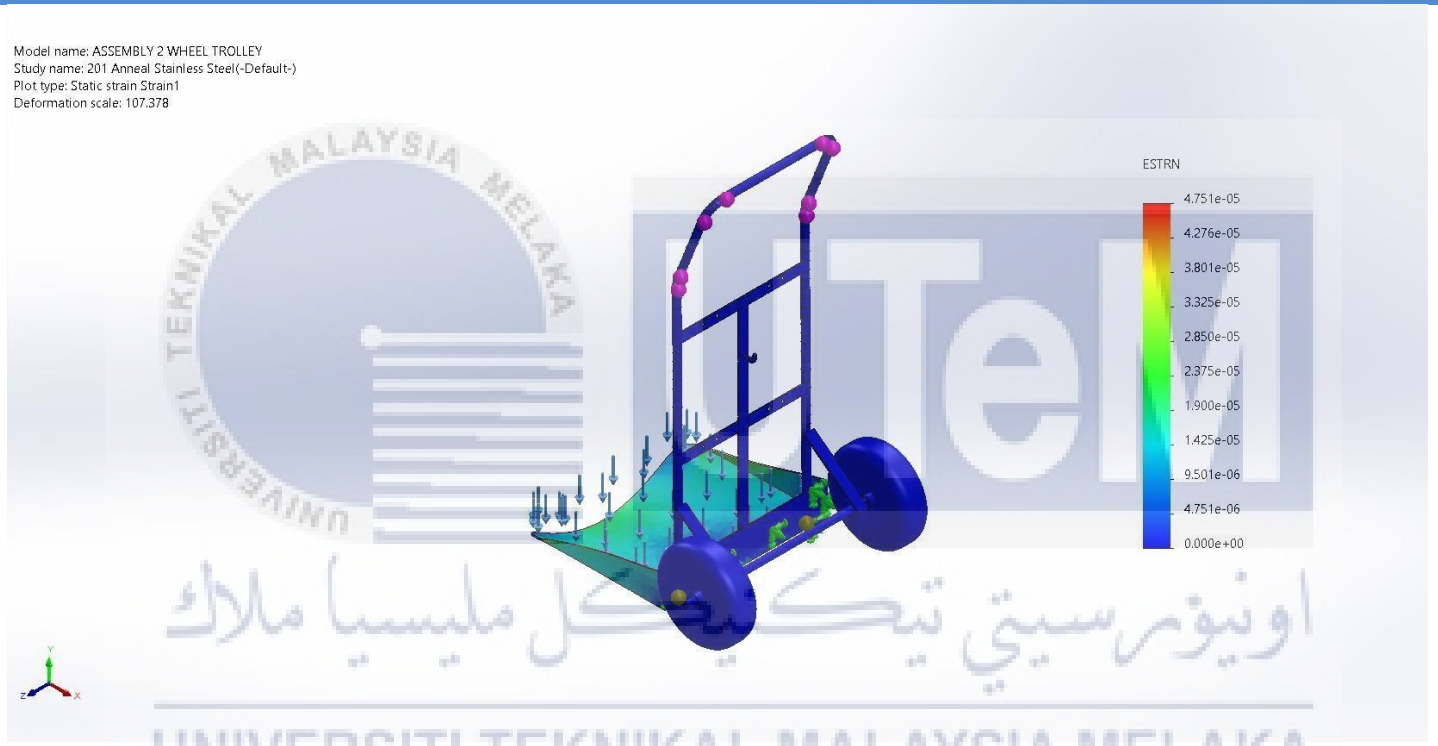
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 631	1.045e+00mm Node: 8826



ASSEMBLY 2 WHEEL TROLLEY-201 Anneal Stainless Steel-Displacement-Displacement1

Figure 4.12 Displacement for 201 Anneal Stainless Steel

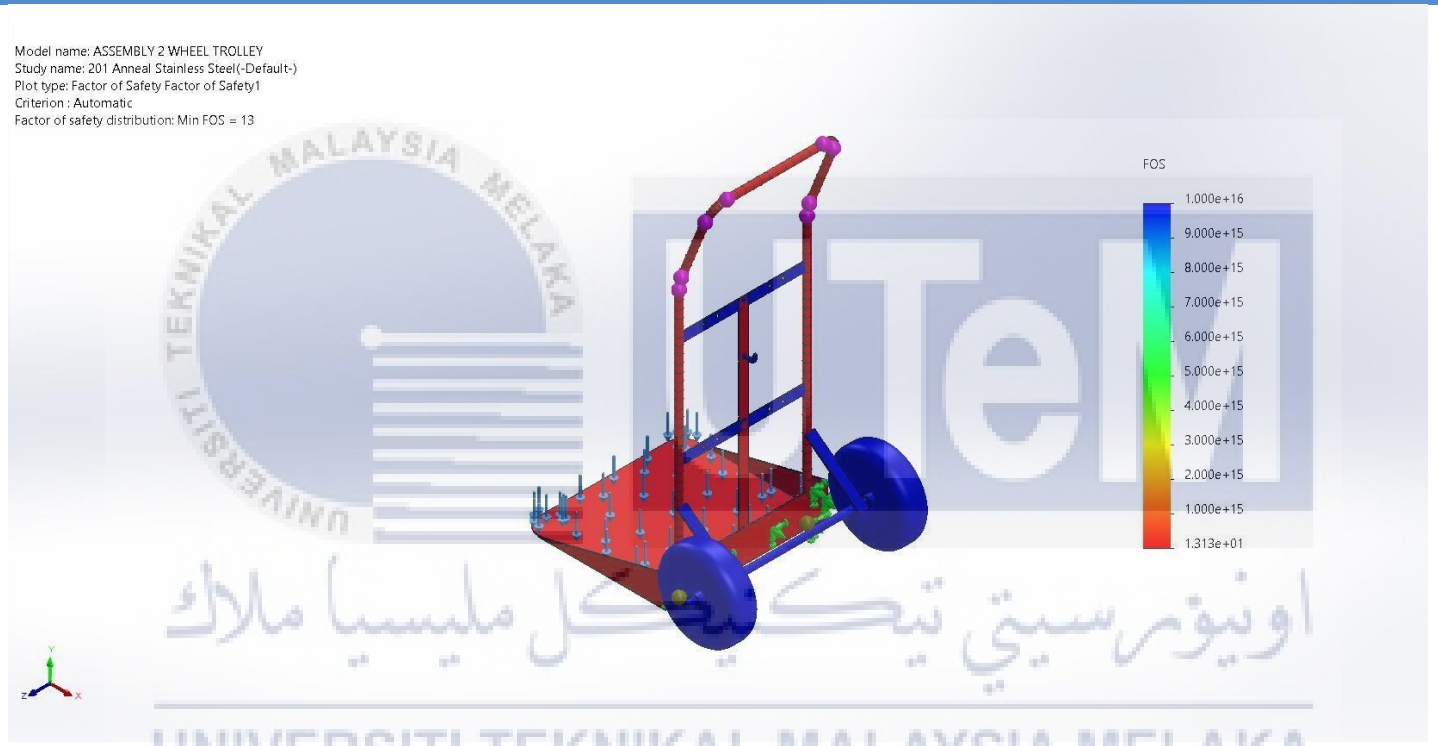
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0.000e+00 Element: 4547	4.751e-05 Element: 4315



ASSEMBLY 2 WHEEL TROLLEY-201 Anneal Stainless Steel-Strain-Strain1

Figure 4.13 Strain for 201 Anneal Stainless Steel

Name	Type	Min	Max
Factor of Safety1	Automatic	1.313e+01 Node: 1547	1.000e+16 Node: 9387



ASSEMBLY 2 WHEEL TROLLEY-201 Anneal Stainless Steel-Factor of Safety-Factor of Safety1

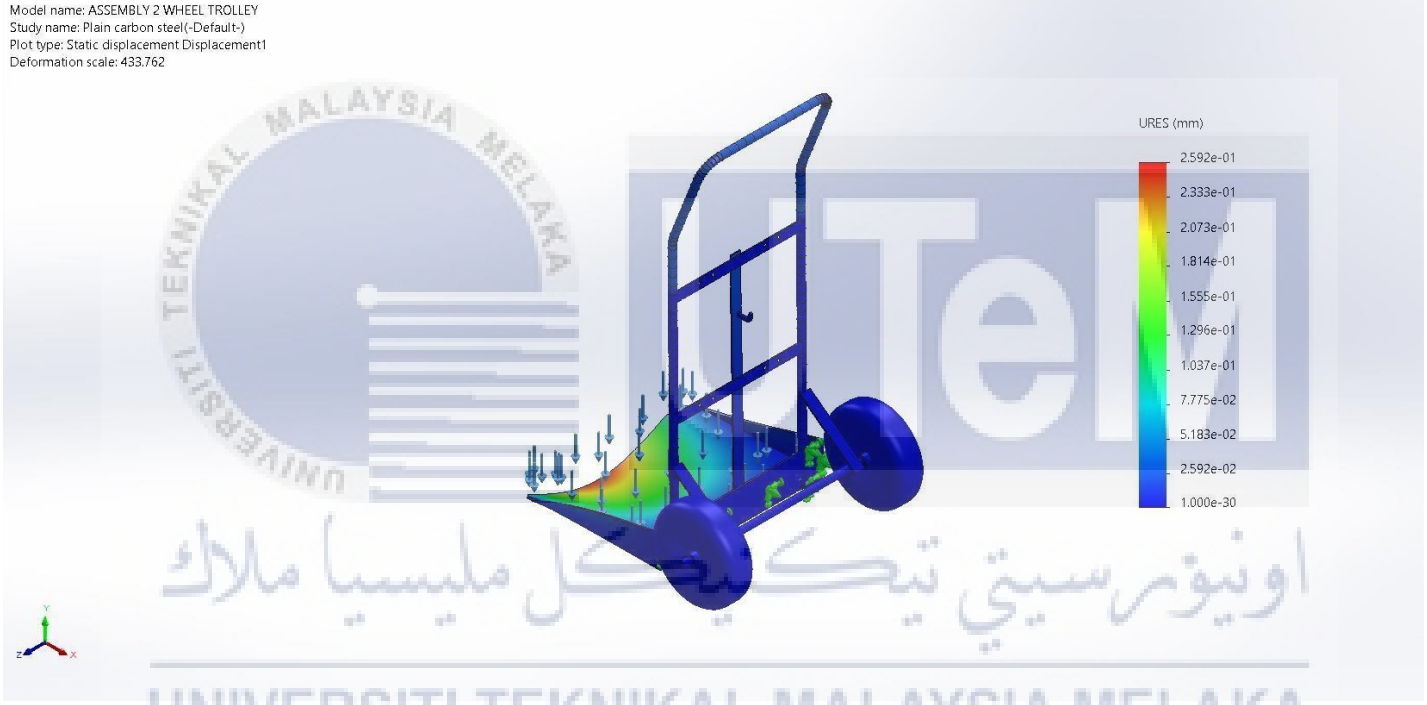
Figure 4.14 Factor of Safety for 201 Anneal Stainless Steel

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 9396	8.053e+06N/m^2 Node: 8898

ASSEMBLY 2 WHEEL TROLLEY-Plain carbon steel-Stress-Stress1

Figure 4.15 von Mises Stress for Plain Carbon Steel

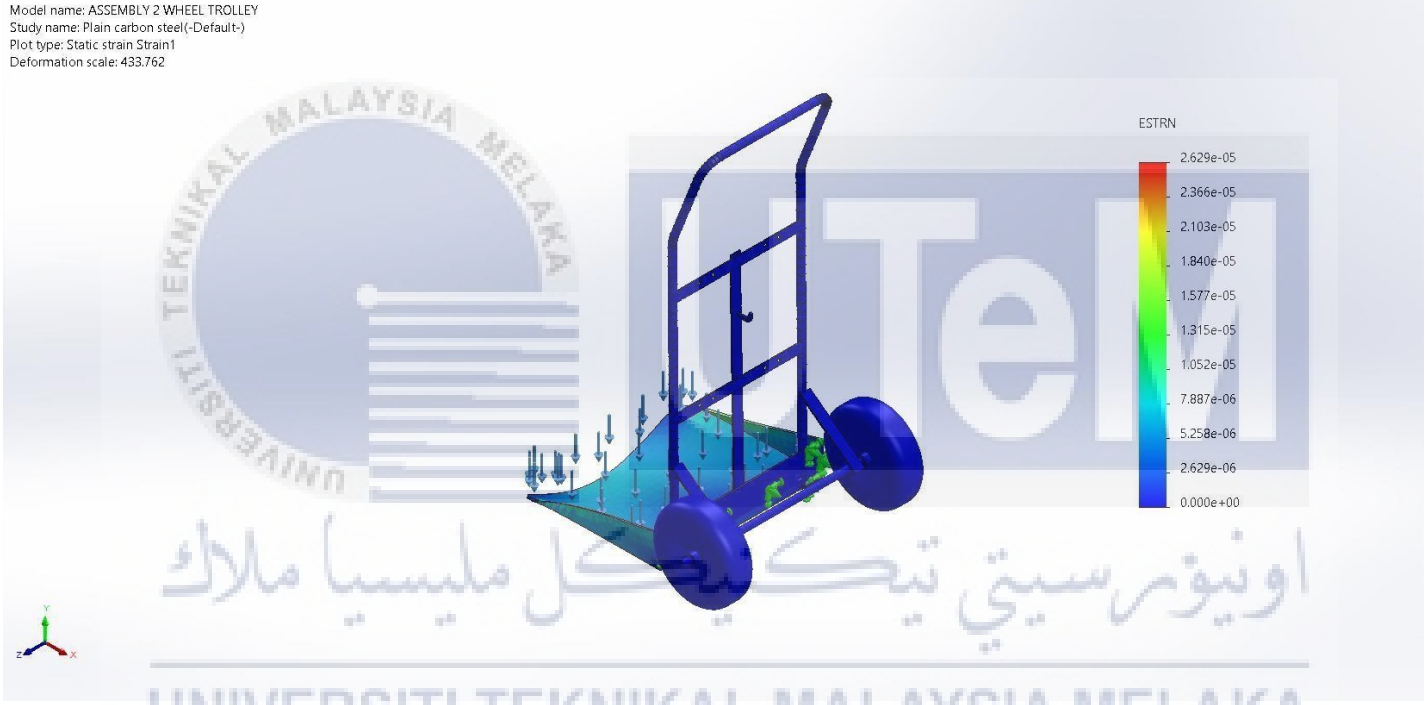
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 634	2.592e-01mm Node: 5042



ASSEMBLY 2 WHEEL TROLLEY-Plain carbon steel-Displacement-Displacement1

Figure 4.16 von Displacement for Plain Carbon Steel

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0.000e+00 Element: 4556	2.629e-05 Element: 4067



ASSEMBLY 2 WHEEL TROLLEY-Plain carbon steel-Strain-Strain1

Figure 4.17 Strain for Plain Carbon Steel

Name	Type	Min	Max
Factor of Safety1	Automatic	2.739e+01 Node: 8898	1.000e+16 Node: 9396

ASSEMBLY 2 WHEEL TROLLEY-Plain carbon steel-Factor of Safety-Factor of Safety1

Figure 4.18 Factor of Safety for Plain Carbon Steel

Table 4.5 Material Comparison

<table>
<tr><th>Features</th><th>Cast Carbon Steel</th><th>201 Anneal Stainless Steel</th><th>Plain Carbon Steel</th></tr>
<tr><td>3D Drawing</td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Force</td><td>200 N</td><td>200 N</td><td>200N</td></tr>
<tr><td>Properties</td><td>
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<tr><td>Name</td><td>Cast Carbon Steel</td></tr>
<tr><td>Model type</td><td>Linear Elastic Isotropic</td></tr>
<tr><td>Default failure criterion</td><td>Max von Mises Stress</td></tr>
<tr><td>Yield Strength</td><td>2.48168e+008 N/m^2</td></tr>
<tr><td>Tensile strength</td><td>4.82549e+008 N/m^2</td></tr>
<tr><td>Elastic modulus</td><td>2e+011 N/m^2</td></tr>
<tr><td>Poisson's ratio</td><td>0.32</td></tr>
<tr><td>Mass density</td><td>7800 kg/m^3</td></tr>
<tr><td>Shear modulus</td><td>7.6e+010 N/m^2</td></tr>
<tr><td>Thermal expansion coefficient</td><td>1.2e-005 /Kelvin</td></tr>
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<table>
<tr><td>Name</td><td>201 Annealed Stainless Steel</td></tr>
<tr><td>Model type</td><td>Linear Elastic Isotropic</td></tr>
<tr><td>Default failure criterion</td><td>Max von Mises Stress</td></tr>
<tr><td>Yield Strength</td><td>2.92000e+008 N/m^2</td></tr>
<tr><td>Tensile strength</td><td>6.85000e+008 N/m^2</td></tr>
<tr><td>Elastic modulus</td><td>2.07e+011 N/m^2</td></tr>
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<tr><td>Mass density</td><td>7859.9999kg/m^3</td></tr>
<tr><td>Shear modulus</td><td>N/m^2</td></tr>
<tr><td>Thermal expansion coefficient</td><td>1.7e-005 /Kelvin</td></tr>
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<table>
<tr><td>Name</td><td>Plain-Carbon Steel</td></tr>
<tr><td>Model type</td><td>Linear Elastic Isotropic</td></tr>
<tr><td>Default failure criterion</td><td>Max von Mises Stress</td></tr>
<tr><td>Yield Strength</td><td>2.20594e+008 N/m^2</td></tr>
<tr><td>Tensile strength</td><td>3.99826e+008 N/m^2</td></tr>
<tr><td>Elastic modulus</td><td>2.1e+011 N/m^2</td></tr>
<tr><td>Poisson's ratio</td><td>0.28</td></tr>
<tr><td>Mass density</td><td>7800 kg/m^3</td></tr>
<tr><td>Shear modulus</td><td>7.9e+010 N/m^2</td></tr>
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<tr><td>von Mises Stress</td><td>Max: 2.284e+07 N/m^2</td><td>Max: 2.224e+07 N/m^2</td><td>Max: 8.053+06</td></tr>
<tr><td>Displacement</td><td>1.096e+00 mm</td><td>1.045e+00 mm</td><td>2.592e-01mm</td></tr>
<tr><td>Strain</td><td>4.670e-05</td><td>4.751e-05</td><td>2.629e-05</td></tr>
<tr><td>Factor of Safety</td><td>Min: 1.086e+01
Max: 1.000e+16</td><td>Min: 1.313e+01
Max: 1.000e+16</td><td>Min: 2.739+01
Max: 1.000e+16</td></tr>
</table>

The outcomes were presented as stress and displacement (deflection). This section was subjected to the maximum stress attributed to moment force due to the vertical loading applied at the base's surface, and it exhibited bend development. For Cast Carbon Steel, Plain Carbon Steel, and 201 Anneal Stainless Steel material, the maximum stress sustained by the trolley has been determined. In comparison for these three materials, material type 201 anneal stainless steel was selected for this project which have the value of max von Mises stress 2.273e+07N/m^2. This material's displacement value is 1.045 mm, which is the lowest. When a product is bearing a load, this displacement value is used. At 1.045 mm, it will flex somewhat but not break at the base. The yield strength of 201 annealed stainless steel is 2.920e+07N/m2, which is more than the maximum von Mises stress value. As a result, even if a 20 kg weight is put on the trolley's base, it will be able to withstand the load without breaking or fracturing. Because this project may be influenced by flood water, which includes characteristics that might alter the material, material selection is critical. Because of the uniqueness of 201 Anneal Stainless Steel, which was invented in reaction to soaring nickel costs, it was chosen. This implies it is less expensive, but it also contains much less nickel. Grade 201 stainless steel has good formability, corrosion resistance, and fabricability. Its kind 201 stainless steel is particularly useful in a cold environment because of its hardness. Form 201 seems to be the most appealing since it is the cheapest type of stainless steel. In a very corrosive environment, however, it will not last as long.

4.1 Chapter summary

This chapter explains the outcomes of the project's methodology. The prototype was created using criteria derived from a market research and product comparison. Several probable components are identified and listed in the morphological chart to produce a conceptual design. A thorough design was created using the Pugh selection process, along with suggested dimensions for prototype development. According to the theoretical results, the PVDF type filter is better than the ceramic filter in every criteria, however after testing the selected parameter, the ceramic quality has a great result, making the water cleaner than PVDF. Ceramic filters may create high-quality, clean water, although its flowrate is lower than PVDF's (126.48 L/H). To create enough clean water to serve 50 victims, three filters may need to be operating simultaneously.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

To summarize, the Mobile Water Supply Unit was designed to fulfill all of the major requirements, including mobility, ease of assembly and disassembly, and robustness, and the prototype was created and presented in this thesis. The project's goals are to develop a mobile clean water supply unit for flood victims, analyze the system, and build a prototype. All of the requirements were satisfied. The mobile water supply unit is meant to provide clean water to flood disaster victims at the evacuation center, which lacks clean water, according to the problem statement stated at the beginning of this article. The goal of this design is to filter flood water until it achieves a safe standard of cleanliness. It will be given to them to use after it has reached the level of clean water. A gasoline turbo water pump is used to increase the flowrate of the filter by raising the pressure. When there is no power at the evacuation center, the use of a gasoline turbo water pump is explored. This system can run on RON95 gasoline even if there is no electricity. Electricity systems have been utilized to power many inquiries and research. This might be one of the project's benefits. The installation procedure takes 31.8 minutes, which is regarded a shorter duration if you're in such condition. The system designed specifically for this project makes it simple to just get safe, clean, and nutritious water. The water quality from this mobile water supply unit filter has been assessed using a number of test parameters to verify that it meets the essential requirements for preventing water-borne diseases such as cholera and typhoid.

5.2 Recommendations

For future improvements, due to the rapidly evolving technology, the compact design can be improved as follows:

1) Select filter with a high flowrate and excellent grade of clean water produced.

2) Use pump that can provide greater pressure to raise the filter's pressure.

3) Create or design a new universal adapter that can be used to match certain pipes for speed of installation, such as plug-in-and-play.

4) Design a compact design that is low cost.

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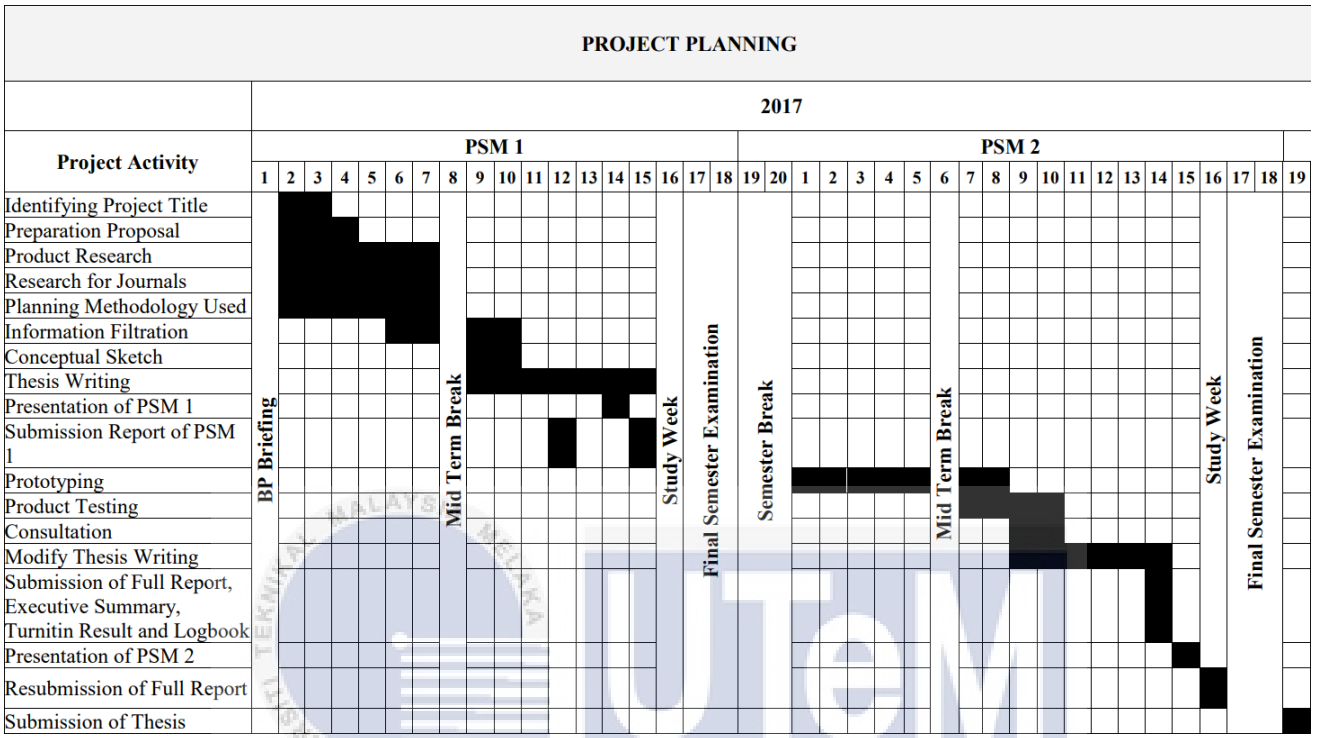
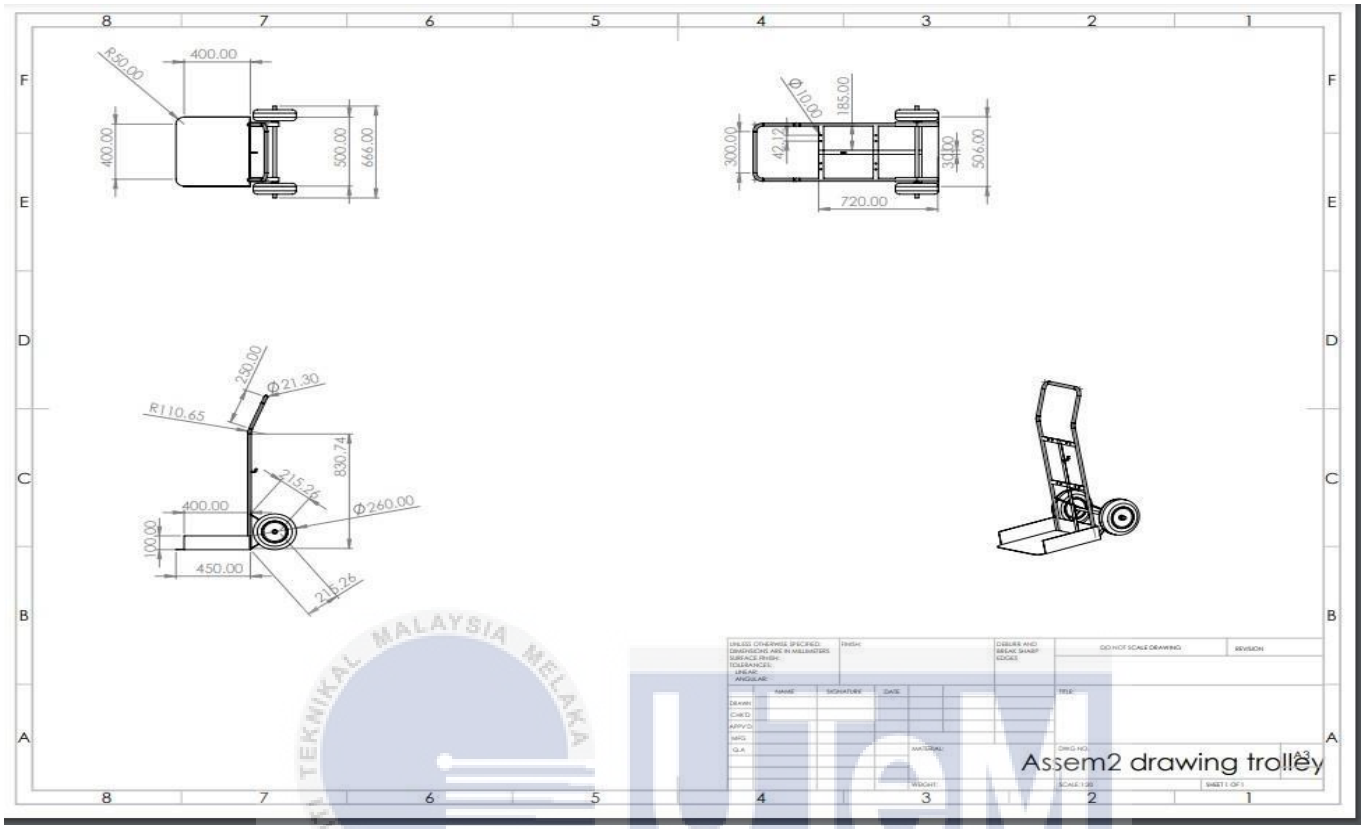
APPENDICES

APPENDIX A Gantt Chart



APPENDIX B Drawing for trolley



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