DEVELOPMENT OF FEMALE HYGIENIC URINAL DEVICE USING DESIGN FOR X

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Development of Female Hygienic Urinal Device Using Design For X” is the result of my own research except as cited in references.

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Date : 2 September 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

……………………….................................

(Professor Ir Dr Hambali bin Arep@Ariff)

ABSTRAK

Pada masa kini, terdapat pelbagai jenis alat bantuan kencing untuk wanita yang terdapat di pasaran. Walau bagaimanapun, tidak banyak alat bantuan kencing direka khusus untuk pesakit di atas katil dan patuh Syariah. Kebanyakan pesakit di atas katil menggunakan lampin pakai buang yang perlu ditukar dengan kerap kerana penggunaan yang terhad, mahal dan tidak mesra alam. Oleh itu, penyelidikan ini bertujuan untuk menghasilkan alat bantuan kencing untuk kaum wanita menggunakan reka bentuk untuk x. Kaji selidik telah dijalankan di rumah penjagaan di Melaka untuk menyiasat kesan lampin pakai buang dan pilihan spesifikasi teknikal bagi menghasilkan produk yang dicadangkan. Selain itu, pelbagai aktiviti reka bentuk termasuk penyiasatan pasaran, penjanaan konsep, pemilihan konsep, pembangunan konsep, dan pengoptimuman menggunakan reka bentuk untuk x telah dijalankan untuk menghasilkan empat reka bentuk berkonsep produk yang dicadangkan. Kaedah logik digital (DLM) dan Teknik Pesanan Keutamaan oleh Persamaan dengan Penyelesaian Ideal (TOPSIS) kemudiannya dilaksanakan untuk menentukan reka bentuk konseptual terbaik. Seterusnya, reka bentuk yang dipilih telah dioptimumkan lagi melalui Mod Kegagalan Reka Bentuk dan Analisis Kesan (DFMEA) dan Reka Bentuk untuk Alam Sekitar (DFE). Pilihan yang dikumpulkan daripada kaji selidik yang dijalankan menyimpulkan bahawa produk yang dicadangkan itu sepatutnya mudah dikendalikan dan mesra alam manakala reka bentuk terbaik yang dipilih melalui TOPSIS dilengkapi dengan sistem basuh semburan tunggal. Oleh itu, pengguna boleh menggunakan semula alat bantuan kencing tanpa kerap menukarnya dan menghasilkan sisa. Selain itu, analisis yang dijalankan menunjukkan bahawa Bilangan Keutamaan Risiko (RPN) selepas DFMEA diaplikasikan adalah kurang daripada 100 dan bertambah baik sebanyak 78%. Seterusnya, analisis DFE telah menunjukkan bahawa akhir hayat produk yang dicadangkan selepas reka bentuk diperbaiki seperti yang ditunjukkan oleh reka bentuk web eko yang lebih besar dan peningkatan 13% dalam nilai penunjuk eko. Kesimpulannya, produk yang dicadangkan ini berfungsi dengan lebih baik dari segi perlindungan dan fungsi alam sekitar berbanding produk sedia ada kerana ia boleh digunakan semula dan dilengkapi dengan sistem pembersihan diri.

ABSTRACT

Nowadays, there are various type of urinal devices for females available on market. However, not much of the urinal devices are specifically designed for bedridden users and Syariah compliance. Most of the bedridden patients utilize disposable diapers that have to be changed frequently due to limited usage which is costly and non-environmentally friendly. Hence, this research aims to develop a female hygienic urinal device using design for x methodology. Survey had been conducted at nursing home in Melaka to investigate the effect of disposable diapers and technical specification preference for develop proposed product. Furthermore, various design activities included market investigation, concept generation, concept selection, concept development, and optimization using design for x were carried out to develop four conceptual designs of proposed product. Digital logical method (DLM) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) were then implemented to decide the best conceptual design. Subsequently, the selected design was further optimized through Design Failure Mode and Effects Analysis (DFMEA) and Design for Environment (DFE) method. The options collected from survey conducted concluded that the proposed product should be easy to handle and environmentally friendly while the best design selected through TOPSIS was equipped with single spray washing system. Thus, users may reuse the urinal device without changing it frequently and create waste. Besides, analysis conducted shown that the Risk Priority Number (RPN) after implemented DFMEA was less than 100 and improved by 78%. Next, the DFE analysis had showed that the end of life of the proposed product after redesign was improved as indicated by bigger eco web design and 13% increment in eco indicator value. In conclusion, the proposed product performs better in term of environmental protection and functionality compared to existing product as it is reusable and equipped with self-cleaning system.

DEDICATION

DEDICATED

TO MY DEAREST PARENTS

Mr. Che Manan bin Saat and Mrs. Jariah binti Ismail

TO MY HONOURED SUPERVISOR

Professor Ir Dr Hambali bin Arep@Ariff

For his advice, support, motivation, and guidance during the accomplishment of this final year project 2.

TO MY SUPPORTIVE FRIENDS

For giving me moral support, encouragement, and cooperation.

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LIST OF ABBREVIATIONS

DfX	-	Design for X
DFMEA	-	Design Failure Mode Effect Analysis
DFE	-	Design for Environment
USD	-	United States Dollar
CAGR	-	Compound Annual Growth Rate
VOCs	-	Volatile Organic Compounds
DfX	-	Design for X
TOPSIS	-	Technique for Order of Preference by Similarity to Ideal Solution
PSSs	-	Product-Service Systems
CE	-	Concurrent Engineering
DFM	-	Design for Manufacturability
DFI	-	Design for Inspection
DFV	-	Design for Variability
DFC	-	Design for Cost
DFA	-	Design for Assembly
DFR	-	Design for Reliability
RE	-	Redesign Engineering
FMEA	-	Failure Mode Effect Analysis
PFMEA	-	Process Failure Mode Effect Analysis
S	-	Severity
O	-	Occurrence
D	-	Detection
RPN	-	Risk Priority Number
LCA	-	Life Cycle Assessment
QFD	-	Quality Function Deployment
PLC	-	Product Life Cycle

BOL	-	Beginning of Life
MOL	-	Middle of Life
EOL	-	End of Life
EI99	-	Eco-Indicator 99
DLM	-	Digital Logical Method
PIS	-	Positive Ideal Solution
NIS	-	Negative Ideal Solution
CAD	-	Computer Aided Design
BMI	-	Body Mass Index
3D	-	3 Dimensions
PUL	-	Polyurethane Laminate
PP	-	Polypropylene
PLA	-	Polylactic Acid
LCT	-	Life Cycle Thinking
CFD	-	Computational Fluid Dynamic

CHAPTER 1
INTRODUCTION

1.1 Research Background

A urinal device is one of the best options for those who were having difficulties going to the toilet especially those who were bedridden. This research related to urinal devices and focuses more on female users as female's anatomy are more complicated than male. There are a lot of urinal devices for females that had been produced but not many of them are made specifically for bedridden users and Syariah compliance.

Mostly, bedridden users will wear disposables diapers as it is easier for the caregiver, but disposables diapers cost a fortune if it is used every day. To get specific data about the usage of disposables diapers, a survey has been conducted at one of the nursing homes in which the branches are both located in Malacca. According to Elders Home Plus (2017), these care centres provide holistic eldercare and nursing services, specifically to address the needs of senior patients who require post-operative care, post-stroke care, palliative care, rehabilitative care, or daily assisted living.

Next, hygiene is something that one should care about, and it is the most important issue in Islam as Muslims need to be physically hygienic and ritually clean whenever possible especially when performing prayers (Hamid, Toyong, & Rahman, 2016). Furthermore, discussing hygiene, water will be the main topic since hygiene and water are inseparable. The fundamental hygiene is united most of the time with water as water is one of the elements used for cleaning.

This research is regarding the development of female hygienic urinal device for bedridden patients. The idea is to make a portable urinal device that specially designs for bedridden users and replace the usage of disposables diapers. There are a lot of existing reusable diapers that have been created but the main objective to be gain here are that all the existing product on the market are not hygienic as the urine will be stagnant in the device itself. Also, they do not have a washing system because mostly the cleaning phase is done using wet tissues or towels. Thus, making the cleaning period longer.

The project has undergone various design activities starting with the development of the design through market investigation, constructing conceptual design, and detail design. Then, the product was optimized using design for x (DfX). The results that have been carried out from this project were to show that the proposed design can function well in terms of product architecture and environmental performance. All the development's requirements were using Design Failure Mode and Effects Analysis (DFMEA) and Design for Environment (DFE). Lastly, a conclusion for this project was discussed and several recommendations were suggested.

1.2 Problem Statement

One of the specifications for the female hygienic urinal device is it can be used for bedridden users as the existing design is not suitable and inconvenient for the users. As mentioned earlier, bedridden users are most likely to use disposables diapers. According to Grand View Research, Inc. (2019), in 2018, the global adult diapers market size was United States dollar (USD) 12.62 billion which is likely to progress at a compound annual growth rate (CAGR) of 12.7% during the forecast period. The global diaper market is increasing at high growth as it is supported by various growth drivers. For example, the aging population, increasing disposable income, and increase in urban population (Anteneh, 2019). Besides its global market that is not environmentally friendly – made from plastics, disposables diapers also potentially posing risks to the person who uses them. This is because some of these plastic materials release volatile organic compounds (VOCs) and endocrine-disrupting chemicals which are absorbed by the skin as the diapers in contact with it. These chemicals are used as liquid absorbents to improve the functionality and softness of the diapers (Park et al., 2019).

Next, the existing urinal device for bedridden users provides less comfort to the user as they have a separate washing system which is wet tissues or towels. It is important to use water for the Muslims to complete the use of the toilet (Istinja ') and for cleaning before the prayer was performed (ablution or wudu). This is because water is one of the most profound elements of Islam. Hence, this research is focusing on producing a Syariah compliance urinal device where the washing system is attached to the device. Over the years, improvements of designs are made on the urinal device for bedridden users such as a catheter for female patients but there are always consequences in something. This catheter increasing the user's risk of catheter-associated urinary tract infections (Warren, Fosnacht, & Tremblay, 2020). Moreover, this research is done to reduce the usage of disposable diapers as the purchasing cost of disposable diapers is extremely high.

Not just that, there were also other cons where the filled diapers will cause an inconvenient smell. Besides, the caregiver needs to change the disposable diapers frequently due to the limited storage of urine. Thus, making it one of the challenges faced by the caregiver or people who assist the bedridden patients. Caregiving activities may have a direct and indirect impact on caregivers' health and life. Schulz and Sherwood (2008) identified a clinical observation and early experimental research that showed a caregiving role can be stressful and burdensome as it has all the features of a chronic stress experience such as physical and psychological strain over extended periods. Not just that, it is accompanied by high levels of unpredictability and uncontrollability. A survey was conducted to identify the effect of disposable diapers plus to support the problem statement.

Generally, this research concentrates on the performance of urinal devices for bedridden users as the replacement of disposables diapers by improving the design and its function. Plus, it will show the importance of implementing Design for X in designing and producing a high-quality product in a short time.

1.3 Objectives

The main objective of the research is to develop a new design of female hygienic urinal device for bedridden.

The specific objectives are as follows:

(a) To study the effect of disposable diapers in nursing homes.

(b) To propose the best conceptual design of the female hygienic urinal device for bedridden users using Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method.

(c) To optimize the selected design using Design Failure Mode and Effects Analysis (DFMEA) and Design for Environment (DFE).

1.4 Scopes of the Research

The scopes of research are as follows:

(a) Research on the effects of disposable diapers is carried out at a nursing home located in Malacca where a survey has been distributed. The survey is to help to improve the technical specification of the product. This research more focuses on gathering the data to seek the consequences of using disposable diapers and opinions about the proposed product.

(b) The development of the proposed design is based on the existing products that have been studied in the literature review where the gap research showed those devices were not hygienic and no washing system was provided.

(c) The concept evaluation of this device is developed using Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method from 4 different conceptual designs generated from a morphological chart.

(d) The proposed design has been analysed and optimized using Design for X which are Design Failure Mode and Effects Analysis (DFMEA) and Design for Environment (DFE) at the concept design stage.

(e) Design for Environment (DFE) consisted of life cycle analysis, eco-design web, and eco indicator that have been applied to the main body of the product.

(f) The proposed design is mainly for the bedridden patient who has difficulty urinating in the toilet. Thus, other problems such as defecating might be the consequences while using the product.

CHAPTER 2
LITERATURE REVIEW

This chapter mainly describes the theory and research which have been defined and done by various researchers years ago. Related information of previous studies is extracted as references and discussion based on their research about design for X framework, its application, and advantages. Furthermore, market investigation on the existing product has been critically reviewed to find the gap between them and lastly, a summary of this chapter.

2.1 Overview Of Urinal Device for Bedridden User

A urinal device is a tool that helps the user to overcome the problems to go to the toilet especially for the bedridden. There are a lot of existing products that have been produced but not much of them are produced for the bedridden. This research presented the process of improving the existing hygienic urinal device using the integrated approach and specifically for bedridden users. Nevertheless, the proposed design is intended to increase hygienic care for them.

2.2 Market Investigation on The Existing Product

The main purpose of this research is to construct a new urinal female design with specific criteria being focus on hygienic and comfortable to the bedridden users. To conduct the research, observation and studies have been made based on the existing female urinal system that already exists in the market. This is to make sure the understanding and ideas to create a new female urinal design can be concluded based on the existing one that has been commercialized in the market globally.

2.2.1 Bedpans

Bedpan use is not that different in today's society than it was in the 18th century. It is a double-layer device with a hole in the middle. The purpose of the bedpan is to collect bodily waste, specifically urine and faeces, in bed-bound individuals or those unable to use toilet or commode. Moreover, it is used most frequently in areas where patient mobility is limited such as in long-term care facilities and acute care hospitals (Hatt, Schindler, Bach, & Greene, 2020). Facilities may use reusable plastic bedpans that are cleaned between uses as shown in Figure 2.1 or single-use disposable bedpans illustrates in Figure 2.2. This device is usually used with the help of the nurses or the caregiver.

Figure 2.1: Reusable plastic bedpans (Vernacare, 2021)

Figure 2.2: Single-use disposable bedpans (Vernacare, 2021)

2.2.2 Aqua Eve Female Urinal

The concept of this design is based on a bottle as shown in Figure 2.3 that can be easily brought everywhere and anywhere. The main attraction of this design is the opening of the bottle illustrated in Figure 2.4 is big, so it is easier for the female user to use it to urinate. Besides, it is made from rubber which is soft and comfortable. Nevertheless, it is also flexible makes it fits the woman's anatomy so it will not leak. It is easy for men as well. The designer designed it specifically for women, but the finding is that in a certain situation, it is much more comfortable for men to use too. The design of the bottle is also suitable for the bedridden to use it.

Figure 2.3: Aqua Eve Female Urinal (Assistive Technology Australia, 2020)

Figure 2.4: Lid of Aqua Eve Female Urinal (Assistive Technology Australia, 2020)

2.2.3 OKASU Unisex Portable Urinal Device

This portable urinal device as illustrates in Figure 2.5 is a funnel that specifically designs for female users. The funnel is used to smoother the flow when the user urinates into plastic water bottles. The plastic water bottle is used to hold and collect the urine that will come through the funnel when the female user used this product. The funnel design enables it to attach to the plastic water bottle as shown in Figure 2.6 and it can be detached to clean up the funnel for hygiene purposes. Besides, the used water bottle can easily be thrown and when the user needs to use this device again, a new bottle is attached to the funnel. As the funnel is designed to match the standard water bottles, it can be used with any brand of water bottle. The design is user-friendly as it gives comfort to use for the female user to urinate properly on the bed. Nevertheless, the device's opening is coated with a rubber-like structure that gives comfort to users.

Figure 2.5: OKASU Unisex Portable Urinal Device (Amazon, 2021)

Figure 2.6: Portable Urinal Device with plastic water bottles (Amazon, 2021)

2.2.4 Handheld Urinal Device

Handheld urinals are plastic containers that are used in the bed when people cannot access the toilet. It is easier to use a handheld urinal device for a male user as shown in Figure 2.7, but it is quite difficult to use them for the female user. Figure 2.8 is the handheld urinal device used by the female user. The difference between these two products is the female’s device has an extra component that needs to be attached to the urinal device. When the female patient is on the bed, it is soft enough and the heavier part of the body falls deep inside the bed, which makes the process of using the handheld urinals hard. It was likely to cause spills during the urination because the bed might shake too much when all the body muscles were under great stress. Nevertheless, there will be spills if the device was removed too quickly and careless. It is easier to complete the urination when standing or sitting. The hard plastic on the edge is not completely body-friendly and those sharp edges might cause problems to the users.

Figure 2.7: Handheld urinal device for male (Hkailoka, 2020)

Figure 2.8: Handheld urinal device for female (Hkailoka, 2020)

2.2.5 Spil-Pruf Portable Urinal Device

This Portable Urinal Device Spil-Pruf product is designed as a portable urinal set for males and females. It has a distinctive style that can avoid leaks and can provide portability. There are two types of design for the spout which are mainly created for males and females as illustrate in Figure 2.9 and Figure 2.10. The specially designed spout prevents spills and leaks especially design for the female user. It can be used for bedridden because it has a container to store the urine and can be washed easily. Besides, the product provides a handle to give ease to the user.

Figure 2.9: Spil-Pruf Portable Urinal Device for male (North Coast Medical Inc., 2021)

Figure 2.10: Spil-Pruf Portable Urinal Device for female (North Coast Medical Inc., 2021)

2.2.6 Urinal devices for bedridden 1

Diaper replacing gives a burden on a caregiver and it becomes a serious social problem through the wide spreading of a paper diaper. A caring system proposed by Hatanaka (2005) consists of a means for mounting a diaper with a discharging port as shown in Figure 2.11. The discharging port then is attached to a dedicated bed as illustrates in Figure 2.12. The urine will flow directly to a sewer system to prevent odor and stagnant as the urine will be stored in a closed container. This invention is a mechanism relating to the urine and the excrement disposal method that does not require human labor, which conventionally reduces the caregiver’s burden.

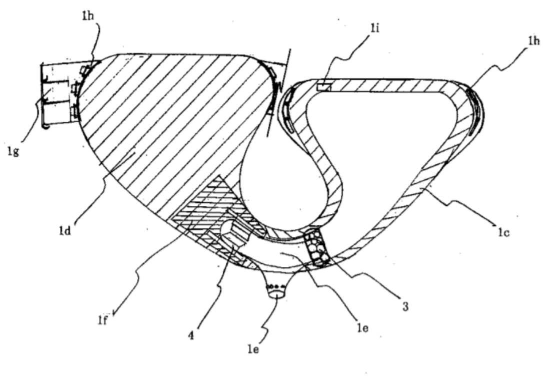


Figure 2.11: Diaper with a discharging port (Hatanaka, 2005)

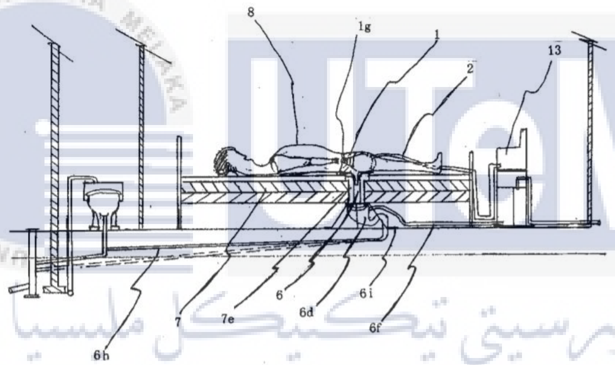


Figure 2.12: Discharging port attached to a dedicated bed (Hatanaka, 2005)

2.2.7 Urinal devices for bedridden 2

The invention from Zhongtang and others (2013) relates to a urinating device for women, which contains a urinating device body frame, an airbag, and a urine collecting bottle, where the urinating device body is provided with telescopic urine receiving cup as shown in Figure 2.13. The back end is connected with a urine guide cavity then a clip that suits the women’s anatomy is located at the upper end of the urine guide cavity. Next, the lower end of the urine guide cavity is vertically connected with the vagina hollow positioning body, and the back end is connected with a urine discharging tube and a liquid injecting tube. The back end of the urine discharging tube is connected to the urine collecting bottle, and the tail end of the liquid injecting tube is connected with a cleaning bottle. The urinating device for women has a simple structure as illustrated in Figure 2.14 and it is convenient to use and suitable for female bedridden patients with various diseases, female patients with urinary incontinence, and female diabetics.

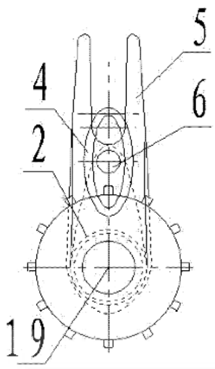


Figure 2.13: Telescopic urine receiving cup (Zhongtang et al., 2013)

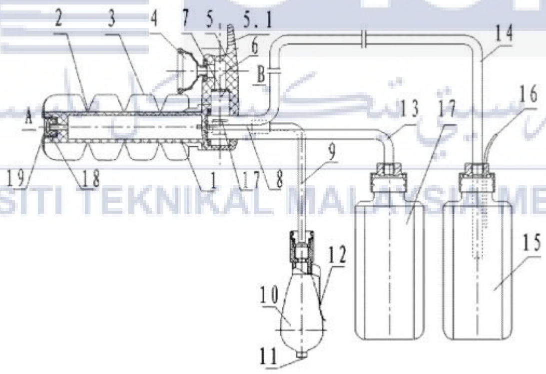


Figure 2.14: Urinating device for women structure (Zhongtang et al., 2013)

2.2.8 Comparison of market product

Table 2.1 shows the comparison of the products available in the market with the proposed design. The proposed design will include all the features to complete the customer's requirements. Plus, this is where the existing product will be critically reviewed.

Table 2.1 Urinal device comparison

Types of urinal system	Criteria				Comparison
	For female user	Urine container	Washing system	Portable	
Bedpans	✓			✓	The bedpans can be used only with the help of other people such as nurses or caregivers. Patients, especially with critical conditions or diseases, really need someone skilled enough to assist them with the bedpans because putting the bedpans needs a lot of energy and knowledge. It is might easy to clean the reusable bedpans and the disposables bedpan can easily be thrown away, but user satisfaction and comfort are always the priority.
Aqua Eve	✓	✓		✓	The design of the opener is round which is not suitable enough for the woman's anatomy. Plus, the height of the bottles when it is placed vertically might be troublesome when using the device. This is because the vagina is located lower near the bed when a person is lying on the bed. It might be difficult to place the opener to the vagina approximately.
OKASU	✓	✓		✓	This design acted like a funnel and the container's function is to store the urine in the plastic bottles. It is an extremely amazing design as the end of the device can fit with any plastic bottles but the only thing that can be reusables is the funnel as the plastic bottles will be thrown away and cause pollution to the Earth. The design is

					somehow suitable for travelers but not for the bedridden.
Handheld	✓	✓		✓	The device has a handle to ease the caregiver when lifting the urinal device. Moreover, it has two designs, especially for males and females. It is just that the females' design needs to add on an extra component to fits the females' urinal system shapes. But the opener might be a little discomfort as it is made from hard plastic.
Spil-Pruf	✓	✓		✓	The device has a spout to channel the urine into the bottles. There are two different designs for both genders. The female's design does not suit the woman's anatomy well and is most likely to spill during the urinating process. Not just that, it is made from hard plastic too which will give an uncomfortable situation to the user.
Bedridden 1	✓	✓			This device requires a special bed to attached with which will cost a fortune. Plus, it is not portable and might use a lot of space in one room. Not just that, this device did not come with a washing system which is the main objective of this research.
Bedridden 2	✓	✓	✓		The design of this device is too big and might give discomfort to the users. Overall, it has a washing system, but it is not portable.

2.3 TOPSIS

TOPSIS is stand for Technique for Order of Preference by Similarity to Ideal Solution where it is a multi-criteria decision analysis method. This method is used for any analytical decision based on collected data where it will compare a set of alternatives based on pre-specified criterion (Soczewica, 2020). TOPSIS was developed by Yoon and Hwang in 1981 where its key concept is that the selected option must be the closest from the ideal solution and furthest away from the negative-ideal solution (Balioti et al., 2018). Figure 2.15 shows the basic concept of TOPSIS where it shows A+ is stand for ideal point while A− is for negative-ideal point.

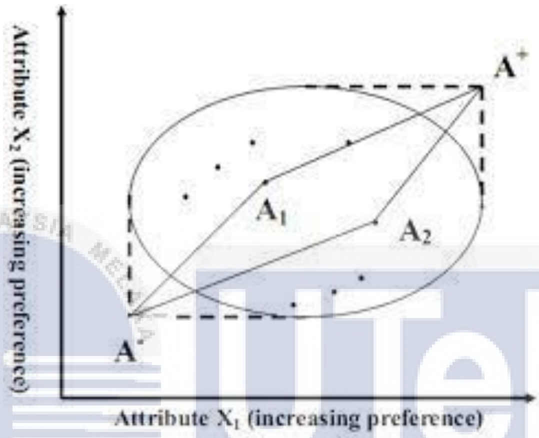


Figure 2.15: Basic concept of TOPSIS method (Balioti et al., 2018)

2.4 Design for X

Sassanelli et al. (2020) proposed that design plays a strategic role in the idea, either considering products, services, or Product-Service Systems (PSSs). Whenever a design is simple to manufacture, a better product that has low cost is produced. It is important to understand and implement the processes to enhance the design of components, assemblies, and whole products. To capture professional expertise, the Design for X families, or better known as DfX techniques, has been developed to guide analysis and redesign (Jack, 2013). Concurrent Engineering (CE) is an ideal product development environment. Improving quality, reducing prices, compressing cycle times, increasing versatility, increasing competitiveness and production, and improving the social picture are its goals. The means of achieving these goals is to consider all interacting problems in the design of products, processes, and systems from conception through development to retirement across cooperative teamwork between multiple disciplinary functions.

Specifically, the guidelines of DfX are interpreted as a concurrent product design plus certain abilities such as features, efficiency, restrictions, and many more to cope with a specific requirement. One of the most powerful approaches to implementing CE is using DfX. This encourages resources that are available to be put to the best use. Over the past two centuries, due to technological evolution, the industry has moved from traditional single-item manufacturing to a mass production model with extremely strict quality requirements. It is led towards the mass production of highly customized products, retaining the economies of scale at the same time. This competitiveness is therefore derived from massive customization and the highest speed of product growth, which includes creativity and disruptive support tools. Consequently, one of the greatest challenges today is to achieve the product requirements as soon as possible and invest the minimum of development steps and iterations (rework) for the given diversified demand from consumers. At the same time, the life cycle of products is decreasing, so agile and more integrated methods are necessary, as DfX is important to invest a minimum of time on more efficient design phases of design (Huang, 2012).

2.4.1 What is X?

Design for X (DfX) is a methodical approach for designing a product where X represents targeted objectives or characteristics of the product or process. The X may represent various features or characteristics, including efficiency, strength, variability, cost, yield, or reliability. This gives rise to the terms design for manufacturability (DFM), design for inspection (DFI), design for variability (DFV), design for cost (DFC). Similarly, other rules may associate other traits, attributes, or objectives for X (Abran, et al., 2004).

Requirements can eventually change throughout the process, and requirements are often impossible to foresee. Managing improvements and getting all the necessary input from internal and external stakeholders in the final framework is a daunting challenge for requirements engineering. and the design process. Built for quality, DfX is one way to meet this challenge. It is a knowledge-based approach that guides the design to maximize desirable product characteristics and minimize total lifetime costs, including, for example, production costs (Bralla, 1996). Examples of views and analyses published about DfX are assembly (DFA), environment (DFE), and reliability (DFR) (Xuan, et al., 2006).

DfX has been analyzed from various backgrounds, such as consistency, manufacturing, and sustainability (Mottonen, et al., 2010). It has been extended to various technological fields, such as the introduction of manufacturing restrictions and the development of new goods. Tools for DfX have been developed and the operational dimensions have been published. However, there are a few articles on DfX in redesign engineering (RE) that indicate that DfX is also a tangible means of handling, organizing, and communicating specifications for product production over the entire development chain. It is very helpful, for example, in the prioritization of criteria, as it takes into account the opinions of various parties in a fair manner. DfX may also be used to organize specifications for engineering operations and practices (Hyysalo, et al., 2009).

The goal of this research is threefold using DfX. First, the study provides a rich description of the DfX frame. Second, identify and analyze the challenges in DfX. Thirdly, as a conclusion based on empirical data and literature, this paper suggests a conceptual framework constructed to address the challenges. Therefore, the framework consists of Design failure mode and effect analysis (DFMEA) and Design for Environment (DFE).

2.4.2 Importance and benefits of DfX

For the benefits of DfX, it is clearer to compare with the traditional manufacturing approaches, traditional manufacturing approaches do not necessarily rely on alignment between the design team of the device and the development and supply chain teams. The DfX method puts together various individuals, skills, and tools as a customer's design challenge occur. DfX catches everything until development and becomes a conduit between the consumer and the design teams. It's a process that takes place in the early design stages with a lot of cooperation between all those involved (Dalgleish, et al., 2000).

DfX is a common term used as a replacement for design priorities in the engineering world. The unique "X" is the secret to performance in the design process. The principles defined by "X" widely used by engineers are production, assembly, testability, cost-efficacy, efficiency, and consistency. Having DfX in the goods as soon as possible with the tech tools widely used today helps TT Electronics to model construction, see the footprint, and what the pieces look like (Cooper, 2004).

There are marked variations between conventional engineering design and DfX implementation design. The map below highlights its key characteristics.

Table 2.2 Traditional engineering design versus Design for X (DfX) (Hyysalo, et al., 2009)

TRADITIONAL ENGINEERING VS DFX	
Traditional Engineering Design	**Design for X (DfX)**
Address issues after the design phase	Address issues at the early design stage
Many iterations of a product	The goal is to limit iterations (get it right the first time).
Use of many tools	Select use of an efficient set of standardized tools
Considers functional requirements	Considers the product life cycle requirements
Less team-based (less involvement from manufacturers, suppliers, and customers)	Team-based (more collaboration, supplier involvement, project management)

DfX refers to all new products and existing products. Defects, new pieces, or restructuring or redesign often arise in mature products, and that is where DfX will make a difference. It provides producers the input they need to make the most reliable product. They choose design features or prohibit excessive features and solutions that encourage cost-effective production, assembly, and testing activities. Their architecture, production, and assembly preparation seek to minimize design iterations and the number of mistakes such as high yield and reduce rework costs. Their process continues with a thorough review of the product plan (Lehto, et al., 2011).

Therefore, DfX importance are stated below: (Hyysalo, et al., 2009)

- Improved cost of goods
- Reduced time on the market

- Minimized product risk
- Improved consistency
- Maximized testability
- Improved output of production
- Improved client loyalty (improved delivery)
- Improved average service performance

2.5 Design framework using Design for X

Design for X (DfX) is key to the realization of competitive and profitable products. Design is for manufacturability, testability, installation, compliance, reliability, and other subsequent considerations. DFX is a theory and practice that guarantees quality goods and services, decreases the time to sell a product, and minimizes the expense of the life cycle, which is why it is necessary to achieve customer satisfaction (Abran, et al., 2004).

2.5.1 Design Failure Mode and Effects Analysis (DFMEA)

In the 1950s, the aerospace and US military sectors created Failure Mode Effect Analysis in systems engineering analysis. It was adopted by the private sector in the late 1960s. FMEA has been used extensively in the automotive and military industries, and it should be updated regularly if major changes to the design or production processes occur. It is still a popular tool in the manufacturing industry, where it is utilised as a stand-alone or as part of larger quality control frameworks. FMEA is a tool for predicting and preventing known or probable failures, improving system reliability and giving data for risk management choices (Moreira et al., 2020). Before finalising the product design, Design FMEA is a process to check that the appropriate materials are being utilised in order to comply with customer specifications and to ensure that government rules are followed. FMEA are divided into two which are Design Failure Mode Effect Analysis (DFMEA) and Process Failure Mode Effect Analysis (PFMEA). These tools are used to test products before they are put into production. FMEA prevents future design changes by resolving product or process failures, maintaining customer quality when it is used correctly (Segismundo & Augusto Cauchick Miguel, 2008).

When it comes to dealing with failure, one of the best features of FMEA is that it takes action rather than reacts. In other words, this is preventive measure taken prior to failure rather than afterward, because resolving difficulties and repairing damage usually costs a lot of money. If the error was caused during the design stage, the number of damages will be maximised. In addition, the FMEA will be completed before the major factor of design and processing faults is registered into the system to improve efficiency. Because of the time and money spent on a thorough and precise implementation of FMEA, it is now possible to make any modification or reform simply and with low cost (Bahrami et al., 2012). The procedure of FMEA is represented Figure 2.16.

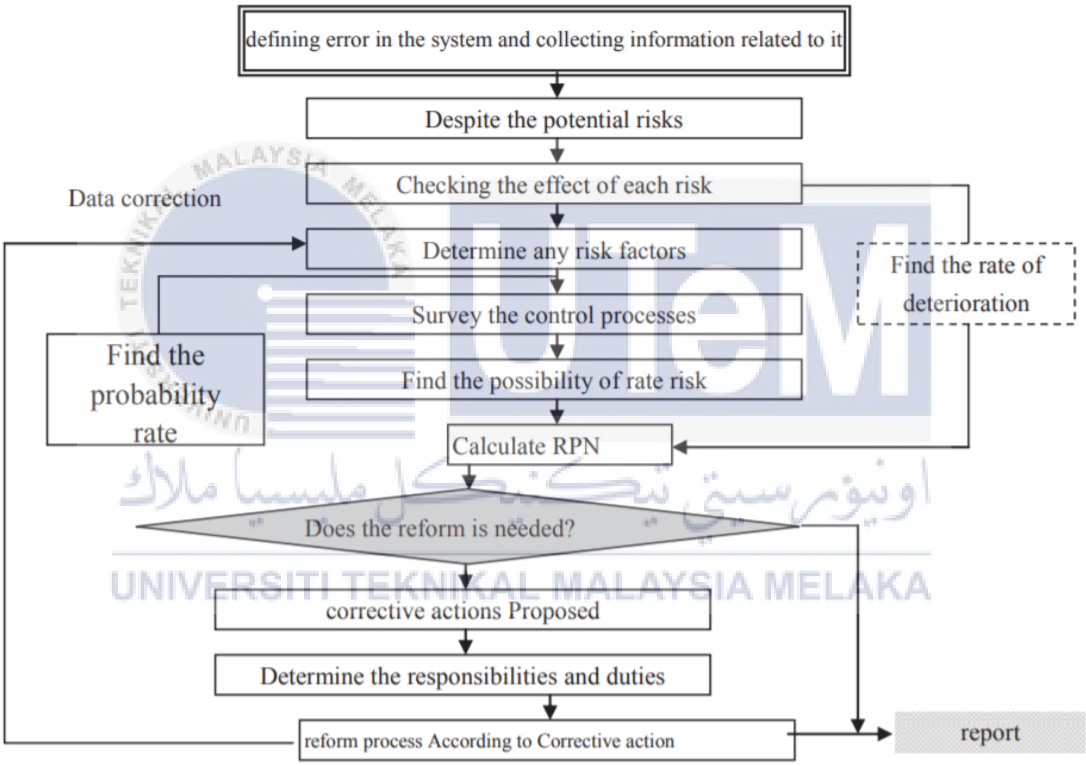


Figure 2.16: Procedure of FMEA (Bahrami et al., 2012)

To use this method, an FMEA team should be established that includes experienced engineers who are familiar with the project process as well as specialists who have the most knowledge about the product/process. One of the advantages of teamwork is that each task is specified and agreed upon by all organisational units. These groups are in charge of all connected tasks, from the early stages to the implementation of proposed activities, surveying the results, and finally the FMEA competition. The tasks of the FMEA team are then detailed in detail at the final stage.

FMEA considers three parameters, where the parameters were associated to a score range and is usually evaluated by easily comprehended verbal terms. The scores range is from 1 to 10, with 1 being the lowest and 10 being the highest. Severity (S), Occurrence (O), and Detection (D) are the three parameters to consider. Severity is the measurement for the effects of a failure mode seriousness while Occurrence is the probability of a failure mode to occur, and the Detection indicates the attitude of a failure mode to be discovered by controls and inspections. The danger and severity of a failure mode are then measured using the Risk Priority Number (RPN), which is calculated by multiplying these three parameters together.

These three variables must be evaluated using pre-determined scales in order to calculate the RPN. FMEA prioritises failure modes based on assumption where a higher the RPN value, the larger the risk of low product reliability. Corrective steps are required for high-risk failure modes, then their RPN is recalculated. This cyclical procedure should be repeated until the risks have been reduced to acceptable levels and the effectiveness of corrective and preventative actions has been determined.

2.5.2 Design for Environment (DFE)

As new product development legislation demands industries to design and produce with a lower carbon footprint, and society as a whole understands the need to actively protect the environment, the usage of Design for Environment (DfE) approaches has gained momentum. As a result, design engineers play a crucial role in incorporating environmental considerations into their design process in order to create environmentally friendly products. Various DfE approaches, such as decreasing resource consumption, selecting low-impact resources and processes, and maximizing product life, could be used in this adoption.

Many approaches and tools connected to DfE have been proposed over the previous two decades. Some authors have recently reviewed and classified them in order to facilitate their proper adoption (Butchert et al., 2014). For example, they were divided into two categories by Bovea & Perez-Belis (2012) which are those assessing the environmental product life cycle and those incorporating environmental aspects into the development of product. The former is based on Life Cycle Assessment (LCA), whereas the latter is based on Quality Function Deployment (QFD).

2.5.2.1 Product Life Cycle

The product life cycle (PLC) frequently begins with the identification of a need or purpose, leading to the formulation of an intention to create a related product, possibly as a result of requirements specification. The PLC then goes through multiple phases, including design, production, one or more usage stages, possibly one or more maintenance phases, and finally disposal stage, which may include some type of recycling.

According to Wiesnera, Freitagb, Westphala and Thobena (2015), in the literature, there are a variety of lifecycle models. The majority of them, however, are based on three primary life cycle phases which consist of Beginning of Life (BOL), Middle of Life (MOL), and End of Life (EOL). BOL, MOL and EOL are the three important stages of a product's life cycle. Planning, design, and production are all included in BOL. Product design, manufacturing planning design, and so on are all examples of design. In general, a design action entails a recursive application of many sub-actions, which includes determining requirements, specifying reference ideas, creating more detailed design, developing prototypes, and conducting tests. Manufacturing involves the production of artefacts as well as the management of internal plant logistics. The product design is created and then physically produced during the BOL phase; the product remains within the enterprise's boundaries.

The middle of life phase is post-manufacturing phase, when product is distributed, used, and serviced. For instance, repair and maintenance. At this point, the product usually is in the hands of the end buyer. Otte et al. (2019) states that customers or service providers are in charge of distributing, using, and maintaining supporting products. The product history, which includes information on distribution routes, usage circumstances, failures, and maintenance, offers information on the product's state as it changes over time.

EOL refers to when products are retired, re-collected in the company's hands (reverse logistic) to be recycled, disassembled, reproduced, reused, or disposed. EOL begins when the product no longer meets the needs of its consumers, whether they are the initial buyer or a second-hand owner. Information from EOL regarding "valuable components and materials" (e.g., what materials they contain, who produced them) and other knowledge that will help material reuse should be routed to recyclers and re-users, who will be able to collect reliable information about product condition and composition.

2.5.2.2 Eco-design web

Ecodesign web is a simple and quick tool that assists designers in qualitatively assessing a product or design in order to determine the important areas on which they should concentrate their efforts. It compares the seven design areas to determine a ‘better than' and ‘worse than' outcome. After the activity has been completed, the shape produced shows which parts require the most attention. Designers should concentrate on improving the identified areas after completing the Ecodesign web analysis (Lofthouse, 2017).

2.5.2.3 Eco-indicator 99

The Eco-Indicator 99 (EI99) impact assessment method for life cycle assessment (LCA) was developed more than a decade ago. It was the first method to allow most mid-point impacts to be further modelled into three so-called endpoint impact categories, representing three safeguard subjects which are human well-being, nature, and resources. It was developed more than a decade ago (Weidema, 2014).

PRé Consultants B.V. developed Eco-Indicator 99, a life cycle impact assessment tool. Eco-Indicator 99 calculates eco-indicator scores for materials and processes used to assist designers in making an environmental assessment of a product. Eco-indicator 99 is a pragmatic eco design method and also a science-based impact assessment method for LCA. It provides a method for calculating numerous environmental impacts and displaying the final result as a single score.

According to Cabeza and Tay, Eco-indicator 99 (EI99) is a top-down method that determines three environmental destruction endpoints which are human health, quality of ecosystem and resource availability. The main benefit of the EI99 methodology is that it allows for the estimation of a single environmental score including both the perspective-specified and perspective-averaged alternatives within the egalitarian, hierarchical, and individualist viewpoints.

2.6 Summary

To summarize, from the market investigation that had been shown earlier, seven products are available on the market. All the products had been compared to the features or specifications to complete the customer's requirement. The products have their limitation where it does not have a water spraying system to clean up or doesn't have the exact size and shape of the female's anatomy. Therefore, the limitation of the existing product will be countered to complete the requirement features. Market investigation can help the designer to choose the best design concept for developing a new urinal device that can counter all these limitations. Optimization of product design from the existing design in the market can help to identify the user need for customers besides improving the complex design to a simpler design that meets all the customer requirements. The limitations of the existing designs can replace with a new proposed design that will include the different shapes of urinal devices and the implementation of a water spraying system.

CHAPTER 3
METHODOLOGY

This chapter defines the methodology and the overall progress of research development which consist of the principles of methods that have been performed to complete the research. The data collection, designing, and optimizing the product were presented after referring to the technical specification of previous research. The flow of charts is discussed to achieve overall objectives and implements appropriate design for x tools.

3.1 Overview of Methodology

The preparation of methodology is to make sure the proposed product design is as planning and expected. The procedures were according to the scopes of research to reach the objective set up. Additionally, a survey has been conducted to support the development of the product and to seek the preference technical specification from the expert. Besides, this study applied the design of X which consisted of DFMEA and DFE to increase the effectiveness of the product proposed. Moreover, the settings of procedures were also based on previous research. The flow chart shown in Figure 3.1 described the overall process to obtain the results starting from data collection, concept design stage, and optimization of the product.

3.2 Flowchart of Methodology

This section reviews the flow chart which explains the flow of the research. The diagram is used to clarify the flow and it is arranged according to the sequence. Figure 3.1 shows the flow chart methodology of the research which has been divided into two parts, Final Year Project 1 and 2.

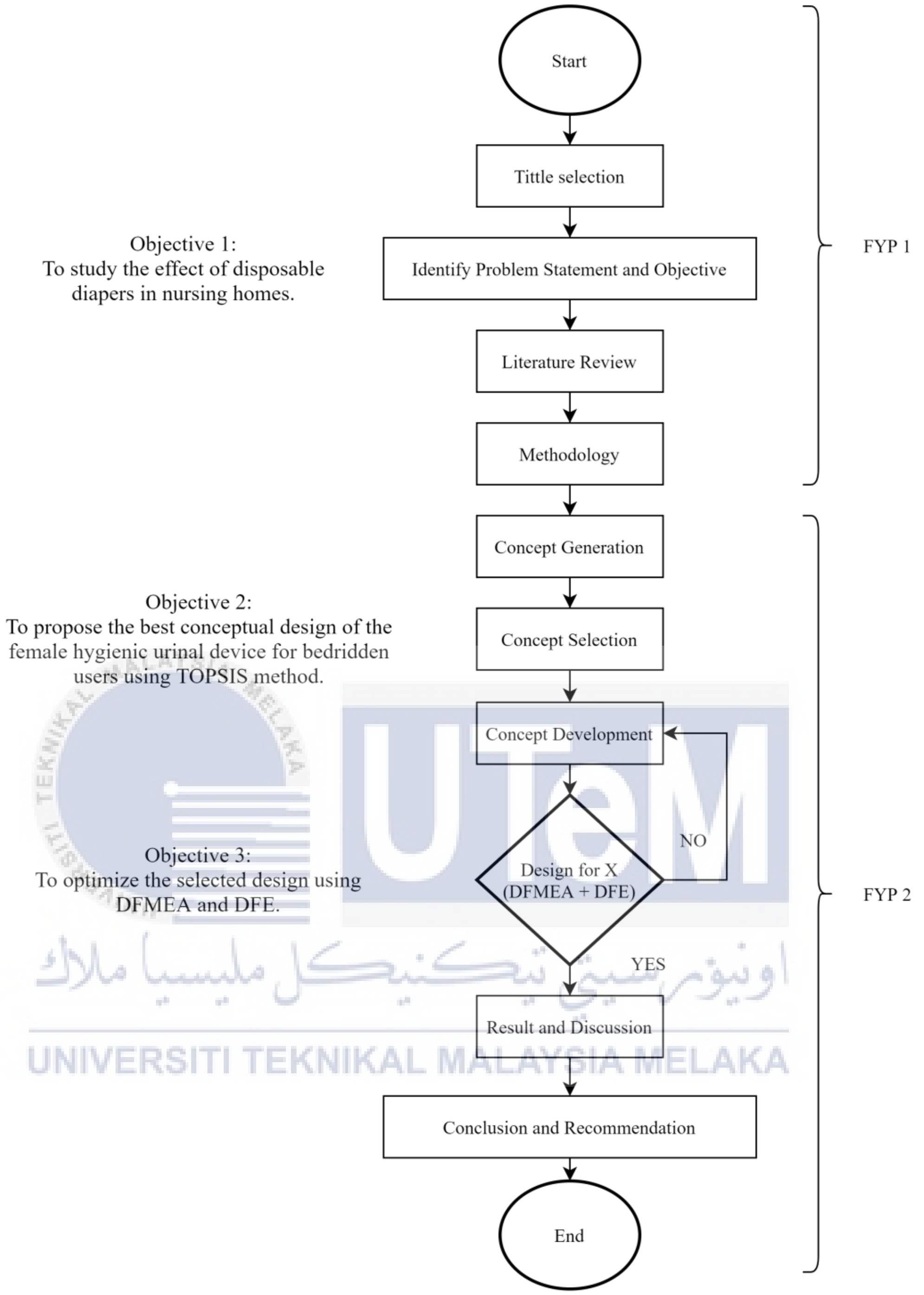


Figure 3.1: Flow chart methodology of the research report

3.3 Problem Statement and Objective

In order to select the best conceptual design, the problem statement and objective of the research need to be identified. The progress of the research must meet up the certain requirement of the research scope which focusing on the right goals and does not deviate from the problem statement and the objective of the study. Thus, the objective of the study will be achieved easier. Methods used to identify the problem statement were through the research on previous studies and limitation findings in the existing product. Plus, a survey was conducted to support the problem statement.

3.4 Literature Review

An in-depth literature review was conducted based on previous related studies to support this study. Various type of sources was gathered such as articles, journals, and patents to analyse and compare the design, methodology used, and any information related to the studies. Nevertheless, the literature review also helps in finding the loopholes in the previous research so that this study will be able to improve it.

3.5 Data Collection

3.5.1 Survey

Data has been collected through a survey at one of the nursing homes located in Malacca in early November 2020. The nursing home was separated into two branches and the survey was administered at both. The instrument used for the research is a questionnaire that consisted of 3 sections. Section A covers personal information with two questions while Section B provides 9 questions on the usage of diapers among the patient at the nursing home. Plus, Section C discussed the technical specification of the diapers with the usage of the 5 Likert scales. The questionnaire was administered in order to seek opinion on the proposed product with those experts that are familiar with the product. It is also to find any consequences of using disposable diapers. In addition, the finding of the survey helped to improve and prepare for the best, comfortable yet suitable portable diapers for the patient staying at the nursing home. Nevertheless, it is also to lessen the burden of the caregiver to assist the bedridden patients. Therefore, the methodology in achieving objective 1 is summarized in Figure 3.2.

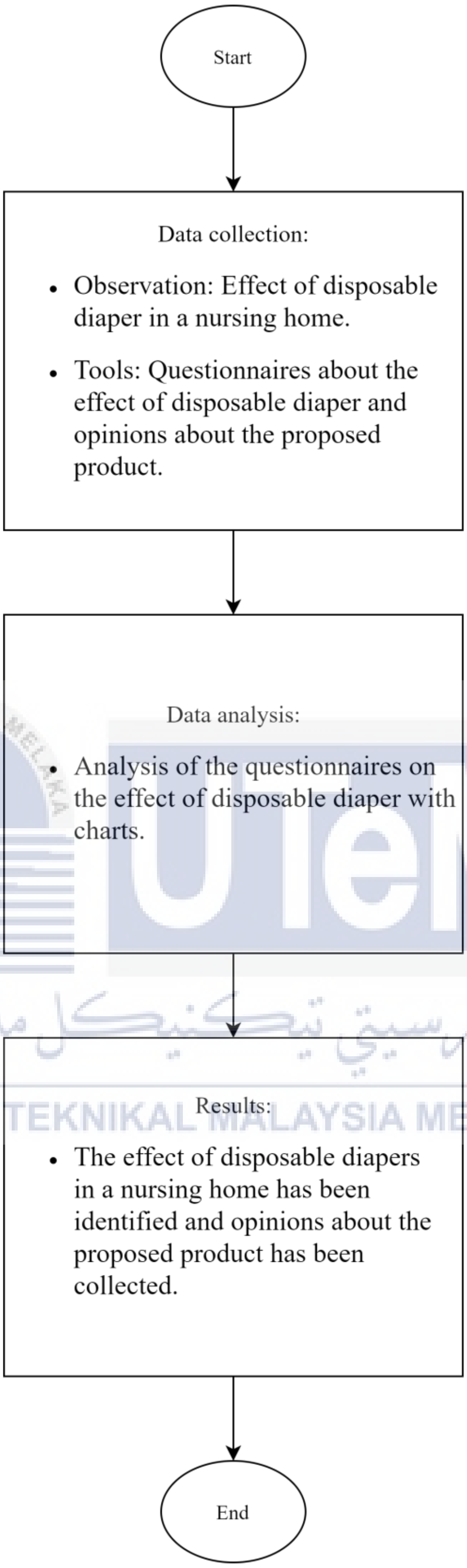


Figure 3.2: Flow chart of objective 1

3.6 Conceptual Design Stage

Conceptual design is the methodology used in this stage to test various ideas and solutions that comprise one aspect of the process of product creation. Conceptual design, however, is more focused on the ideas for each criterion and the generation of solutions. There are three main stages of conceptual design, which are concept generation, concept selection, and concept development. At the end of the design process that met the specific requirements, the best design is chosen.

3.6.1 Concept generation

The female hygienic urinal device was designed by identifying the issues that exist in the surrounding environment, and the idea used to select the best product specification design. First and foremost, this research will use a morphological chart to develop diverse concepts and several generations of ideas for each conceptual design. There are several factors to consider while designing and creating a female hygienic urinal device, including ease of use, ergonomics, ease of maintenance, cost, and manufacturability.

3.6.1.1 Morphological chart

Morphological chart is a method used to generate concepts analytically and systematically. The idea generation is accomplished by making a single concept from various components illustrated in the morphological chart. The proposed solution in the morphological chart was distinguished from existing products, patents, and journals. The method begins with identifying the technical specifications and sub-functions of the parts proposed for the items. These elements will be used in the morphological chart. The procedures of creating a morphological chart are as below:

1. Identify all the product components.
2. Construct a morphological chart with product components as the columns.
3. Fill the rows with the physical components that are linked to the specific product component. Components can be found by analysing comparable items or thinking up new principles for the parameters.

4. Use the evaluation strategies by analysing the product components and the physical components.
5. Create conceptual designs by combining the physical components from each product component.
6. The developed conceptual designs have then been sketched.

3.6.2 Concept selection

Four conceptual designs of the female hygienic urinal device were developed after carrying out the concept generation stage. Then, for further steps, choosing one of the best conceptual designs is crucial. The selection method for deciding the best design principle is completed by TOPSIS method. Other than that, digital logical method (DLM) is used to calculate the criteria's weightage in order to complete the TOPSIS calculation. Based on this, the result of the concept design has been selected and finalized.

3.6.2.1 TOPSIS

TOPSIS stands for Technique for Order Preference by Similarity to Ideal Solution. According to Afsordegan (2016), it is a multicriteria decision-making approach method based on the concept that the best alternative should have the shortest geometric distance to a positive ideal solution (PIS) and the geometric farthest distance from a negative ideal solution (NIS). Before proceeding with the TOPSIS calculation, criteria that are used to evaluated need to be clarified first along with the ranking scale.

i. Criteria

Criteria is used to evaluate the TOPSIS method. Thus, there are 5 criteria that have been chosen to evaluate following the appropriateness as well as the market requirements. The criteria that have been emphasized are shown in Table 3.1.

Table 3.1: Criteria

Number	Criteria
1	Ease of Use
2	Ergonomics
3	Ease of Maintenance
4	Cost
5	Manufacturability

ii. Rating scale

Rating scale is used to estimate the relatives' importance of criteria for each design. Each attribute is given certain points on a 1-10 rating scale by a team of decision-makers. Table 3.2 shows the rating scale that has been used to evaluate the design.

Table 3.2: Rating scale

Number	Criteria	Rating's Scale
1	Ease of use	10 Very Good – 1 None
2	Ergonomics	10 Very Good – 1 None
3	Ease of Maintenance	10 Easy – 1 Complicated
4	Cost	10 Low – 1 High
5	Manufacturability	10 Easy – 1 Complicated

iii. Digital logical method

Digital logical method (DLM) is used to define the weightage for the criteria before proceed with TOPSIS calculation. Criteria were compared pairwise to determine their relative importance for device application (Dong, 2020). The positive decision of the criteria was determined along with supervisory decision. The total weightage should be equal to 1. Next, the total positive decision should be divided by the total number of possible design combinations. Table 3.3 shows the example of the DLM table.

Table 3.3: Digital logical method

No.	Criteria	Possible design combinations										Positive decisions	Weighting factors (w)
		1	2	3	4	5	6	7	8	9	10		
		1-2	1-3	1-4	1-5	2-3	2-4	2-5	3-4	3-5	4-5		
1	Ease of Use												
2	Ergonomics												
3	Ease of Maintenance												
4	Cost												
5	Manufacturability												

iv. TOPSIS calculation

The procedure of fuzzy TOPSIS can be expressed in a series of steps:

1. Construct the decision matrix consists of criteria, weightage, and conceptual designs.

2. Construct the normalized decision matrix which represents the relative performance of the generated design alternatives. The equation was shown below.

$$R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}}}$$

3. Not all the selection criteria may be of equal importance. Thus, the weighting decision matrix is constructed by multiply each element of each column of the normalized decision matrix by the weightage that has been calculated using the Digital Logical Method (DLM). The formula used to calculate the weighting decision matrix is as below.

$$V_{ij} = w_j \times R_{ij}$$

4. Identify the Positive and Negative Ideal Solution. The positive ideal (A+) and the negative ideal (A-) solutions are defined according to the weighted decision matrix via the equations below.

- A+ = { V1 + ,V2 + …, Vn + },where:Vj +={(maxi(vij) ifjJ);(mini(vij) if j J')}

- ={V1 -,V2 -,..., Vn -}, where: Vj -={(mini(Vij) if jJ);(maxi(Vij) if j J')}

Where J is associated with the beneficial attributes and J' is associated with the nonbeneficial details.

5. Calculate the relative closeness of each competitive alternative from the ideal and non-ideal solutions using the formula shown.

$$S^+ = \sqrt{\sum_{i=1}^{n} \left(V_j^+ - V_{ij}\right)^2} \; i = 1,2,\dots.m$$

$$S^- = \sqrt{\sum_{j=1}^{n} \left(V_j^- - V_{ij}\right)^2} \; i = 1,2,\dots.m$$

6. Measure the relative closeness of each location to the ideal solution. For each competitive alternative, the relative closeness of the potential location concerning the ideal solution is computed.

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \; 0 \le C_i \le 1$$

7. Rank the preference order. According to Ci's value, the higher the value of the relative closeness, the higher the ranking order and hence the better the performance of the alternative. Ranking of the preference in descending order thus allows relatively better arrangements to be compared.

3.6.3 Concept development

After evaluation and decision-making, the selected conceptual design has been selected. Next, computer-aided design (CAD) is used to complete the detailed drawing of the product. The dimension of the product is crucial in this stage. Thus, the product will be drawn based on the researcher's size since the Body Mass Index (BMI) is ideal.

3.6.3.1 Autodesk Fusion 360

Autodesk Fusion 360 software has been used to draw parts of the female hygienic urinal device. At this stage, the body frame, urinal flow housing, and washing system concepts were drawn into 3D solid modeling. All the designed subassemblies and parts including respective multi-view drawings of all parts with overall necessary dimensions and tolerances as appropriate. Consequently, the methodology in achieving objective 2 is comprised in the following flow chart as illustrated in Figure 3.3.

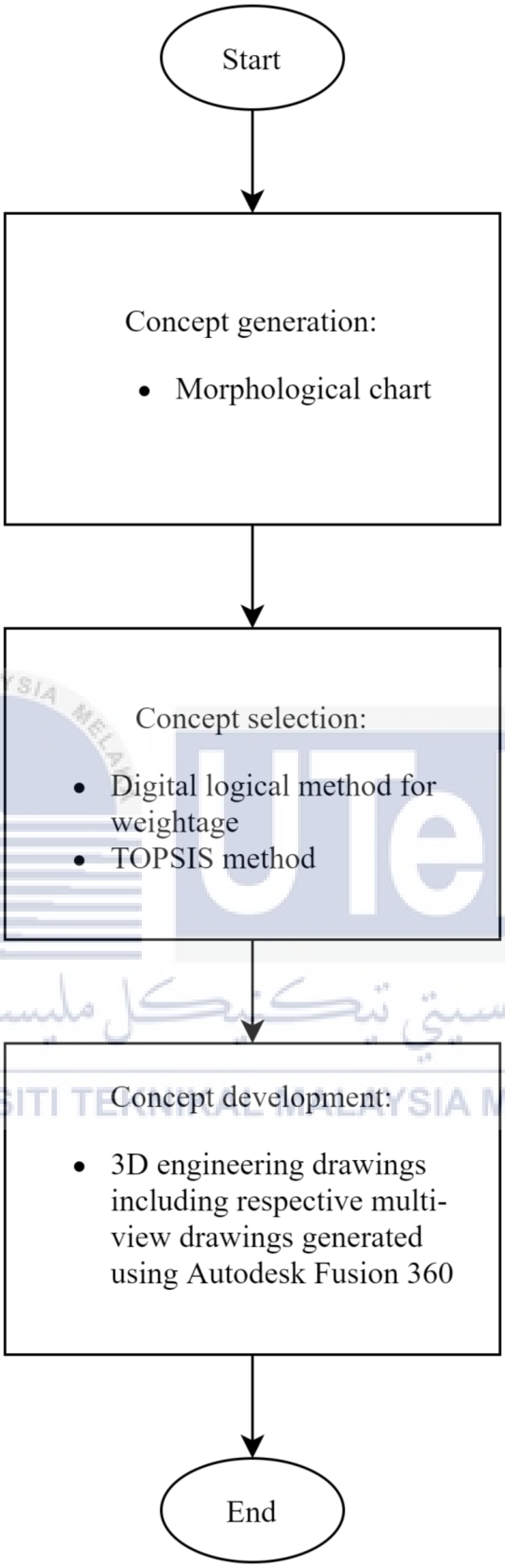


Figure 3.3: Flow chart of objective 2

3.7 Engineering Analysis and Validation

Engineering work is important as there is an entire context to delivering safe, functional, and efficient designs in mechanical applications. Besides, making sure that a design will work is a must especially in a safe way for customers and the public. Thus, validation of the designs must be done and some calculations for the product need to be completed to confirm that the design will work as intended before any metal gets cut or designs get fabricated.

Professional engineering analysis and reporting need to be accomplished so that there is confidence in such validations. Sometimes, the designs require reinforcement or geometry changes. Modeling performance and safety is much cheaper than the rare, devastating event. Seeing it virtually or computationally is due diligence that engineering design work benefits from by removing some of the unknowns and it helps clarify assumptions.

3.7.1 Design Failure Mode and Effects Analysis (DFMEA)

Design Failure Modes and Effects Analysis (DFMEA) is a systematic, proactive method for analysing product design before releasing it to production with a focus on product function. Likewise, this tool helps to analyse systems and subsystems in early concept and design stages. DFMEA is a structured process to identify where and how the product might fail and their associated causes as well as the mechanisms that have been considered during the design process. According to Shoults (2016), DFMEA is created to be "a stimulant for the exchange of ideas amongst the impacted functions". Thus, DFMEA can only be effectively completed with a selected team and the decision for DFMEA is the collective decision from the team. Therefore, this project was completed with the following DFMEA team:

a) Supervisor of the project
b) Final year project student
c) 2 nurses from nursing home
d) 1 diaper consumers

There are steps for DFMEA Process:

1. Identify potential failures that might happen to meet the design intent.
2. Determine the severity level of the failure mode as it is important to detect the effect on customer. The severity level is based on in Table 3.4.

Table 3.4: Severity ranking table (Shoults, 2016)

Severity Ranking		
Ranking	Effect	Criteria
10	Hazardous – without warning	affects safe operation without warning
9	Hazardous – with warning	affects safe operation with warning
8	Very high	makes product inoperable
7	High	makes product operable at reduced performance (customer dissatisfaction)
6	Moderate	results in customer discomfort
5	Low	results in comfort and convenience at reduced level
4	Very low	result in dissatisfaction by most customers
3	Minor	result in dissatisfaction by average customers
2	Very minor	result in dissatisfaction by few customers
1	None	no effect

3. Identify potential causes of each failure mode.
4. Determine the occurrence level for each cause. Occurrence defines the frequency with which the cause occurs and creates failure modes. Table 3.5 shows the occurrence level table.

Table 3.5: Occurrence ranking table (Shoults, 2016)

Occurrence Ranking		
Ranking	Effect	Time period
10	Extremely high	More than 5 times per day
9	Very high	Less than 5 times per day
8	Very high	Less than 3 times per day
7	High	Once per day
6	Moderate	Once every 2 days
5	Low	Once every 4 days

4	Very low	Once every 6 days
3	Minor	Once every 14 days
2	Very minor	Once every 21 days
1	None	Never

5. List current controls for each cause.
6. Determine the detection level for each cause and prevent it from happening. The detection level was given according to Table 3.6.

Table 3.6: Detection ranking table (Shoults, 2016)

Detection Ranking		
Ranking	Effect	Criteria
10	Absolute uncertainty	No chance that design control will detect cause mechanism and subsequent failure.
9	Very remote	Very remote chance that design control will detect cause mechanism and subsequent failure.
8	Remote	Remote chance that design control will detect cause mechanism and subsequent failure.
7	Very low	Very low chance that design control will detect cause mechanism and subsequent failure.
6	Low	Low chance that design control will detect cause mechanism and subsequent failure.
5	Moderate	Moderately chance that design control will detect cause mechanism and subsequent failure.
4	Moderate high	Moderately high chance that design control will detect cause mechanism and subsequent failure.
3	High	Very remote chance that design control will detect cause mechanism and subsequent failure.
2	Very high	Very high chance that design control will detect cause mechanism and subsequent failure.
1	Almost certain	Design control will almost certainly detect cause mechanism and subsequent failure.

7. Calculate the Risk Priority Number (RPN). The Risk Priority Number (RPN) is a mathematical product of the numerical Severity, Occurrence, and Detection ratings. RPN can

be calculated by multiply severity, occurrence, and detection values as shown in the formula below.

RPN = (Severity) x (Probability) x (Detection)

8. Develop recommended actions to address potential failures that have a high RPN and take actions. These actions could include inspection, testing, or quality procedures such as material selection, redesign the item to avoid the failure mode, and many more. The higher RPN value will be given the priority to be discussed first.
9. After these actions have been taken, the severity, occurrence, and detection value need to be re-assessed and the RPN value needs to be revised until the value is less than 100.

3.7.2 Design for Environment (DFE)

Design for Environment has been implemented onto the product to increase environmental performance. It consisted of life cycle thinking, eco-design web, and eco indicator 99.

3.7.2.1 Life cycle thinking

The life cycle of the female hygienic urinal device has been sketched focus on the production side and manufacturing processes based on three aspects which are environment, social and economic impacts of a product over its entire product life cycle. The product will be sketched with its components followed by the process life cycle used to manufacture and fabricate the product to form a life cycle mapping system. All the sketches will be labeled and named in detail. Figure 3.4 shows the example of product life cycle thinking sketching.

Figure 3.4: The example of product life cycle thinking sketching

3.7.2.2 Eco-assessment qualitative tools

The quality tools used in this project are eco-design web and eco indicator 99 to evaluate the impacts of human activities on the environment.

i. Eco-design web

Eco-design web is a simple and quick tool that assists designers in qualitatively assessing a product or design (Lofthouse, 2017). It is used to identify a product or design based on 7 elements. Based on the eco-design web analysis, the designer can redesign and improve a product in order to sustain the environment. The 7 elements will be categorized into 3 level aspects which are product component level, product structure level, and product system level. First, the product component level includes a new way of doing it, material selection, and material usage. The second level is the product structure level which involved the distribution. The last level aspects are product system level which included the product use, optimal life, and end of life of a product or design. All the elements will be discussed on the existing design and redesign of the female hygienic urinal device. Figure 3.5 shows the eco-design web template.

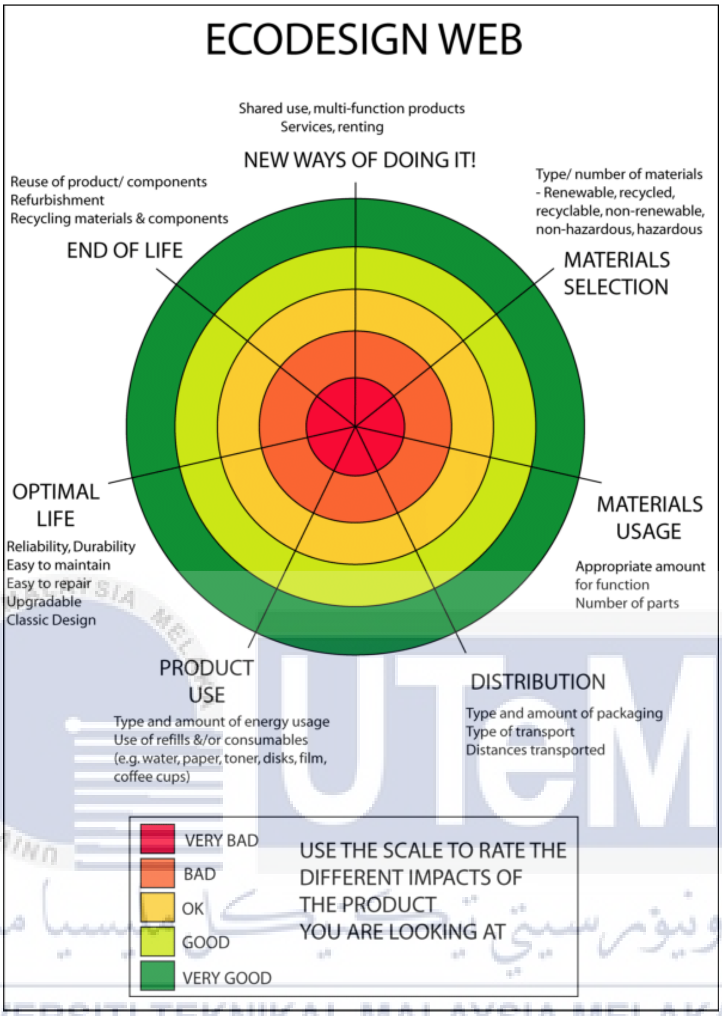


Figure 3.5: The eco design web template (Lofthouse & Bhamra, 2000)

The region in Figure 3.5 is discussed in below section:

Region 1: New Way of Doing It

i. Shared use
ii. Multi-function of product
iii. Services
iv. Renting

Region 2: Material Selection

i. Clean material
ii. Renewable material
iii. Recyclable material
iv. Non-hazardous material

Region 3: Material Usage

i. Appropriate amount for function
ii. Number of parts
iii. Weight reduction
iv. Volume reduction

<u>PRODUCT STRUCTURE LEVEL</u>

Region 4: Distribution

i. Under reusable/cleaner packaging
ii. Transport mode energy efficient
iii. Logistics with energy efficiency

<u>PRODUCT SYSTEM LEVEL</u>

Region 5: Product Use

i. Reduce energy use
ii. Simpler source of energy
iii. Less necessary consumables
iv. No energy waste/consumer waste

Region 6: Optimal Life

i. Robustness and longevity
ii. Easier repair and maintenance
iii. Structure of modular product
iv. Good interaction between product and consumer

Region 7: End of Life

i. Service reuse
ii. Removal/renovation
iii. Material and material recycling

ii. Eco indicator 99

Eco indicator 99 is one of the life cycle assessment tools to evaluate a product or design life cycle impact on the environment based on its materials and processes used. It gives a fast evaluation of a product or system in terms of the impact on human health, ecosystem quality, and resource damage in milli points (mpts) (Consultants., 2000). Figure 3.6 shows the example of process tree of a product. The steps of produce the Eco indicator 99 of a product or design:

Step 1: Start with the purpose of the Eco-indicator calculation.

- Illustrate the analyzed product or product component.
- Identify whether an analysis of one specific product or comparison between several products is being carried out.
- Characterize the level of accuracy required.

Step 2: Identify the life cycle.

- Illustrate a process tree of the products based on life cycle, paying equal attention to production, use, and waste processing.

Step 3: Compute materials and processes

- Define a functional unit.
- Compute all relevant processes from the process tree created in step 2.
- Do assumptions for any disappeared data.

Step 4: Create and fill in the form.

- List down and record the quantities of the materials and processes on the form.
- Relevant Eco-indicator values will be scored in the form.
- Multiplying the amounts with the indicator values to Calculate the scores.
- Add the subsidiary results together.

Step 5: Clarify the results obtained.

- Discuss the results obtained.
- Examine and explain the effect of assumptions.
- Amend conclusions (if appropriate).
- Verify the calculation whether meet the purpose.

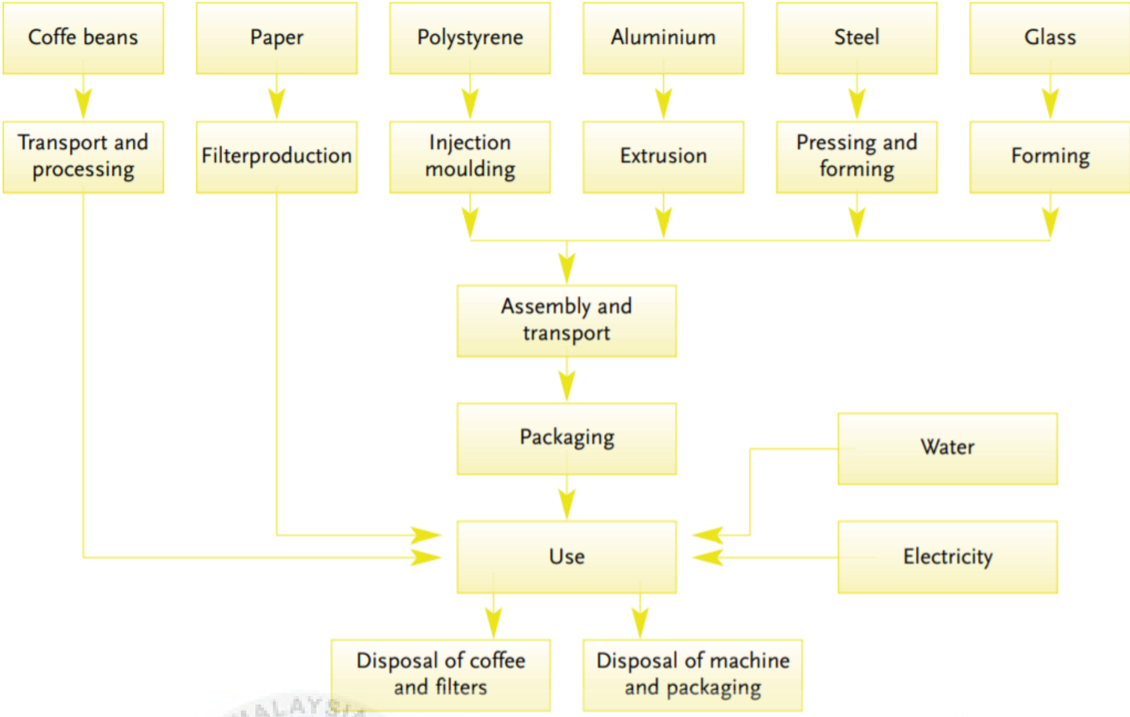


Figure 3.6: The example of process tree of a product (Ministry of Housing, Spatial Planning and the Environment, Communications Directorate., 2000).

Figure 3.7 shows the flow chart of optimization of the selected design using DFMEA and DFE.

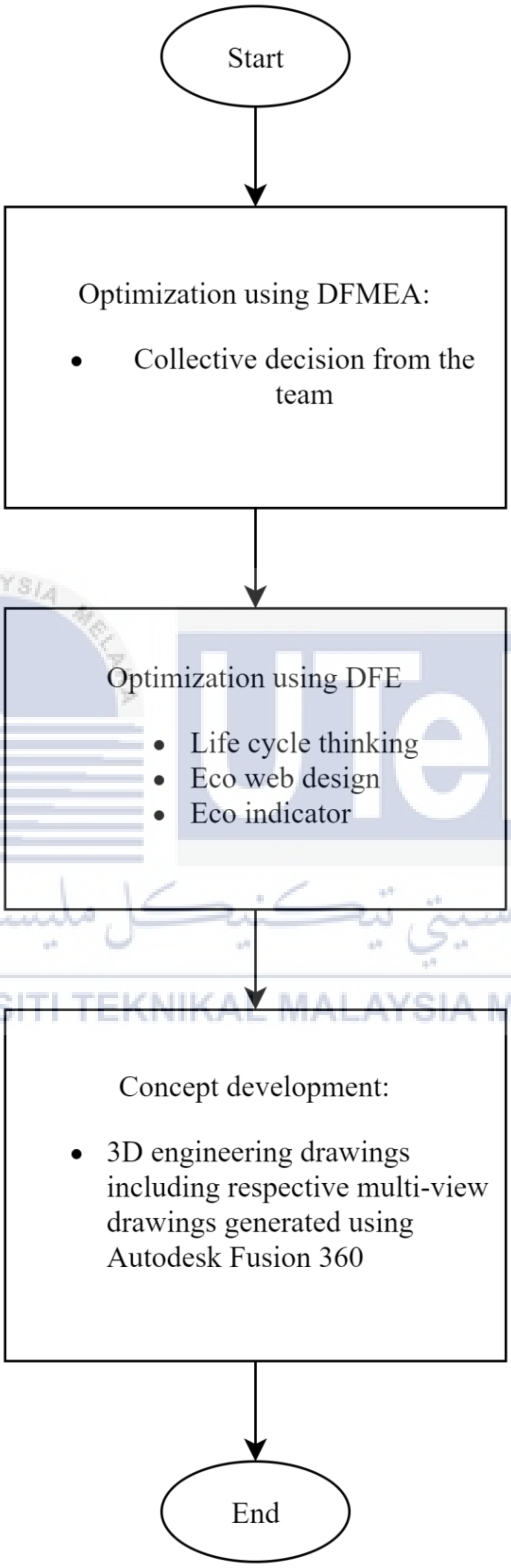


Figure 3.7: Flow chart of objective 3

CHAPTER 4
RESULTS AND DISCUSSION

This chapter mainly explained the results and discussion of the project regarding the development of female hygienic urinal device according to the scope and methodology. The outcomes obtained after conducting survey at nursing home were discussed and TOPSIS method were applied to select the best conceptual design. Then, the selected design was optimized using design for X which are Design Failure Mode Effect Analysis (DFMEA) and Design for Environment (DFE). Design for Environment consist of life cycle thinking of the product before and after redesign followed by eco design web and eco indicator 99.

4.1 Overview

The primary purpose of this research is to develop a female hygienic urinal device for bedridden patients using design for X framework that can lessen the caregiver's burden. Since the bedridden patient had difficulty going to the toilet, a urinal device is essential for them. The product has its washing system attached to the device and it is reusable as the material can be easily washed. The specification of the proposed product was improved by conducting market investigation and data collection from a nursing home using questionnaires. Next, there were 4 conceptual designs for this device extracted from a morphological chart, and the best design is chosen by using the TOPSIS method. Thus, the design is developed using an Autodesk Fusion 360 then DFMEA and DFE were applied to the design.

4.2 Data Collected from Nursing Home

The results for the conducted survey at the nursing home were summarized using charts and explained in detail. As mentioned in Chapter 3, the questionnaire was divided into 3 sections which are Section A, B and C. Section A explained about the demographic profile and followed by questions on the usage of diapers among the patient at the nursing home while Section C discussed the technical specification of the diapers with the usage of the 5 Likert scales.

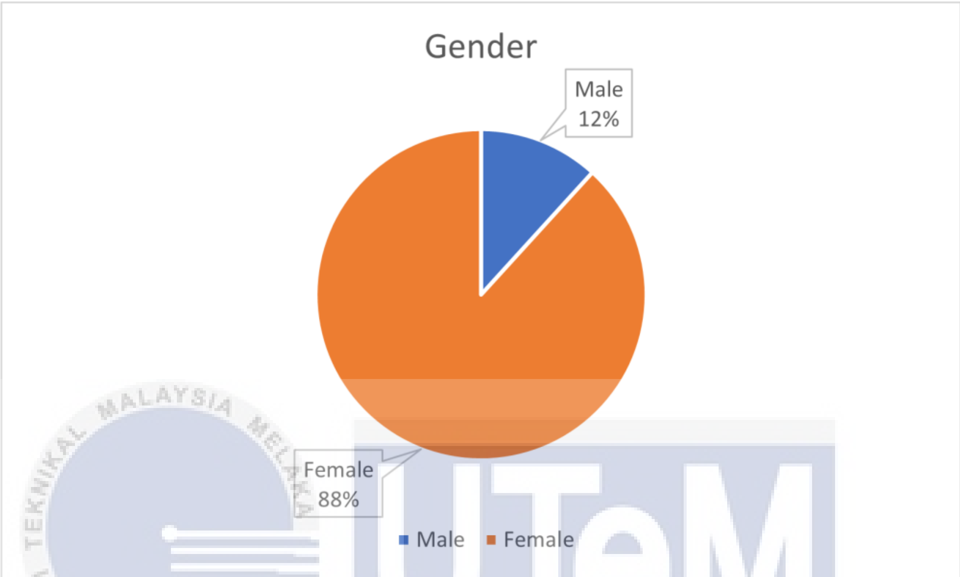


Figure 4.1: The number of participants according to gender

Figure 4.1 shows that gender distribution was higher for female respondents than male respondents. Amongst 17 respondents, the majority (88%, N=15) is female and the rest (12%, N=187) is male.

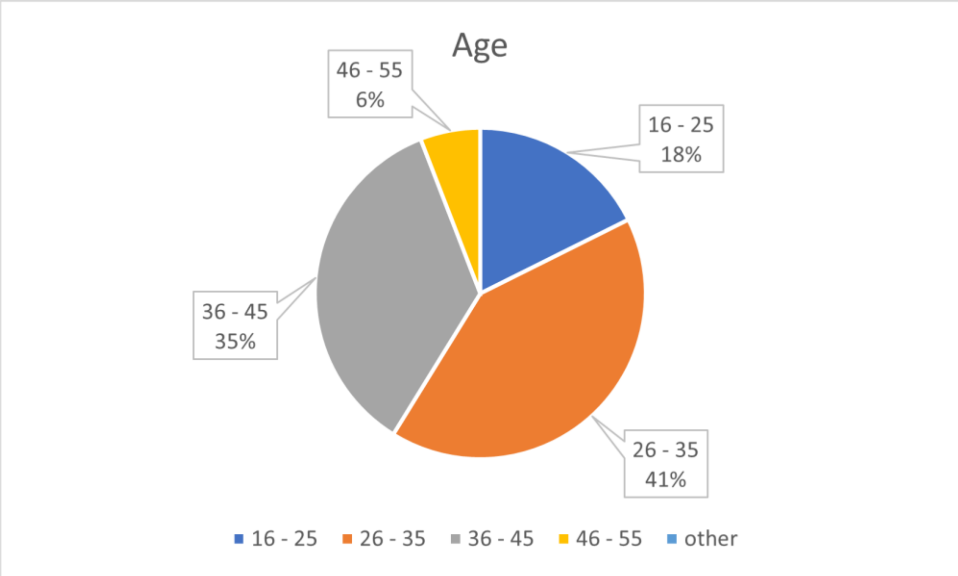


Figure 4.2: The number of participants according to age

Based on Figure 4.2, the majority of respondents were at the age range of 26 to 35 years old (41%) and 36 to 45 years old (35%) with the total number of respondents are 7 and 6 respectively. For the respondents at the age range of 16 to 25 years old is 18% (N=3) and lastly, the lowest age group is 46 to 55 years old is 6% (N=8). The percentage distribution of the age group of the respondents is shown in the figure above.

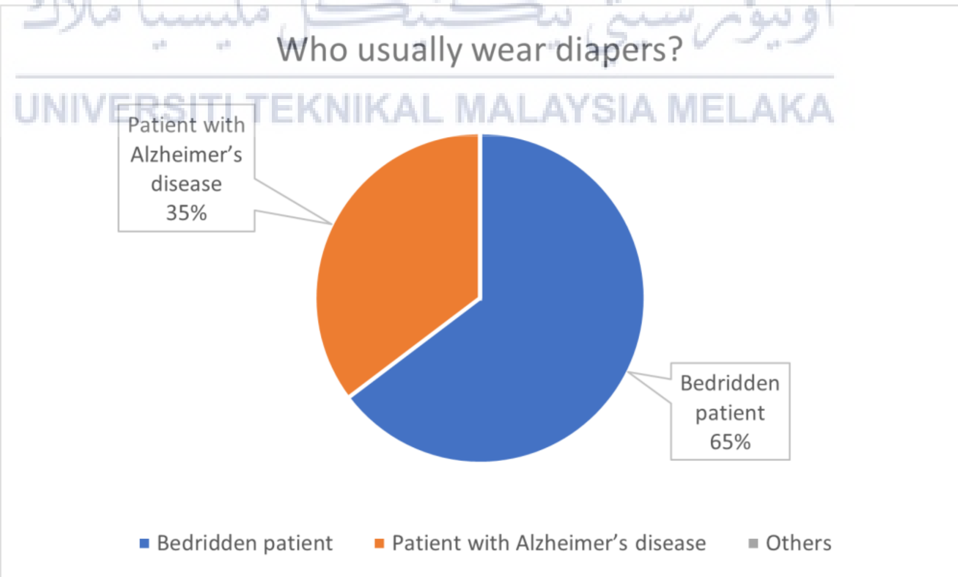


Figure 4.3: Question regarding who usually wear diapers

According to Figure 4.3, 11 respondents answered bedridden patients for questions who usually wear diapers which cover 65% of the pie chart, and 6 respondents (35%) answered patients with Alzheimer's disease. Thus, it clearly shows that the majority group who wore diapers are bedridden patients.

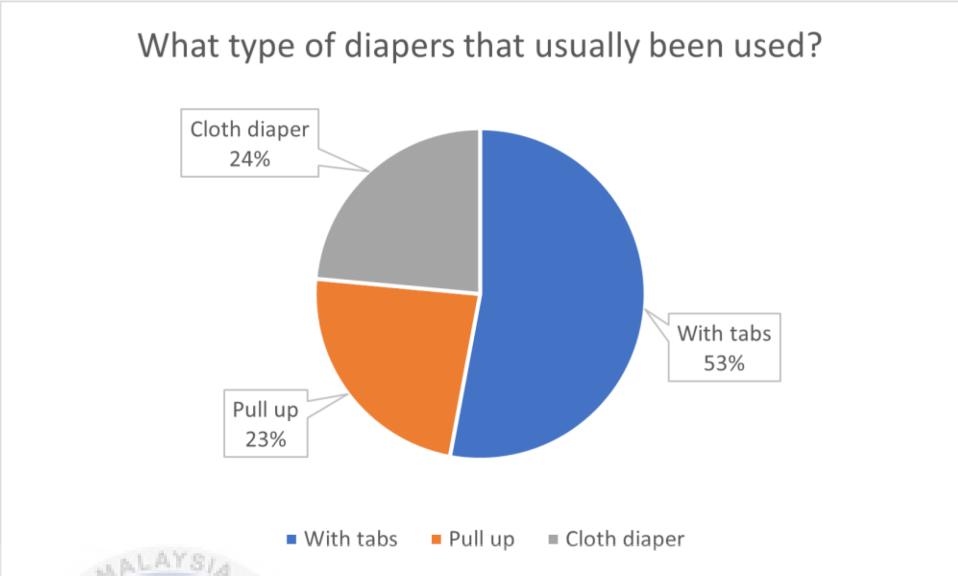


Figure 4.4: Question regarding the type of diapers that have been used

As can be seen in Figure 4.4, the majority of respondents answered diapers with tabs which is 53% of the pie chart (N=9), followed by pull up 23% (N=4) and cloth diaper 24% (N=4).

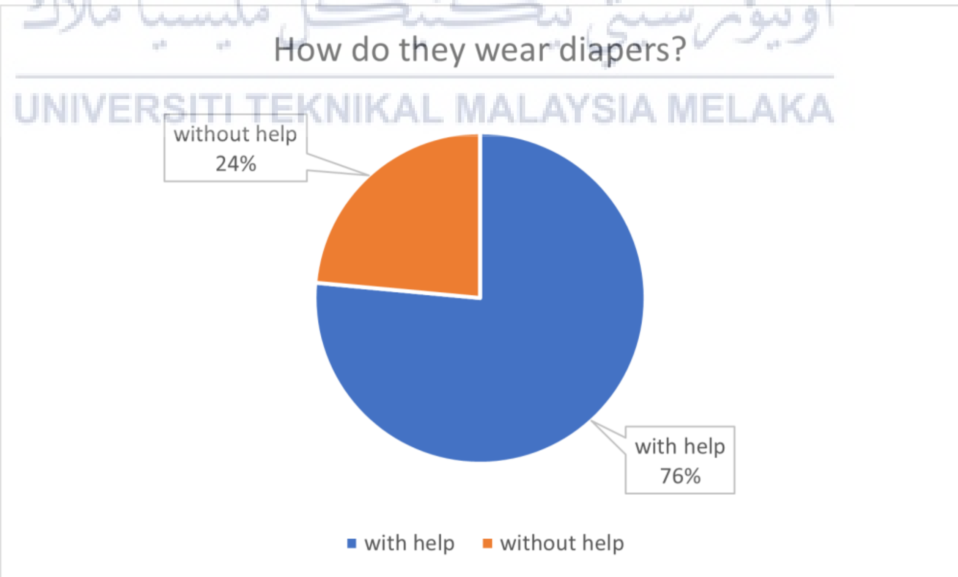


Figure 4.5: Question regarding the way of wearing diapers

According to Figure 4.5, 13 respondents (76%) answered that patients need help when they wear diapers. Only 4 respondents (24%) answered without help. Hence, most of the patient needs someone to assist them wearing diapers which make the caregiver or nurse have extra work to do.

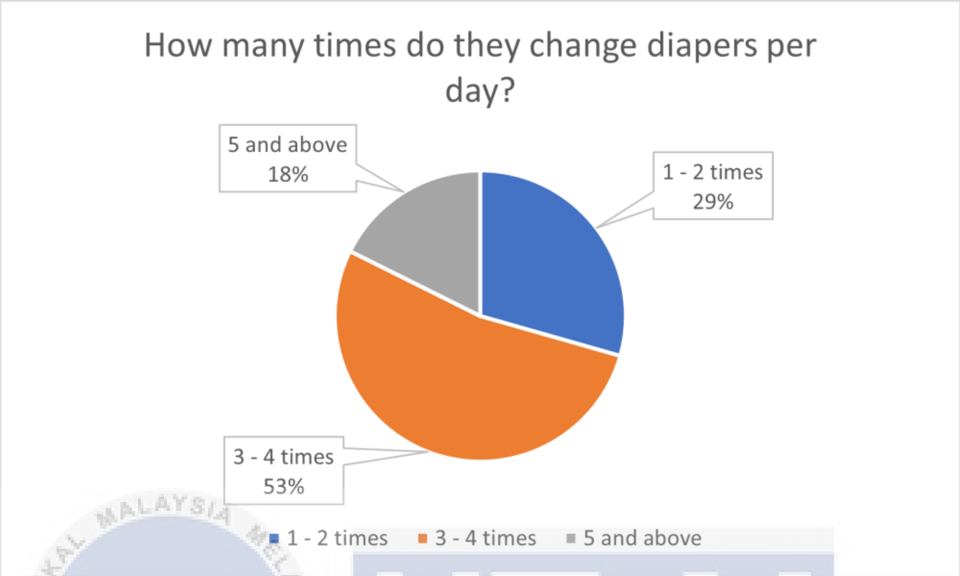


Figure 4.6: Question regarding the number of diaper changes per day

Based on Figure 4.6, the result shows that most patients changed their diapers 3 to 4 times a day as the percentage is 53% (N=9). In addition, 5 respondents (29%) answered that the patient changed their diapers 1 to 2 times a day and 3 respondents answered 5 times and above. This result shows that it is quite frequent for the patients to change their diapers more than 3 times a day.

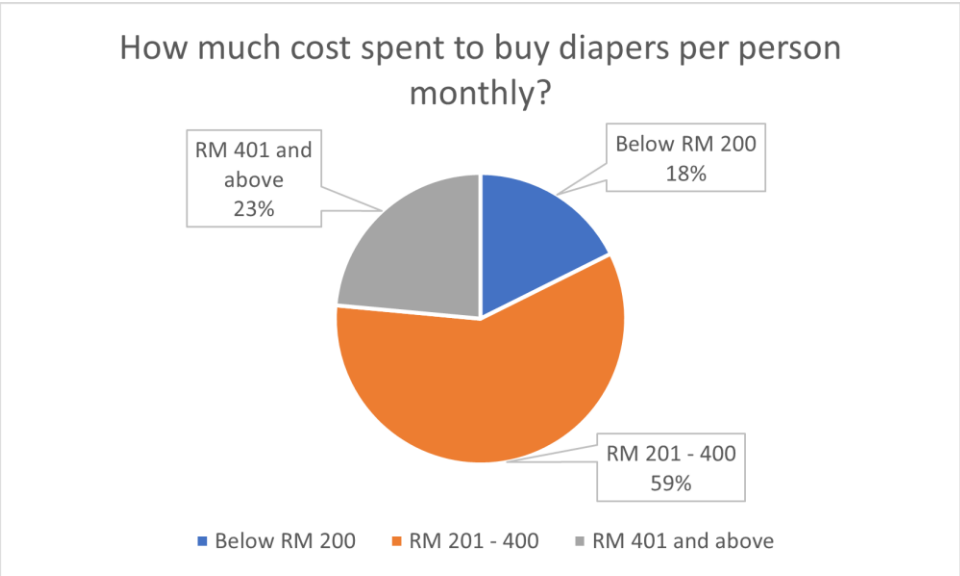


Figure 4.7: Question regarding the cost spent to buy diapers per person monthly

The findings in Figure 4.7 showed the difference costs for each person to spend on the diapers. The highest percentage is 59% which RM 201 to RM 400 with the total number of respondents is 10. Next, 23% (N=4) for RM401 and above while 18% (N=3) for below RM 200.

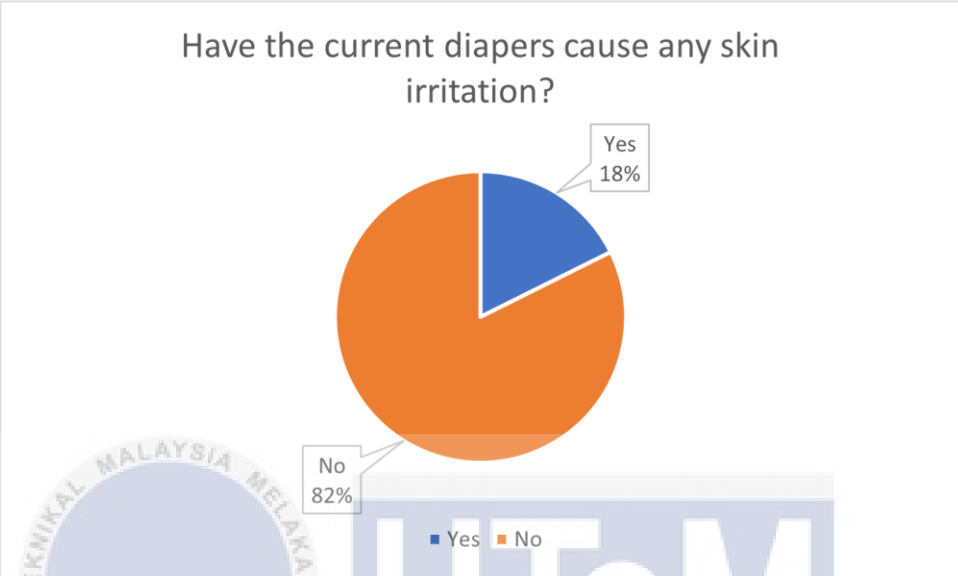


Figure 4.8: Question regarding the skin irritation caused by diapers

Figure 4.8 shows that 14 respondents answered diapers do not cause any skin irritation which covers 82% of the pie chart while 3 respondents (18%) answered vice versa.

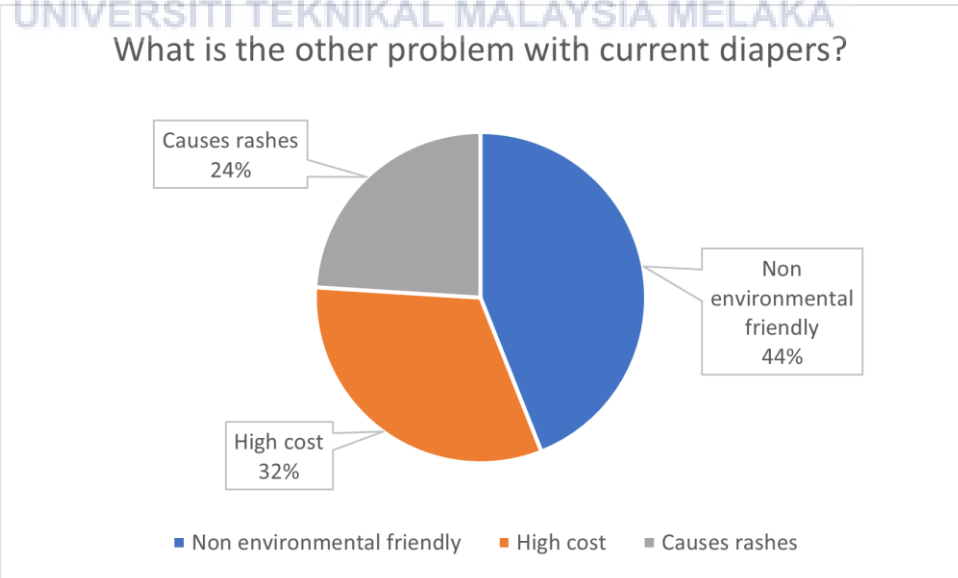


Figure 4.9: Question regarding the other problem with current diapers

The summarization for this question is majority of the respondents (44%, N=11) answered that non environmental friendly is the other problem with current diapers. Based on the Figure 4.9, 32% (N=8) answered that current diapers are high cost. Besides, 6 respondents answered current diapers caused rashes to the users which cover 24% of the pie chart.

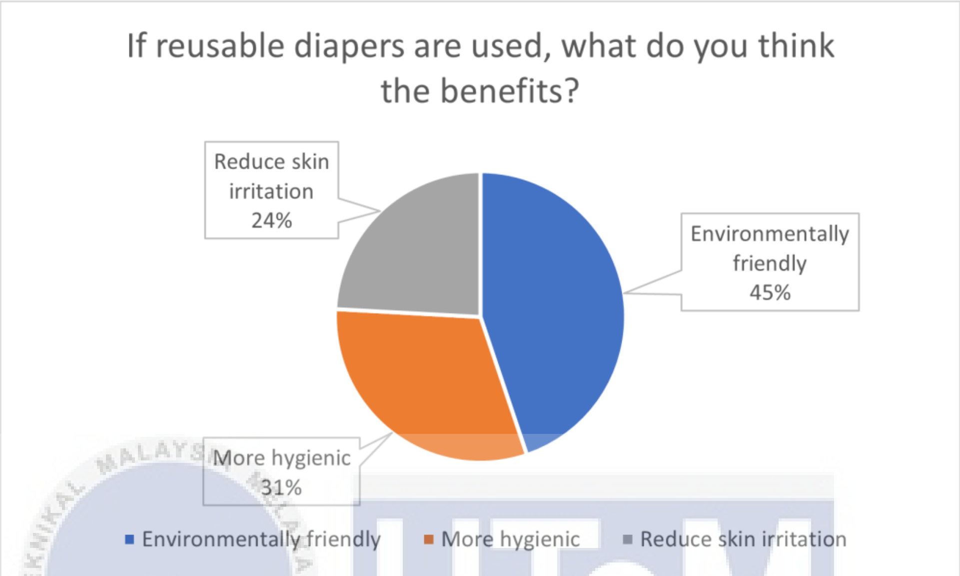


Figure 4.10: Question regarding the benefits of reusable diapers

Based on Figure 4.10, most of the respondents (45%, N=13) answered that reusable diapers are environmental friendly. Besides, 31% (N=9) answered it is more hygienic than the disposable diapers. In addition, 7 respondents answered that reusable diapers can reduce skin irritation which cover 24% of the pie chart.

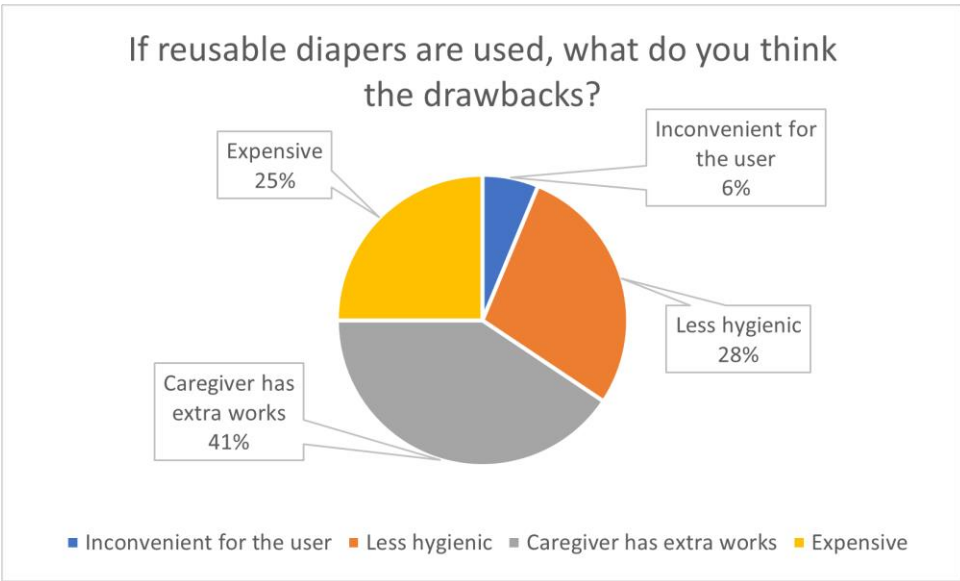


Figure 4.11: Question regarding the drawbacks of the reusable diapers

There are some opinions about the drawbacks if reusable diapers were used. As illustrated in Figure 4.11, the majority of the respondents (41%, N=13) answered that caregiver will have extra work and 28% (N=9) answered it will be less hygienic to the user. Not just that, 25% (N=8) answered that the reusable diapers are expensive. Only 2 respondents (6%) answered the reusable diapers might be inconvenient for the user.

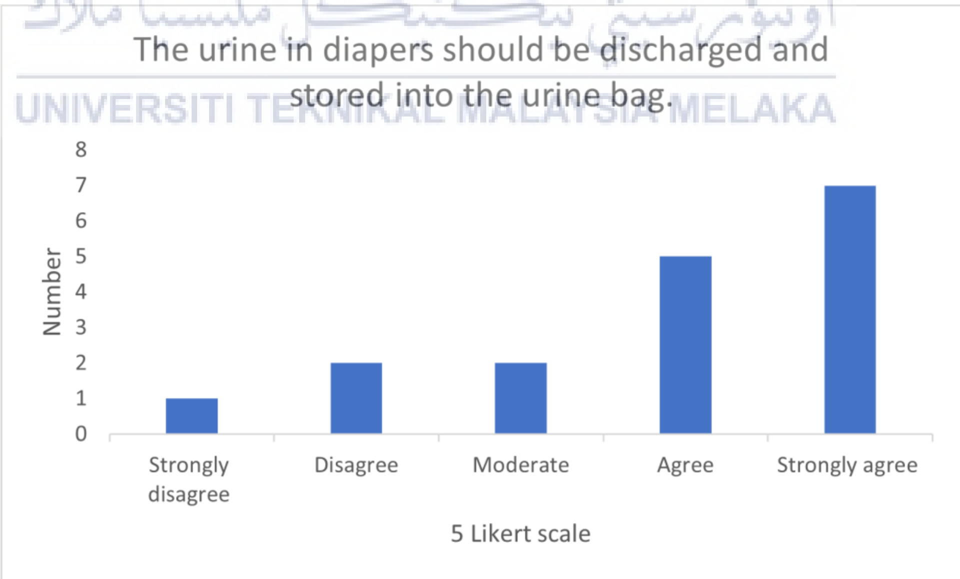


Figure 4.12: Question regarding the technical specification of the reusable diapers

According to the Figure 4.12, most of the respondents (N=7) answered strongly agree for the first technical specification of the proposed product. There were 7 respondents answered strongly agree if the urine will be discharged and straightly stored into the urine bag while 5 respondents answered agree. Next, there was 1 respondent that answered strongly disagree to the specification while 2 respondents answered disagree and moderate.

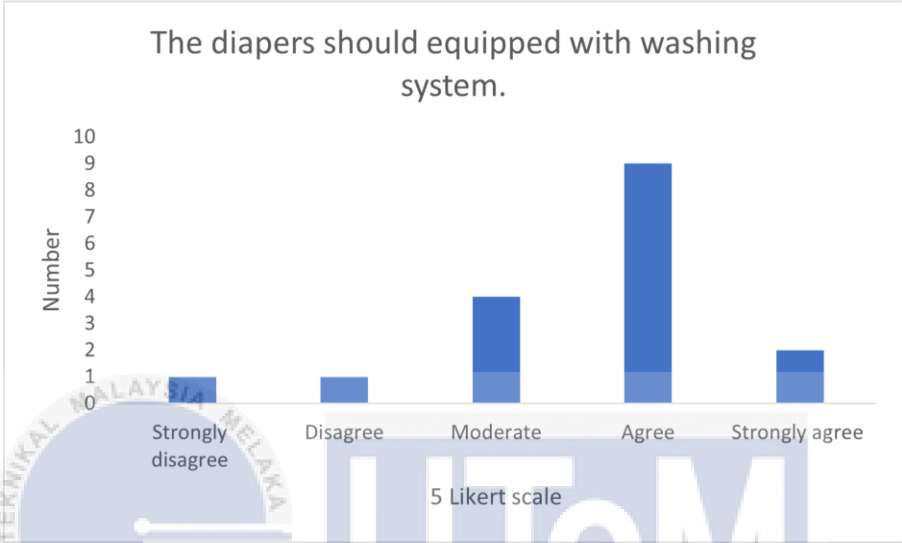


Figure 4.13: Question regarding the technical specification of the reusable diapers

Majority of the respondents (N=9) agreed that diapers should equipped with washing system as shown in Figure 4.13. There was 1 respondent that answered strongly disagree and disagree. Next, 4 respondents answered moderate, and 2 respondents answered strongly agree.

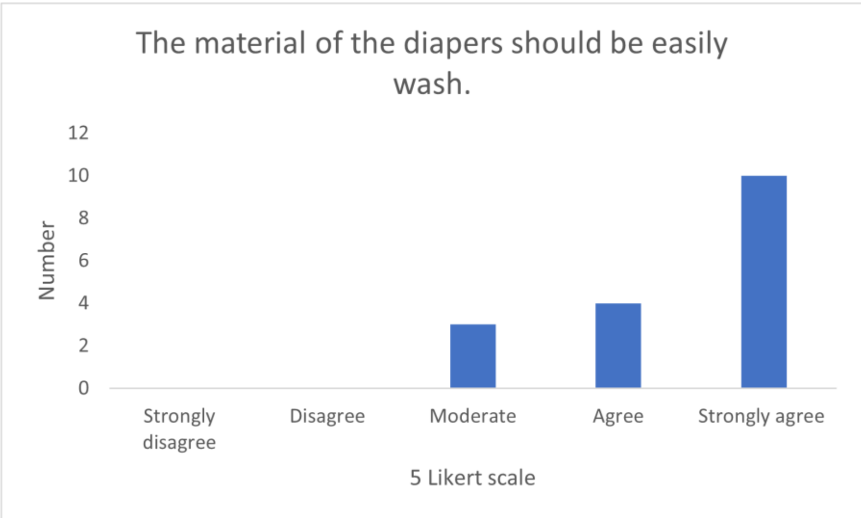


Figure 4.14: Question regarding the technical specification of the reusable diapers

Figure 4.14 shows that most of the respondents (N=10) answered strongly agree and 4 respondents agree that the material of the diapers should be easily washed. Next, 3 respondents answered moderate for the question. None of them answered strongly disagree and disagree with this question.

Table 4.1 shows the summary of questionnaires feedback on disposable diapers and proposed design for female hygienic urinal devices. It is concluded that diapers with tabs are the common diapers used by the patients in the nursing home compared to pants and cloth type. Thus, this type of diaper is likely to be better than the other type. Nevertheless, the design of the diapers with a tab is much easier to handle. Moreover, the disposable diapers need to be changed at least 3 times a day with the help of nurses or caregivers thus the development for the proposed product must be improved and can be wear for a long time. This is because the proposed diapers should lessen the caregiver's work by reducing the number, they need to change the diapers. In addition, there are drawbacks of using disposable diapers such as high cost and being non-environmental friendly. High cost due to the frequent usage and those diapers are not recyclable. Additionally, disposable diapers also cause skin irritation to some patients hence a good and harmless material need to be select properly. Furthermore, the questionnaires also seek the respondent's opinion on reusable diapers and most of the respondents agreed that it will cause them to have extra work due to cleaning phase. Thus, the proposed diapers should be easy to handle and wash so that it will ease the caregiver's work.

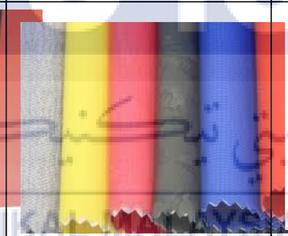
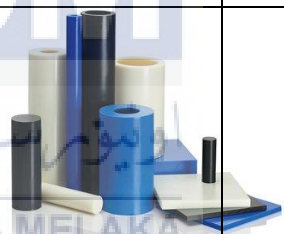
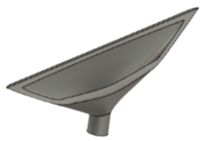
Table 4.1: Summary of questionnaires feedback on disposable diapers and proposed design

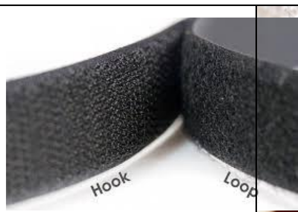
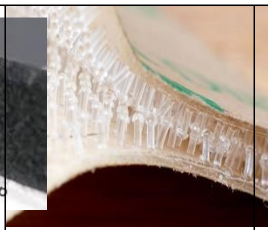
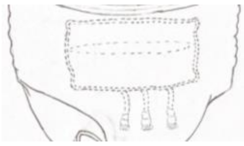
Disposable diapers	**Proposed product**
Diapers with tabs are commonly used	Diapers with tabs better than pants and cloth type
Diapers need to be changed at least 3 times and more per day	Develop diapers that need to be changed less than 3 times
Diapers cause skin irritation and rashes	Material used for the proposed product should be harmless
Diapers is high cost (frequent used) and non environment friendly	Develop an environment friendly diaper with long life span
Reusable diapers cause caregiver has extra work	Develop diapers that easy to handle

4.3 Concept Generation

Table 4.2 below shows the morphological chart used to create 4 conceptual designs for the product development of female hygienic urinal device for bedridden patients. This chart consists of 6 product components and several types of physical components. The physical components' design came from the existing product available in the market.

Table 4.2: Morphological chart

		Physical Components (Types)			
Product Component		A	B	C	D
Type of body frame	1	 Brief with tabs	 Pants		
Type of material for the main body frame	2	 Polypropylene	 Polyurethane Laminate fabric	 Nylon	
Type of urinal flow housing	3	 Irregular shaped housing	 Oval shaped housing	 Isosceles shaped housing	 Round shaped housing

Type of side adhesive	4	 Zip type	 Velcro	 Dual lock strips	 Red line elastic tape
Position of water container	5	 Inside	 Outside		
Spray systems	6	 Two sprays	 One spray	 Three sprays	

4.4 Design selection

Table 4.3 shows the result of design selection from morphological chart to form design concept from each selection. The selection of each part is taken out from each section to form one design concept.

Table 4.3: Design selection result

Design concept	Design Selection
Concept 1	**A1 C2 D3 C4 A5 B6**
Concept 2	**B1 A2 B3 A4 B5 A6**
Concept 3	**A1 B2 C3 B4 B5 B6**
Concept 4	**B1 B2 A3 D4 A5 C6**

The design selection is selected based on the market investigation and specification to be fitted into the urinal device. Nevertheless, the combination of each product components was based on discussion with supervisory committee and consumer.

4.5 Concept Design Stage

The characteristics of concept designs 1, 2, 3, and 4 are described in the concept design stage. Then, TOPSIS method are implemented to select the most satisfied criteria after the design stage.

4.5.1 Conceptual design 1

Figure 4.15 shows the conceptual design 1 for development of female hygienic urinal device. In this conceptual design, diaper with tabs is used as the body frame and the material is nylon. The type of urinal flow is rounded shaped, and the water system is placed inside the diaper. Dual lock strip is used as the type of adhesive.

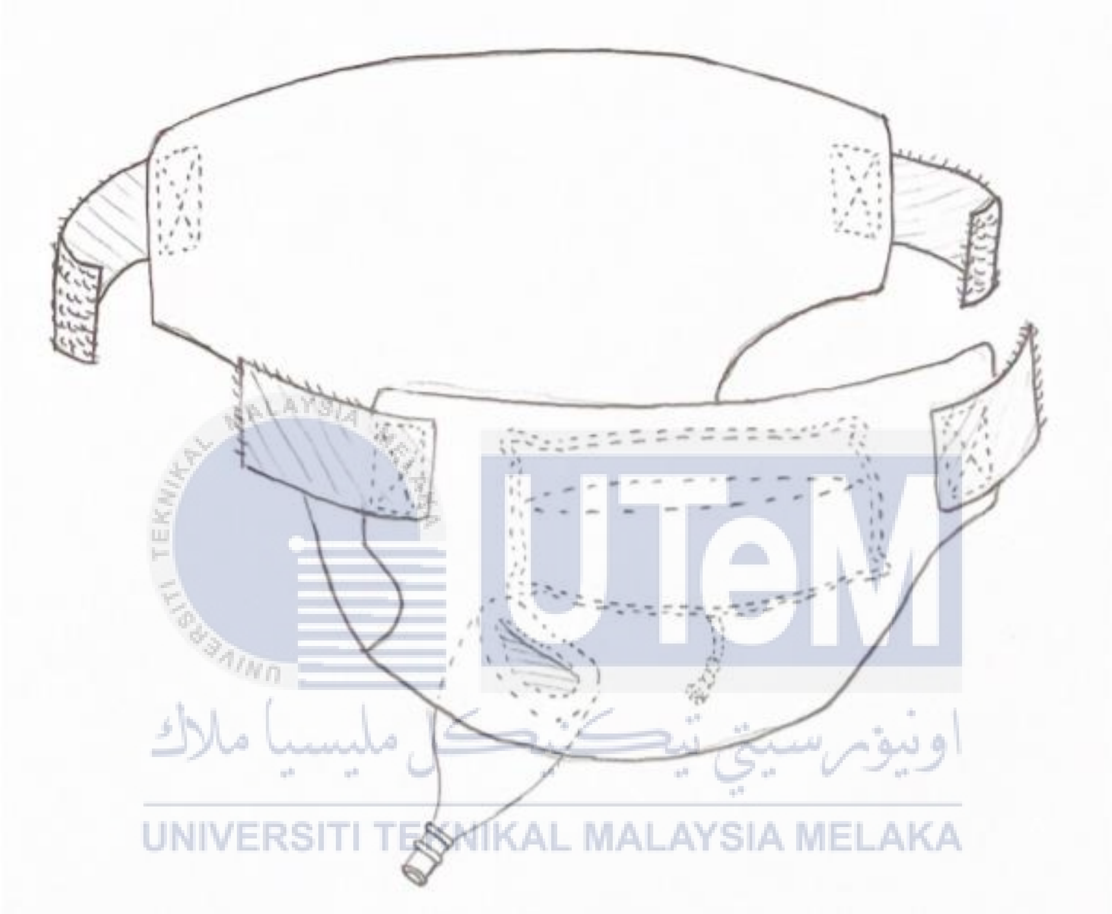


Figure 4.15: Conceptual design 1

4.5.2 Conceptual design 2

Figure 4.16 shows the conceptual design 2 where pants type is used for the body frame. The material used for the body frame is polypropylene and the water system is placed outside of the diaper. Oval shaped is used for the urinal flow housing and zip type is for the side adhesive.

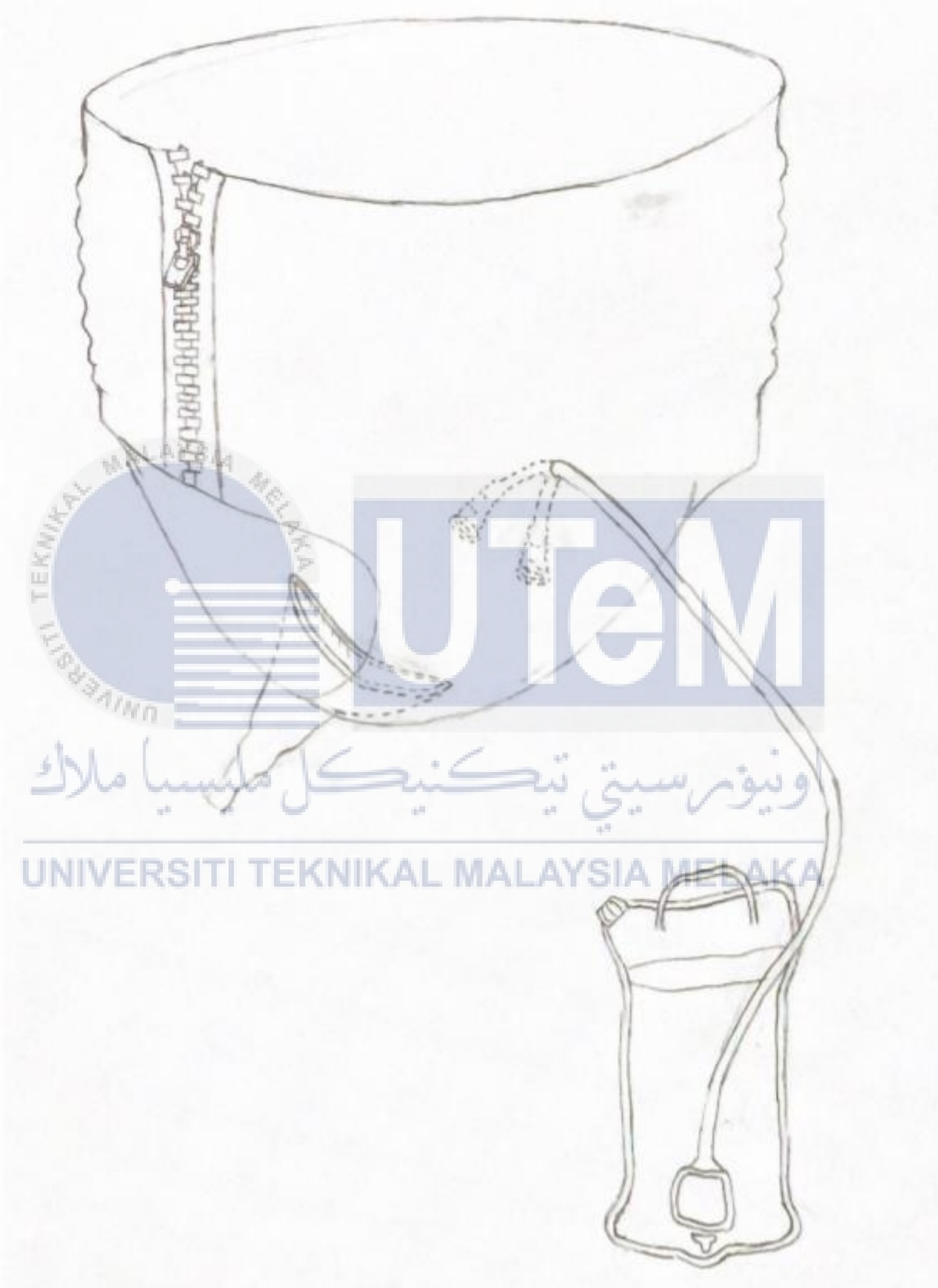


Figure 4.16: Conceptual design 2

4.5.3 Conceptual design 3

Figure 4.17 shows the conceptual design 3 where diaper with tab is used for the body frame and its material is polyurethane laminate (PUL) fabric. Next, the urinal flow housing is isosceles shaped and the water system is outside of the diaper. Plus, velcro is used for the side adhesive.

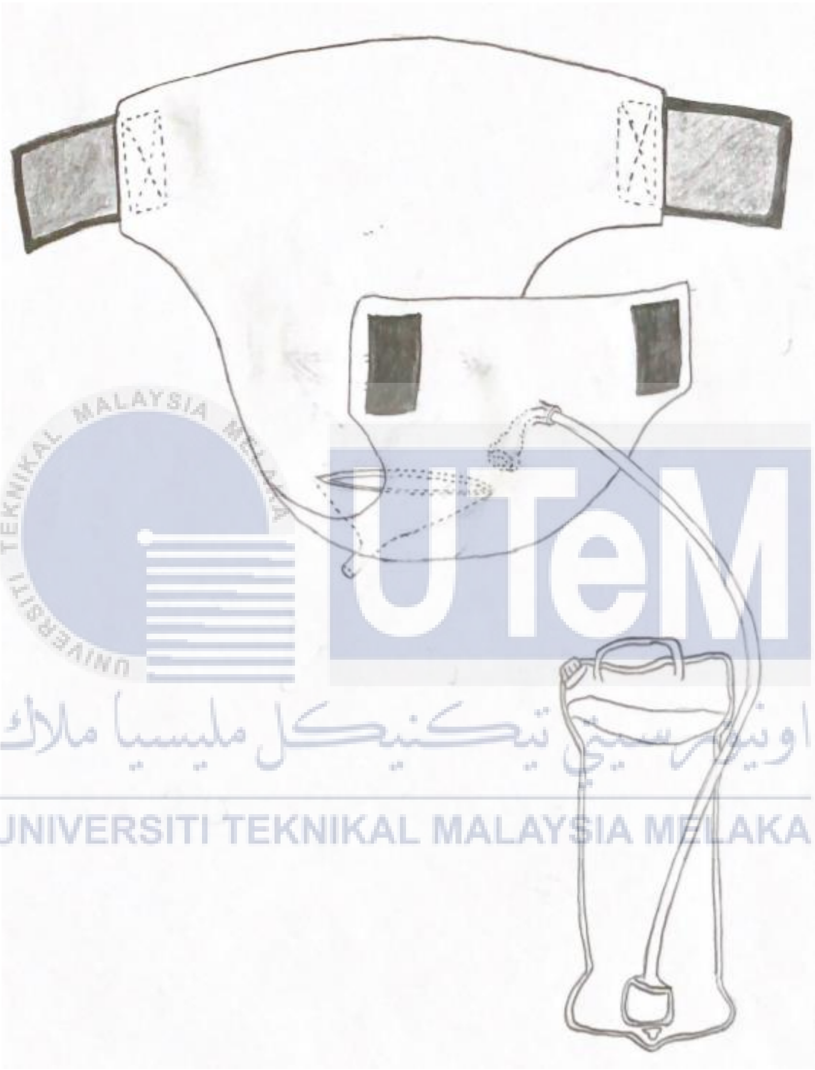


Figure 4.17: Conceptual design 3

4.5.4 Conceptual design 4

Figure 4.18 shows the conceptual design 4 where the type of body frame is pants type and the material used for the body frame is polyurethane laminate (PUL) fabric. Then, irregular shaped housing is used for the urinal flow housing. Next, the water system is attached inside of the diaper and red line elastic tape is used as the side adhesive.

Figure 4.18: Conceptual design 4

4.6 Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) Method

The TOPSIS method is used to evaluate the conceptual designs by reducing negative aspects for the product effectiveness. The criteria and rating scale for the calculation were based on Table 3.1 and Table 3.2 in Chapter 3.

4.6.1 Weighting factor

The weighting factor of each criteria was determined through Digital Logical Method (DLM) by comparing them pairwise to determine their relative importance for device application. It was identified that ease of use and cost were the most important criteria with the weighting factor of 0.3. It was followed by manufacturability with a weighting factor of 0.2 while the ergonomics and ease of maintenance were the least important with a weighting factor of 0.1. Table 4.4 shows the DLM table.

Table 4.4: Digital logical method

No.	Criteria	Possible design combinations										Positive decisions	Weighting factors (w)
		1	2	3	4	5	6	7	8	9	10		
		1-2	1-3	1-4	1-5	2-3	2-4	2-5	3-4	3-5	4-5		
1	Ease of Use	1	1	0	1							3	0.3
2	Ergonomics	0				0	0	1				1	0.1
3	Ease of Maintenance		0			1			0	0		1	0.1
4	Cost			1			1		1		0	3	0.3
5	Manufacturability				0			0		1	1	2	0.2

4.6.2 TOPSIS Calculation

This section will precisely detail the data calculation. There were six stages that must be completed to reach the final selection result. Table 4.5 until Table 4.15 shows the calculation and results of applied TOPSIS.

i. Selection of the best

Table 4.5: Selection of the best

Weightage	Criteria	Concept 1	Concept 2	Concept 3	Concept 4
0.3	Ease of Use	7	6	9	5
0.1	Ergonomics	5	4	8	7
0.1	Ease of Maintenance	8	6	9	5
0.3	Cost	6	5	8	7
0.2	Manufacturability	7	5	9	4

ii. Normalize decision matrix

Calculate $(\Sigma x^2)^{\frac{1}{2}}$ for each column.

Table 4.6: Normalize decision matrix

Criteria	Concept 1	Concept 2	Concept 3	Concept 4	Σxij^2	$(\Sigma x^2)^{\frac{1}{2}}$
Ease of Use	49	36	81	25	191	14
Ergonomics	25	16	64	49	154	12
Ease of Maintenance	64	36	81	25	206	14
Cost	36	25	64	49	174	13
Manufacturability	49	25	81	16	171	13

Divide each column by $(\Sigma x^2)^{\frac{1}{2}}$ to get r_{ji}.

Table 4.7: Normalize decision matrix

Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Ease of Use	0.5065	0.4341	0.6512	0.3618
Ergonomics	0.4029	0.3223	0.6447	0.5641
Ease of Maintenance	0.5574	0.4180	0.6271	0.3484
Cost	0.4549	0.3790	0.6065	0.5307

Manufacturability	0.5353	0.3824	0.6882	0.3059

iii. Weighted normalized decision matrix

Multiply each column by w_j to get rv_{ij}.

Table 4.8: Weighted normalized decision matrix

Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Ease of Use	0.1520	0.1302	0.1954	0.1085
Ergonomics	0.0403	0.0322	0.0645	0.0564
Ease of Maintenance	0.0557	0.0418	0.0627	0.0348
Cost	0.1365	0.1137	0.1819	0.1592
Manufacturability	0.1071	0.0765	0.1376	0.0612

iv. Determine the positive ideal and negative ideal solution

Determine positive ideal solution A^+.

Table 4.9: Positive ideal solution A+

Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Ease of Use	0.1520	0.1302	**0.1954**	0.1085
Ergonomics	0.0403	0.0322	**0.0645**	0.0564
Ease of Maintenance	0.0557	0.0418	**0.0627**	0.0348
Cost	0.1365	0.1137	**0.1819**	0.1592
Manufacturability	0.1071	0.0765	**0.1376**	0.0612

The positive ideal values are as follows:

$A^+ = (0.1954, 0.0645, 0.0627, 0.1819, 0.1376)$

Find negative ideal solution A^-.

Table 4.10: Negative ideal solution A-

Criteria	Concept 1	Concept 2	Concept 3	Concept 4

Ease of Use	0.1520	0.1302	0.1954	**0.1085**
Ergonomics	0.0403	**0.0322**	0.0645	0.0564
Ease of Maintenance	0.0557	0.0418	0.0627	**0.0348**
Cost	0.1365	**0.1137**	0.1819	0.1592
Manufacturability	0.1071	0.0765	0.1376	**0.0612**

The negative ideal values are as follows:

$A^- = (0.1085, 0.0322, 0.0348, 0.1137, 0.0612)$

v. Calculate the separation measures for each alternative.

Determine separation from positive ideal solution A^+. $A^+ = (0.1954, 0.0645, 0.0627, 0.1819, 0.1376)$

Table 4.11: Separation from positive ideal solution A+

Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Ease of Use	0.0019	0.0042	0.0000	0.0075
Ergonomics	0.0006	0.0010	0.0000	0.0001
Ease of Maintenance	0.0000	0.0004	0.0000	0.0000
Cost	0.0021	0.0047	0.0000	0.0005
Manufacturability	0.0009	0.0037	0.0000	0.0058

Determine separation from an ideal solution $S_i|$*.

Table 4.12: Separation from an ideal solution *

	Concept 1	Concept 2	Concept 3	Concept 4
$\Sigma(vj^* - vij)^2$	0.0055	0.0141	0.0000	0.0140
Si* = $[\Sigma\,(vj^* - vij)^2]^{\frac{1}{2}}$	0.0743	0.1188	0.0000	0.1182

Determine separation from ideal solution $A^- = A^- = (0.1085, 0.0322, 0.0348, 0.1137, 0.0612)$

Table 4.13: Separation from ideal solution A-

Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Ease of Use	0.0019	0.0005	0.0075	0.0000
Ergonomics	0.0001	0.0000	0.0010	0.0006
Ease of Maintenance	0.0004	0.0000	0.0008	0.0000
Cost	0.0005	0.0000	0.0047	0.0021
Manufacturability	0.0021	0.0002	0.0058	0.0000

Determine separation from ideal solution $S_i{}'$.

Table 4.14: Separation from ideal solution

	Concept 1	Concept 2	Concept 3	Concept 4
$\Sigma(vj^* - vij)^2$	0.0050	0.0008	0.0199	0.0027
Si' = $[\Sigma\,(vj^* - vij)^2]^{\frac{1}{2}}$	0.0708	0.0275	0.1409	0.0515

vi. Calculate the relative closeness to the ideal solution C_i* = S'i / (Si* + S'i)

Table 4.15: Relative closeness to the ideal solution

	Concept 1	Concept 2	Concept 3	Concept 4
S'i / (Si* + S'i)	0.0708/0.1451	0.0275/0.1463	0.1409/0.1409	0.0515/0.1697
C_i*	0.4878	0.1877	1.0000	0.3035

Regarding to the result by using TOPSIS method, concept design 3 is selected as a model to develop the female hygienic urinal device. Table 4.15 shown the result obtained from the TOPSIS method which determined the relative closeness of each design concept to the ideal solution. It was found that conceptual design 3 was the best concept with the closeness to ideal value of 1 followed by conceptual design 1 with ideal value of 0.4878. Next, conceptual design 4 has the third closeness to the ideal solution where the value is 0.3035 and conceptual design 2 has the least closeness with the value of 0.1877. The body frame is made with tabs. It is equipped with polyurethane laminate (PUL) fabric body frame, isosceles shaped housing and velcro as the side adhesive. Plus, the washing system was placed outside the diaper and single spray system is used. However, Design Failure Mode Effect Analysis (DFMEA) was applied followed with Design for Environment (DFE) consists of life cycle thinking, eco design web and eco indicator to optimize the design selected.

4.7 Concept development

The following stage is the development concept, which is adapted once the best concept is selected using the previous technique. In concept development, Autodesk Fusion 360 software was utilized to create 3D engineering drawings of all designed subassemblies, components, and parts, as well as multi-view drawings of parts.

4.7.1 Detail Design of Female Hygienic Urinal Device

Figure 4.19 shows the detail design of conceptual design 3 before optimization.

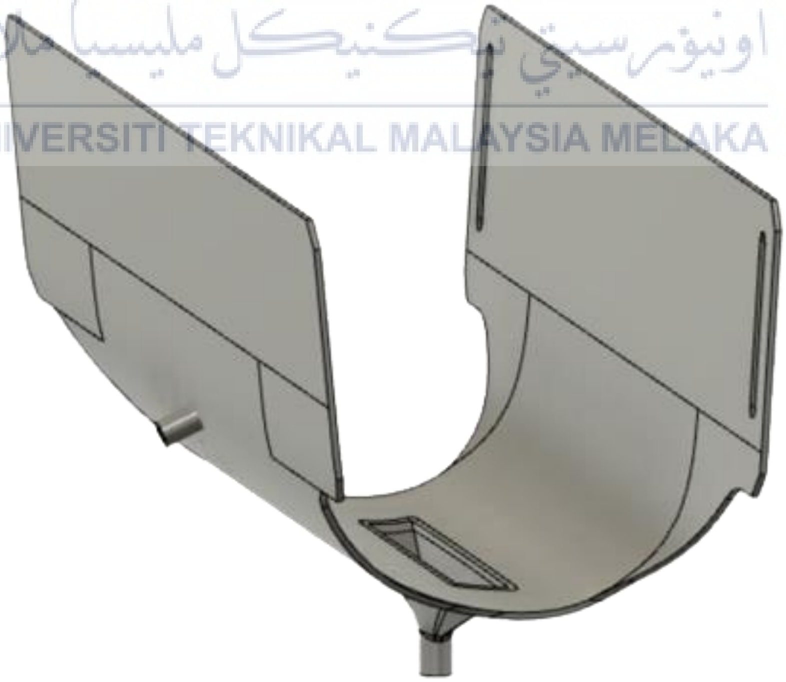


Figure 4.19 Female hygienic urinal device before optimization

Figure 4.20 shows the exploded view of female hygienic urinal device before optimization.

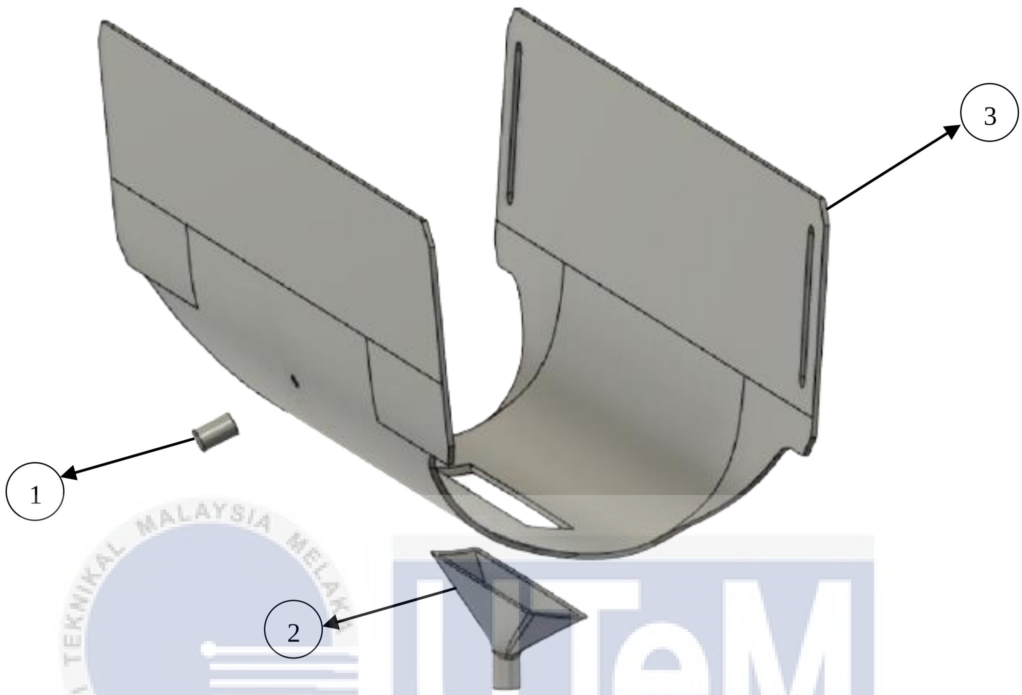


Figure 4.20: Female hygienic urinal device before optimization (exploded view)

Table 4.16 shows the components of the product before optimization.

Table 4.16: List of components before optimization

No.	Component Names	Material	Quantity
1	Washing system	Polypropylene	1
2	Urinal flow housing	Polypropylene	1
3	Body frame	PUL fabric	1

4.8 Design analysis

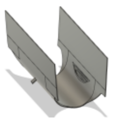
The design analysis that has been implemented into the selected design were Design Failure Mode Effect Analysis (DFMEA) and Design for Environment (DFE) consist of life cycle thinking, eco design web and eco indicator.

4.8.1 Design Failure Mode Effect Analysis (DFMEA)

Design Failure Mode Effect Analysis (DFMEA) is a systematic activity team to recognize and review the possible design failures. DFMEA defines the failures or acts as consequences and outcomes. It avoids or mitigates errors and gives an overview of the job carried out in writing. This analysis is widely used in many industries, especially the manufacturing industry. DFMEA also can compare the rating of the product early and after the overcome action is taken by using the RPN value. The RPN value is calculated by multiplying the severity rank, occurrence rank and detection rank. These ranking table have been embedded in Chapter 3 and the scoring for the DFMEA is a collective decision form the supervisor and nurses.

Table 4.17 shows the DFMEA table with 3 items that have been optimized. The first item is the body frame where the severity before is 8, occurrence is 10 and detection is 4. Thus, the numbers were multiplied in order to get the RPN value and the total value is 320. After took action for the possible failures, the RPN value is decreased to 72. Next, the urinal flows housing where the severity is 8, occurrence is 10 and detection is 3. Thus, the RPN value before is 400 and after taking action for the possible failures the RPN dropped to 84. Nevertheless, the last item is the washing system has severity of 8, occurrence is 10 while detection is 4. The RPN value before is 320 and after taking action recommended, the RPN value reduced to 70. Overall, the results showed that the proposed design has been optimized 78% after implemented DFMEA. Thus, it can be concluded that the DFMEA can make a design better for the satisfying performance of the product.

Table 4.17: Design Failure Mode Effect Analysis

Item	Potential failure mode	Potential effect of failure	Severity	Potential cause mechanism of failure	Occurrence	Current design control detection	Detection	RPN	Action recommended	Action taken	Severity	Occurrence	Detection	RPN
Body frame 	• Tear apart	• Urine will leak through the side of the body frame. • Not hygienic.	8	• Body motion from the users. • Design of the body frame is too flat. • Wrong material selection.	10	• Material needs to be changed. • Redesign is required.	4	320	• Redesign the side of the body frame. • Change the material to waterproof and elastic material.	• Material polyurethane laminate fabric change to silicone. • Rib is added at the side of the body frame to avoid leaking.	4	6	3	72
Urinal flow housing 	• The item easy to be uprooted.	• Urine cannot be channel to the urine bag. • Not hygienic.	8	• The item is a separate part. • The position and dimension of the	10	• Attached the subitem to the main body. • Check the position and the	5	400	• Permanent attached the item to the main body. • Change the position and dimension of	• Attached the item to the main body permanently using strong adhesive.	3	7	4	84

				housing is not suitable. • Over body weight of the users.		dimension of the design with woman's anatomy then redesign.			the item.	• Position of the item has been changed by lowering it down and the dimension has been widened.				
Washing system 	• Cannot clean well.	• Water cannot be channel into the device well. • Not hygienic.	8	• The item is a separate part. • The position of the item is not suitable.	10	• Attached the subitem to the main body. • Check the position of the design with woman's anatomy then redesign.	4	320	• Permanent attached the item to the main body. • Change the position of the item.	• Position of the item has been changed by lowering it down. • Attached the item to the main body permanentl y using strong adhesive.	5	7	2	70

4.8.2 Design for Environment (DFE)

Design for Environment (DFE) has been applied after implementing Design Failure Mode Effect Analysis (DFMEA) to the product. Life cycle thinking of the product before and after redesign has been discussed in the following section followed by the eco-design web and eco indicator.

4.8.2.1 Product life cycle

Figure 4.21 shows the product life cycle of female hygienic urinal device before redesign. There were 3 separate parts for the female hygienic urinal device which are the body frame, urinal flow housing, and water system. The material used to make the body frame is polyurethane laminate (PUL) fabric while urinal flow housing and water system are made from polypropylene. Then the 3 separated parts for the device will be assembled. Polyurethane laminate is a fabric that is produced by laminating a cloth fabric to one or both sides of a thin polyurethane film. Most of the PUL fabric is made by laminating a lightweight polyester interlock knit fabric to a thick polyurethane film. The laminating process is done in two ways. The first process is solvent lamination, which blends the fabric and polyurethane film into a single monolithic fabric, followed by hot melt, which adheres the fabrics together using heat-activated glue. Next, the end of life of the material is that it can be recycled but most of them will straight away to the landfills. Then, the material used to fabricate urinal flow housing and washing system is polypropylene which is a thermoplastic polymer. It is produced by chain-growth polymerization from the monomer propylene.

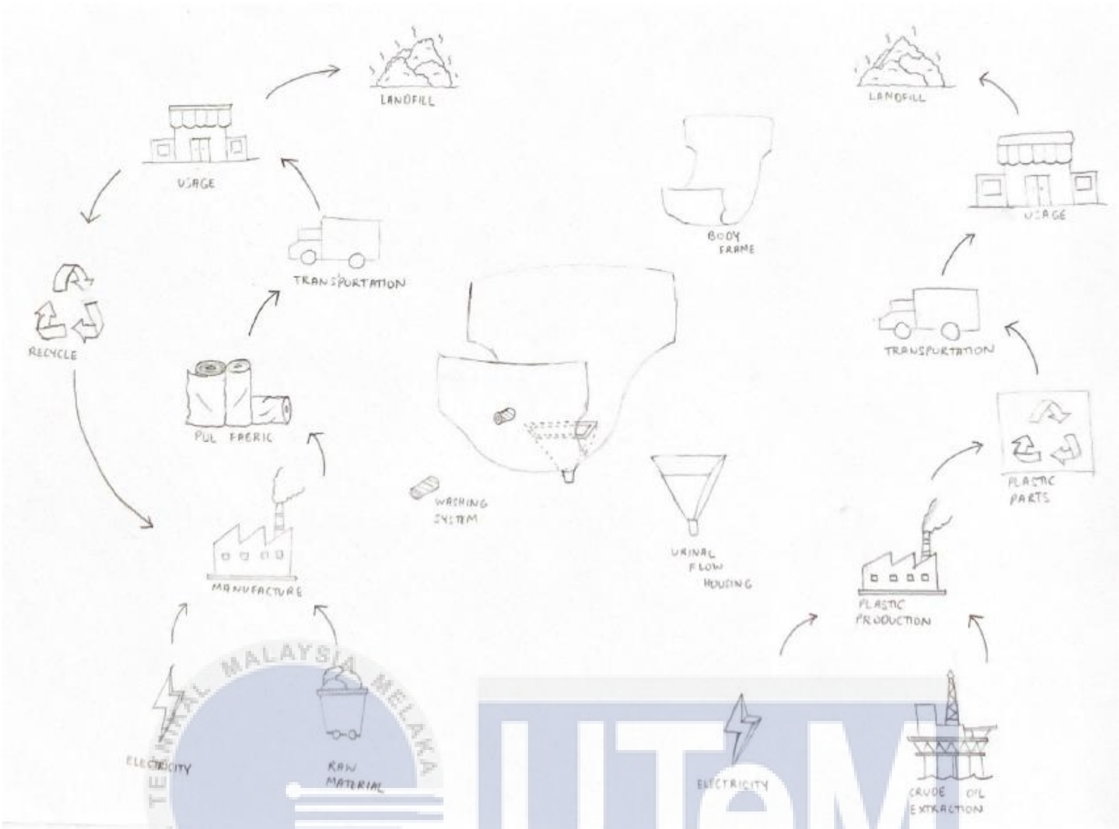


Figure 4.21: Product life cycle before redesign

Figure 4.22 shows the life cycle thinking of female hygienic urinal device after redesign. It can be seen that the number of parts has been reduced from 3 to 1 part. Furthermore, the raw material used to fabricate the new design is by using silicone. A silicone or also known as polysiloxane is a polymer made up of siloxane. They are typically colorless, oils or rubber-like substances. Some common forms include silicone oil, silicone grease, silicone rubber, silicone resin, and silicone caulk. The characteristic of silicone is that it is highly recyclable. Thus, all the 3 parts will be built together in 1 mold and will be processed by using vacuum casting. The fabrication of the mold is by using 3D printing with polylactic acid (PLA) filaments. PLA filaments is made from a bioplastic and thermoplastic made from natural materials like corn starch. In addition, PLA filaments can be recycled and become rolls of PLA filaments again.

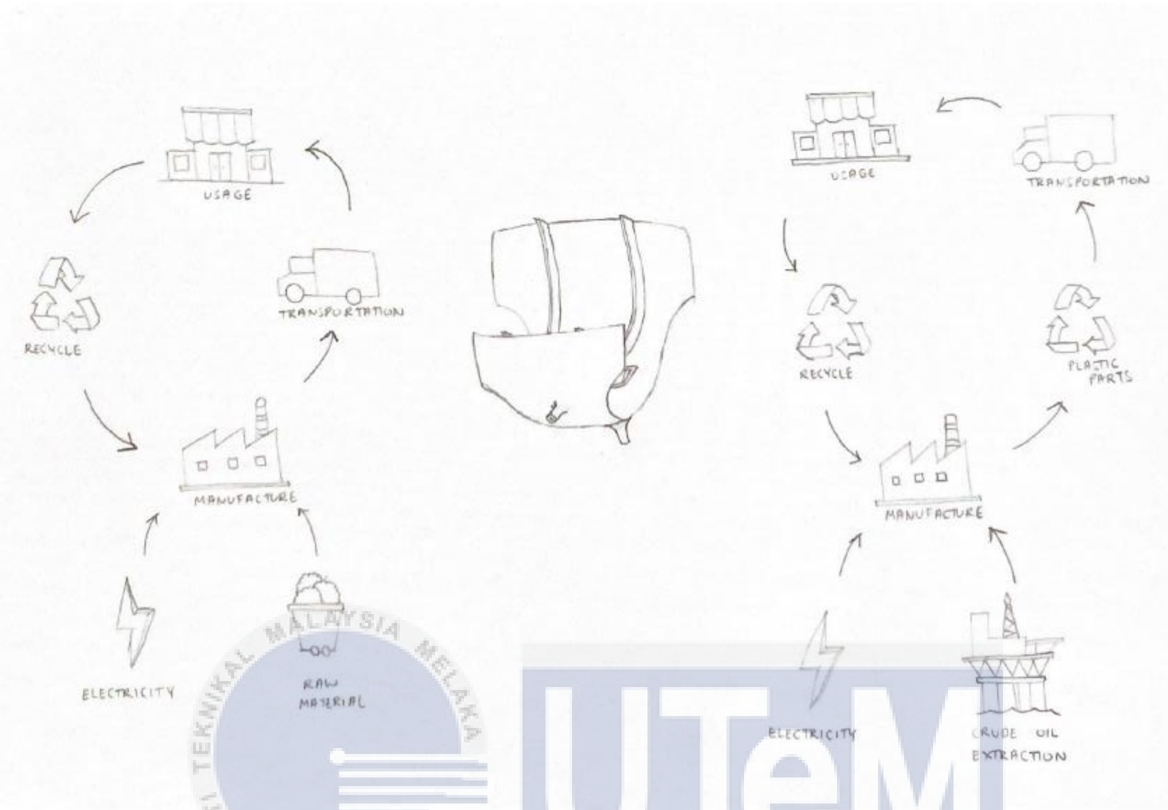


Figure 4.22: Product life cycle after redesign

Comparison life cycle thinking (LCT) of the designs

Table 4.18 shows the comparison life cycle thinking (LCT) before and after redesign. The number of materials used before redesign is 2 which are polyurethane laminate (PUL) fabric for the body frame while polypropylene is used to fabricate urinal flow housing and washing system. After redesign, material used are silicone and polylactic acid (PLA). This is because the number of parts has been reduced to 1 part from 3 separate parts. By reducing the amount of the part, the productivity of the manufacturing process will become higher. In addition, there is no assemble phase for the new product as the 3 parts will be fabricate using the same process. Vacuum casting is used to fabricate the product by using 1 printed mold using 3D printer hence, polylactic acid (PLA) is used as the filament for the 3D printing. The usage for the product mostly same for both before and after redesign yet the end of life of the product is much better after redesign as silicone can be recycled. Moreover, PLA mold used to fabricate the product also can be recycled.

Therefore, material used to fabricate the product after redesign are highly recyclable and have a lower impact on the environment compared to the material used before redesign which mostly will end up at the landfills and some of them can be recycled.

Table 4.18: Comparison life cycle thinking before and after redesign

	Before redesign	After redesign
Number of Materials	2 • Polyurethane laminate (PUL) fabric • Polypropylene	2 • Silicone • Polylactic Acid (PLA)
Number of parts	3	1
Manufacturing Process	Higher	Lower
Usage	Mostly the same as the new design	Mostly the same as the old design
End of life	Landfill and recyclable	Highly recyclable

4.8.2.2 Eco design web

The eco design web for female hygienic urinal device before redesign is shown in Figure 4.23. Eco design web is used to evaluate the current product's environmental performance. It evaluates several environmental aspects of a product, including as its materials, distribution, use, lifetime, and end of life.

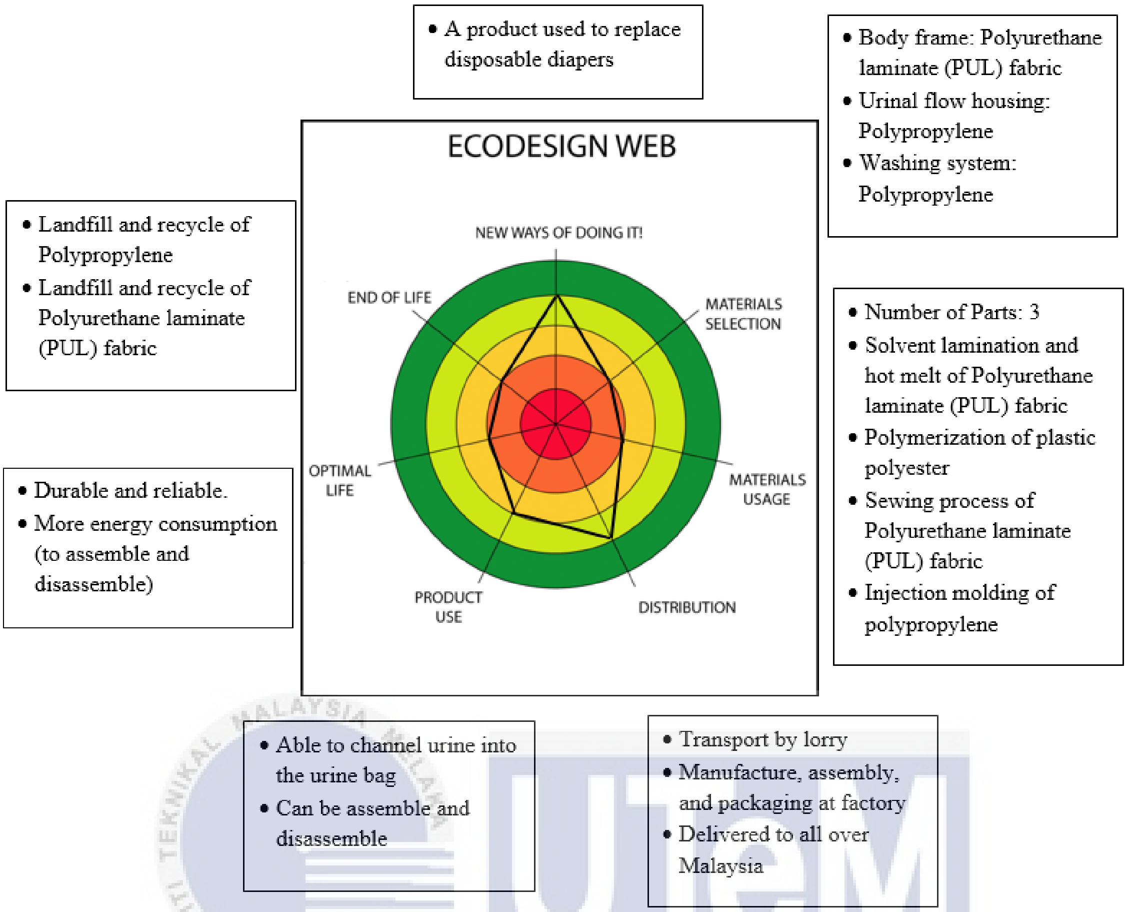


Figure 4.23: Eco design web for female hygienic urinal device before redesign

The eco-design is decided by the scale to rate the different impacts of the product which have several stages. The first stage is new ways of doing it. For female hygienic urinal device, it is a product used to replace disposable diapers as disposable diapers gives impact to the environment. Then, the next stage is material selection for the product. There are 2 types of material have been chosen to fabricate the product which are polyurethane laminate (PUL) fabric and polypropylene. Thus, this element can be altered to get a better rating since the scale is ‘BAD’. Same goes to the material usage’s rating is at the ‘BAD’ area thus this element can be altered and improve. The distribution is that the products will be transported by using lorry plus manufacture, assemble and packaging at the factory. After that, the product will be delivered to all over Malaysia. The product can be used to channel the urine into urine bag. The product is durable and reliable. Moreover, it requires more energy consumption to assemble and disassemble. Nevertheless, the end of life of the product will end up at the landfill and recycle. Therefore, the rating for the optimal life and end of life for the product is ‘BAD’ and can be altered and improved.

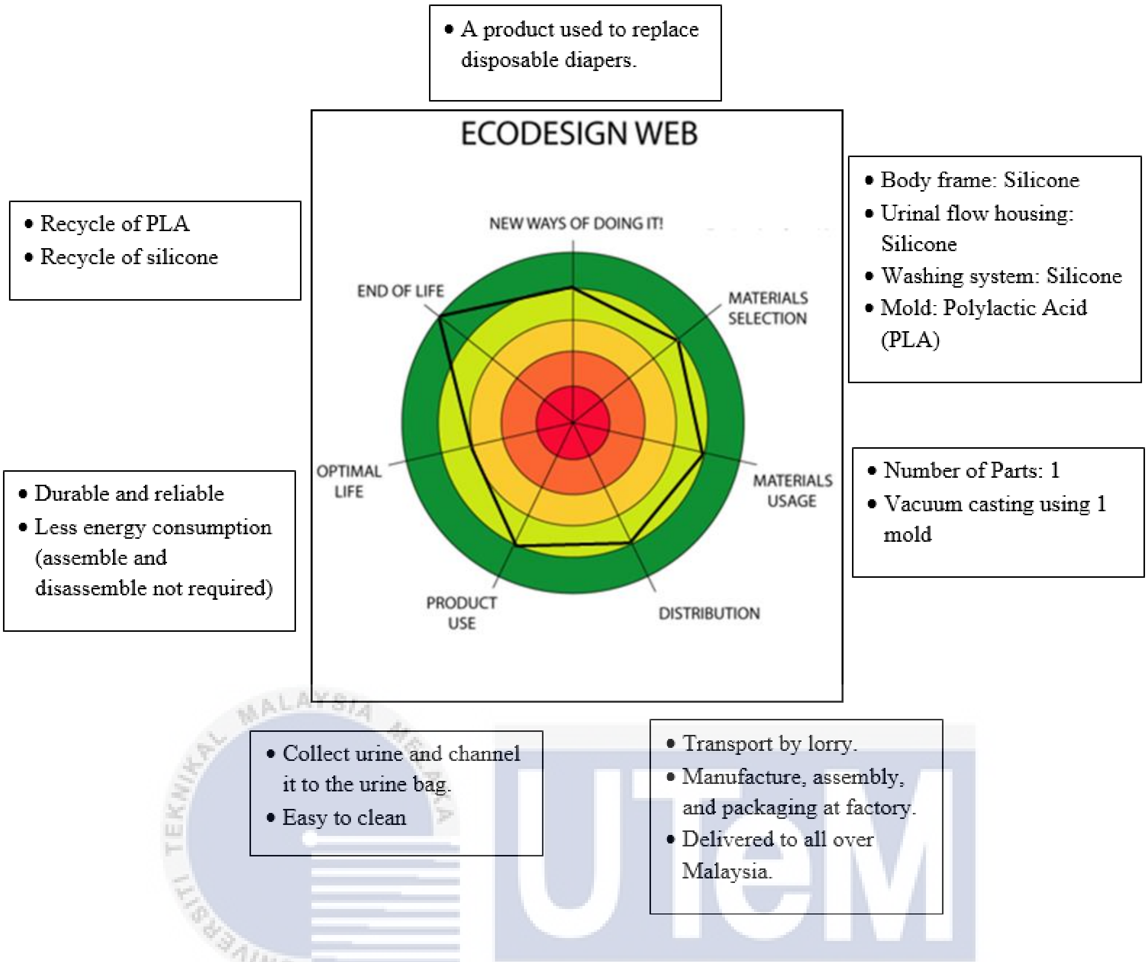


Figure 4.24: Eco design web for female hygienic urinal device after redesign

Figure 4.24 shows the eco design web for female hygienic urinal device after redesign. The product's function is still the same which is it is used to replace the disposable diapers. Next, the materials selection for the product is silicone. Moreover, the number of parts after redesign has been reduced to 1 from 3 therefore only 1 process is needed to fabricate the product. The rating for material selection and material usage have been improved from 'BAD' to 'GOOD'. The distribution is still the same, but the product use is improved as it is easy to clean. Consequently, the rating for product use before redesign is 'OK' but after redesign the rating is improved to 'GOOD'. The optimal life also has been improved from 'BAD' to 'GOOD' as there is no assemble and disassemble process needed. Furthermore, the end of life of the product has been improved from 'BAD' to 'VERY GOOD' since the material used is highly recyclable.

4.8.2.3 Eco indicator

Eco indicator is a simplified Life Cycle Assessment method that identifies the stage of the life cycle that has the greatest environmental impact by calculating eco-indicator scores for materials and processes used. The calculated eco-indicator scores were divided into three categories which are production, use and disposal. The resulting scores provide an indication of areas for product improvements. The eco indicator for the female hygienic urinal device is done as follows starting with process tree. Figure 2.25 shows the process tree of the product before redesign. It can be seen that there are 2 types of raw material used which are polyurethane laminate (PUL) fabric and polypropylene. PUL fabric is used to manufacture the body frame by using sewing process while polypropylene is used to manufacture urinal flow housing and washing system through injection molding. Then, these parts will be assembled and packed before it is transported. The end of life of the product ends with landfills and recycling.

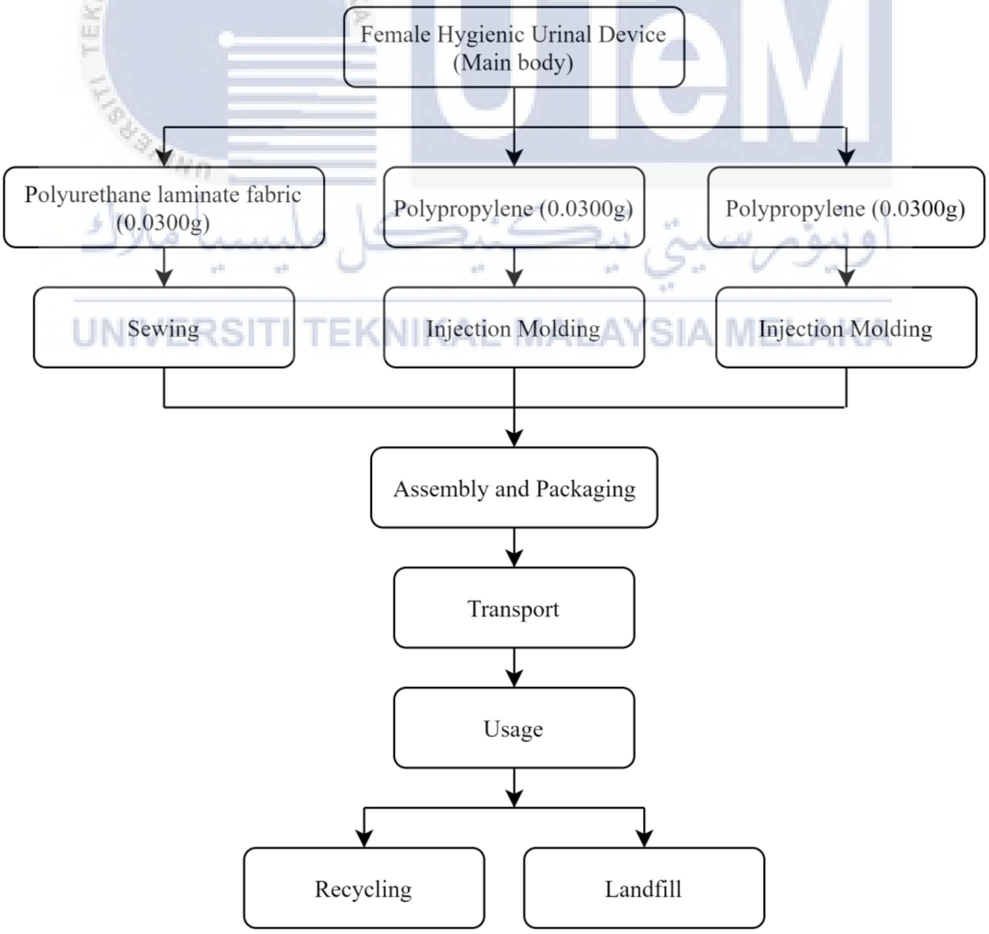


Figure 4.25: Process tree before redesign

Eco indicator before redesign

Table 4.19 shows the eco indicator before redesign. The result shows that the indicator value for the production phase is quite low which is 24.93 and the disposal phase also very low. Thus, the disposal phase needs to be altered so that the product would have high environmental performance. After calculating the overall indicator, it shows that the total value for the product before redesign is 115.46. The indicator for usage phase is 92.4.

Table 4.19: Eco indicator before redesign

Female Hygienic Urinal Device (main body)			
Production Material, Processing, Transport, and extra energy			
MATERIAL OR PROCESS	**AMOUNT**	**INDICATOR**	**RESULT**
Polyurethane laminate fabric	0.0300kg	480	14.4
Polypropylene (PP) Plastic	0.0300kg	330	9.9
Injection Molding PP Plastic	0.0300kg	21	0.63
		TOTAL	**24.93**
Usage Transport, energy, and auxiliary materials			
Transport (16-ton truck)	2.7 tkm	34	91.8
Distribution (tkm)	0.04 tkm	15	0.6
		TOTAL	**92.4**
Disposal Disposal processes per type of material			
PROCESS	**AMOUNT**	**INDICATOR**	**RESULT**
Landfill of Polyurethane laminate fabric	0.0192kg	9.7	0.19
Landfill of PP Plastic	0.0127kg	3.5	0.04
Recycle of PP Plastic	0.0100kg	-210	-2.1
		TOTAL	**-1.87**
OVERALL TOTAL			**115.46**

Figure 4.26 shows the process tree after redesign. The number of materials used for the product is reduced from 3 to 2 types. The raw material for the product after redesign is silicone and polylactic acid (PLA). The 3 separate parts will be combined and build using 1 mold through vacuum casting process so there is only 1 mold needed. The fabrication of

the mold can be done using 3D printing with PLA filaments. Not just that, the mold can be used for several times before it is recycle. Next, after vacuum casting process the product will be packed and transport to the users. The end of life of the product also has high environmental performance as the silicone can be recycled.

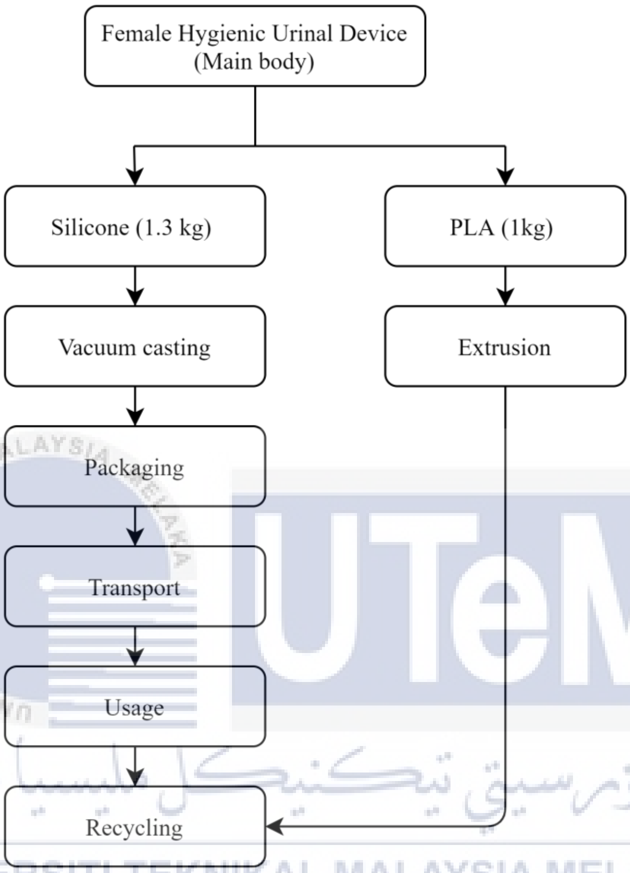


Figure 4.26: Process tree after redesign

Eco indicator after redesign

Table 4.20 shows the eco indicator after redesign. The indicator for production phase is 811.93 which is quite high compared to before redesign. Nevertheless, the disposal phase’s indicator is -804 which is much better than before redesign. The indicator of usage phase is the same which is 92.4. Thus, the total number of indicators after redesign is 100.33 which is slightly lower compared to before redesign.

Table 4.20: Eco indicator after redesign

Female Hygienic Urinal Device (main body)			
Production Material, Processing, Transport, and extra energy			
MATERIAL OR PROCESS	**AMOUNT**	**INDICATOR**	**RESULT**
Silicone	1.3 kg	360	468
Polylactic acid (PLA)	1 kg	330	330
Vacuum casting Silicone	1.3 kg	9.1	11.83
Extrusion Polylactic acid (PLA)	1 kg	2.1	2.1
		TOTAL	**811.93**
Usage Transport, energy, and auxiliary materials			
Transport (16-ton truck)	2.7 tkm	34	91.8
Distribution (tkm)	0.04 tkm	15	0.6
		TOTAL	**92.4**
Disposal Disposal processes per type of material			
PROCESS	**AMOUNT**	**INDICATOR**	**RESULT**
Recycle of Silicone	1.6 kg	-240	-384
Recycle of PLA	2 kg	-210	-420
		TOTAL	**-804**
OVERALL TOTAL			**100.33**

Comparison eco indicator before and after redesign

The materials used for the product are polyurethane laminate (PUL) fabric and polypropylene before the product was redesigned. Both material can be recycled but mostly will be end up at the landfills. The process tree was built before the eco indicator can be completed with details. It is the proceedings that a product undergoes during its lifespan. The material is being manufactured, packaged, distributed, built, managed, maintained, and disposed of between its origin and disposal. Sewing, injecting molding and extrusion are the manufacturing processes that involve this product. Whenever the data is delivered to the eco-indicator table, the material and process used refers to eco 99 because it has the indicator needed to fill up the table. The indicator is not found in some of the materials and processes. After the calculation of the table has been done, the value obtained in the eco indicator for this product is 115.46. This is attributed to the material used to produce the product. The higher the value of the eco indicator, the higher the environmental effects emit on man and the earth, which may be considered a non-environmental product.

The product has been redesigned as more engineering research has been carried out on this product which shows that it has an impact on all parties. Self-sustaining products provide natural, social, and financial benefits while safeguarding the public and environmental protection during the life cycle from raw material extraction to the final disposal. The engineering analysis has been carried out and has agreed to minimize the material used and redesign the product to be more sustainable. The design of this product has been modified and the material used for this product has been minimized and changed. The material used in the latest version of this product is silicone. This decision is based on a process tree that has been developed in a new design. The manufacturing process is different for the new product design as the material which has a negative impact has been substituted with the material that has less effect. Thus, it decreased the number of parts for this product. The current value of the eco indicator for this product is 100.33 where the environmental performance increased by 13% than before. This value should be deemed to be good value and safe for human use as the disposal value is -804. Although, it may have had little effect, but it has been improvised by reducing the number of environmental and human impacts than before redesign.

4.9 Detail design of Female Hygienic Urinal Device after optimization

The detailed design of the product after implemented DFMEA and DFE was shown in Figure 4.27.

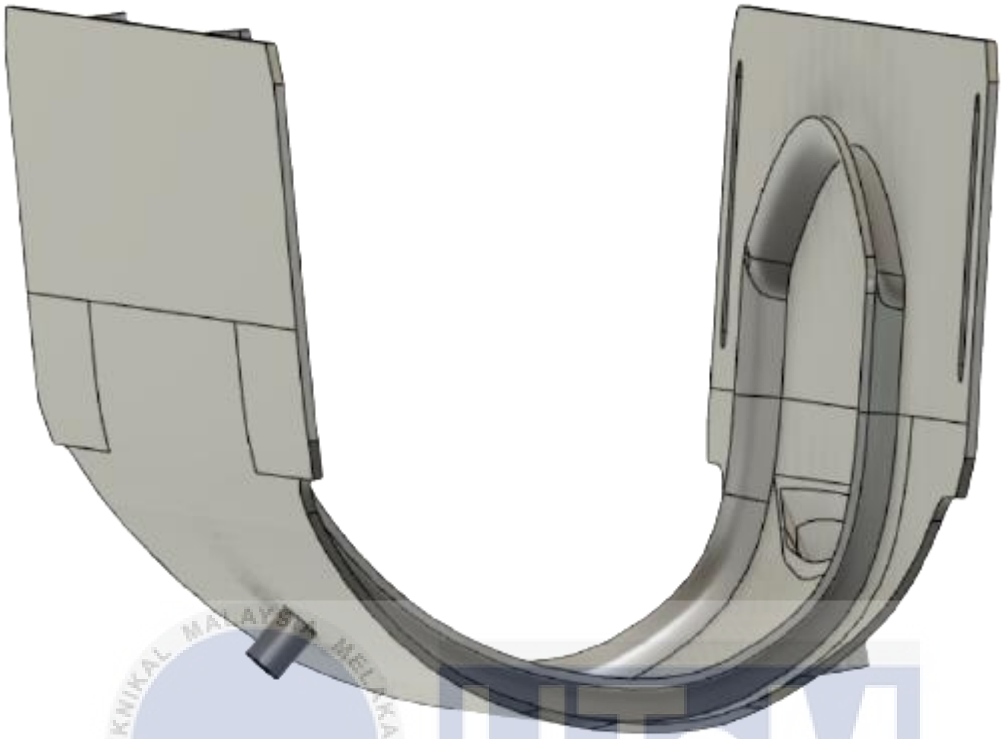


Figure 4.27: Female hygienic urinal device after optimization

Figure 2.28 shows the exploded view of female hygienic urinal device after optimization using DFMEA and DFE.

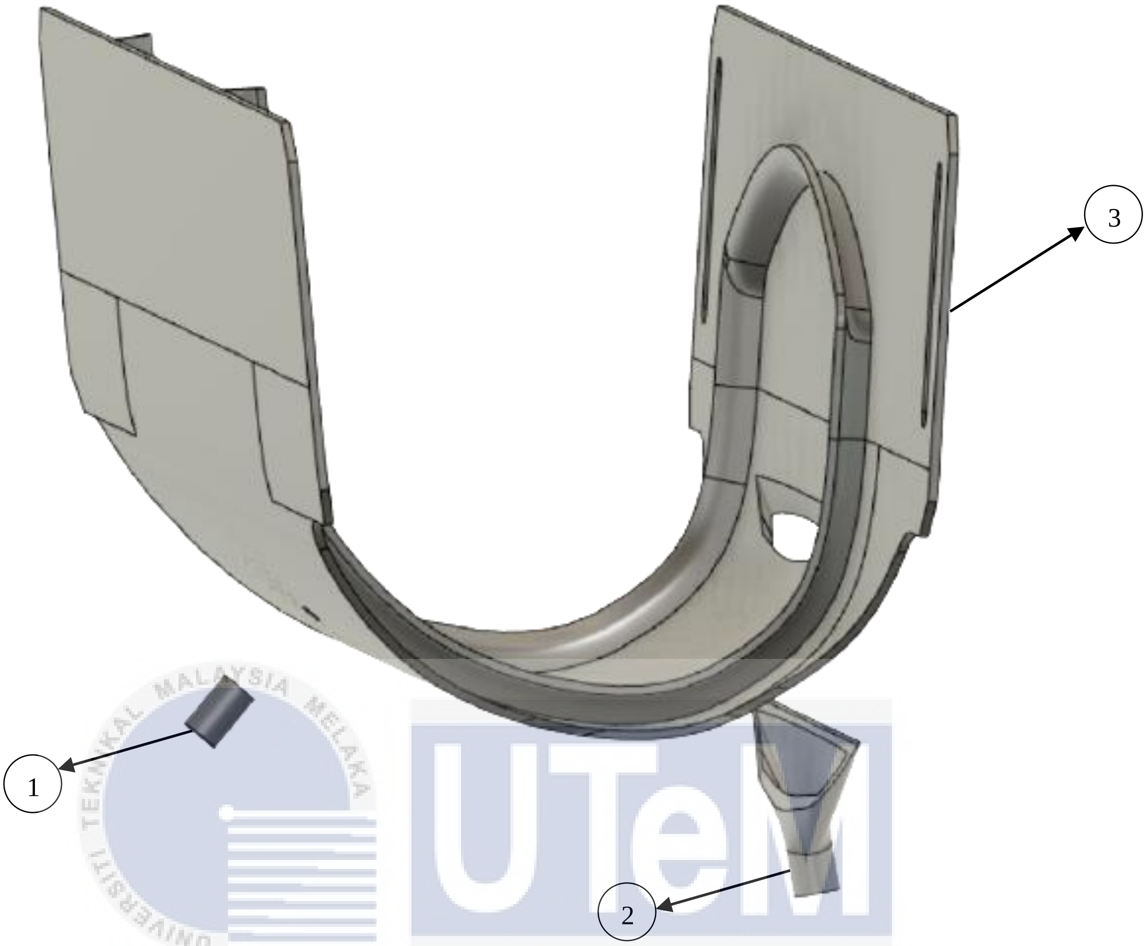


Figure 4.28: Female hygienic urinal device after optimization (exploded view)

Table 4.21 shows the components of the product after optimization.

Table 4.21: List of components after optimization

No.	Component Names	Material	Quantity
1	Washing system	Silicone	1
2	Urinal flow housing	Silicone	1
3	Body frame	Silicone	1

Figure 2.29 shows the product before and after optimization using DFMEA and DFE. It showed that the product before optimization has a simple design compared to the after optimization. The urinal flow housing was located at the bottom of the product while washing system was located at the front and quite high. After implement DFMEA, the locations of both items were relocated according to woman's anatomy when the person is lying on a bed. The dimension of the urinal flow housing also has been widened to ensure all urine goes into the urine bag. Then, a rib was added to avoid backflow of the urine and water for cleaning phase. After that, silicone is used as the material for the components of the product thus only one manufacturing process is needed. Before implemented DFE, the product was made from two different materials which are PUL fabric and polypropylene plus the fabrication required two manufacturing processes. Furthermore, the end of life of the product after optimization also improved since silicone can be recycled.

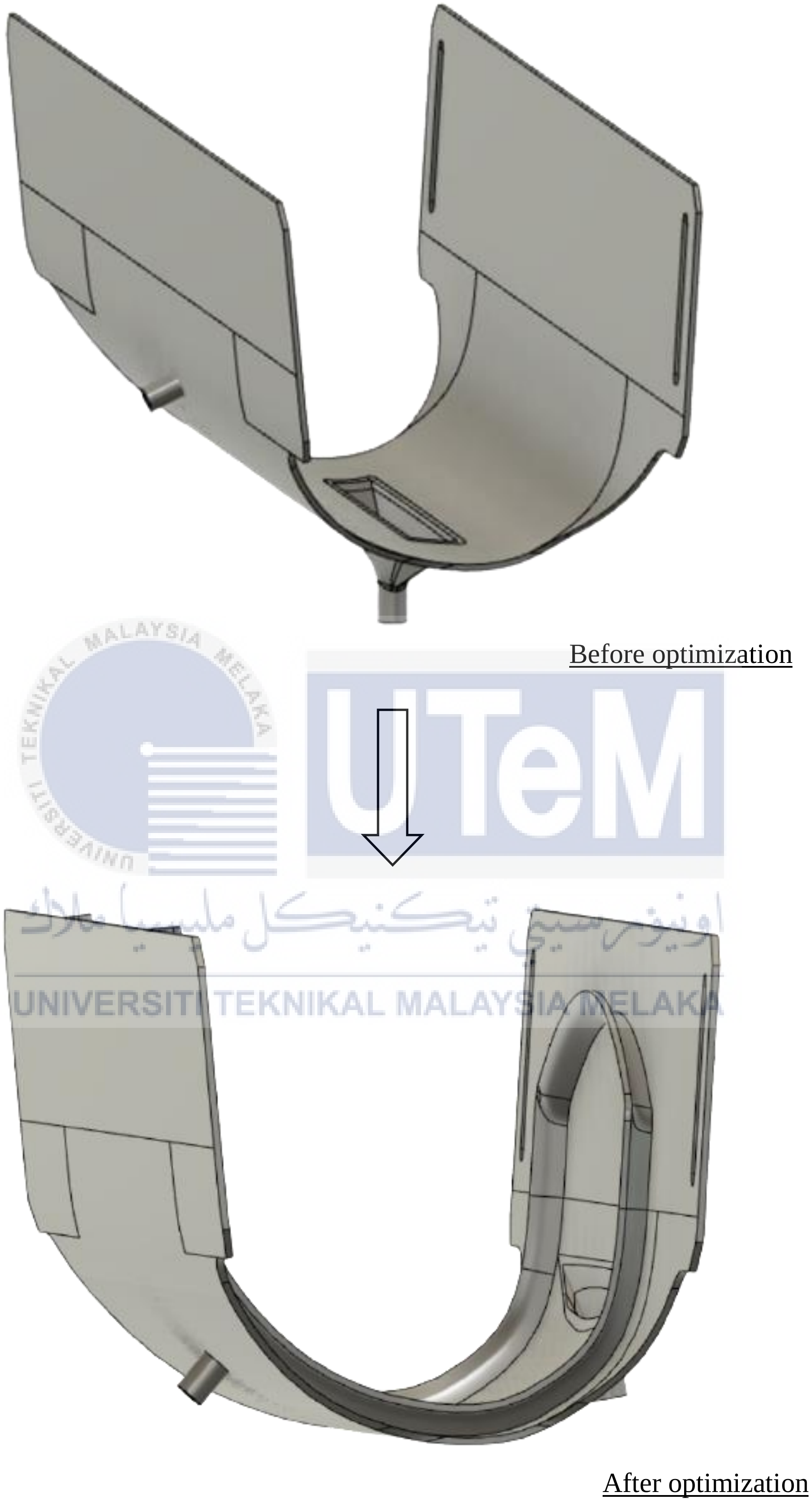


Figure 4.29: Female hygienic urinal device before and after optimization

Figure 30 shows the complete set for the female hygienic urinal device including its child parts. The child part for the device is water bag, urine bag and velcro. Water bag is used to supply water for cleaning purposes while urine bag is to store the urine. Velcro is used as the side adhesive for the device.

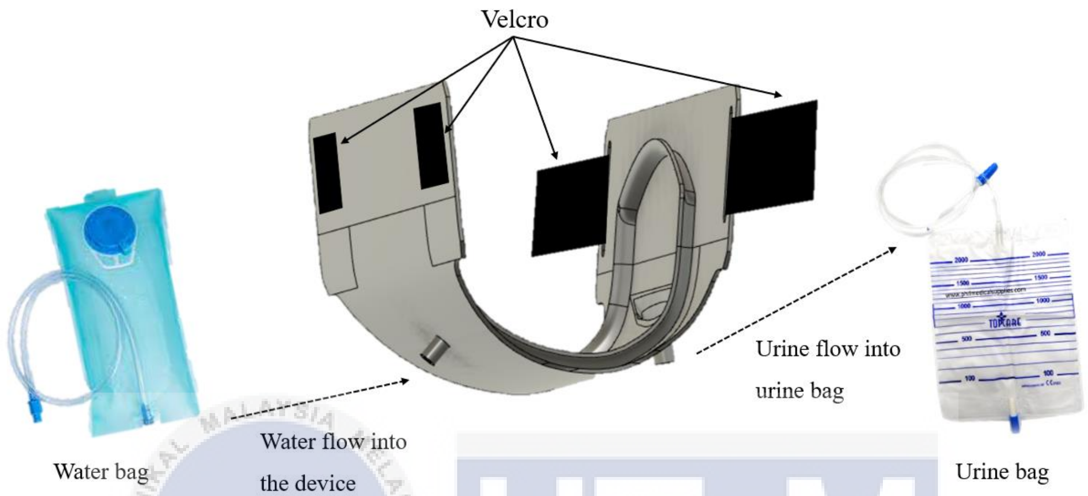


Figure 4.30: Complete set for female hygienic urinal device

CHAPTER 5
CONCLUSION AND RECOMMENDATION

In this chapter, the results and discussion based on the objectives were concluded along with the level of complexity of this project. The sustainability of the proposed product and its life-long learning were discussed for future continuity. Furthermore, the recommendations for further progress also have been suggested in this chapter.

5.1 Conclusion

This study reviews three objectives, one is to study the effect of disposable diapers in nursing homes. From a thorough analysis of the results, it is proven that the application of disposable diapers generally creates negative impacts on the caregivers and environment. The technical specification of the female hygienic urinal device is also based on the caregiver's preference. The next objective is, proposing the best conceptual design of the female hygienic urinal device for bedridden users using TOPSIS method solution. It was found that conceptual design 3 was the best concept with the closeness to ideal value of 1. The method applied was based on the existing device in market and discussion with supervisory committee along with the consumer. Following with the last objective which is to optimize the selected design using Design Failure Mode Effect Analysis (DFMEA) and Design for Environment (DFE). The DFMEA was conducted to identify potential failures and redesign has been made till the RPN value is less than 100 and the design improved 78%. Then, the optimization was continued with DFE. It is concluded that life cycle thinking after redesign is better than before as the end of life of the product can be recycled same goes for the eco-design web and eco indicator of the product. Eco-design web after redesign is better than before since the web is much bigger and toward the green areas. Moreover, the indicator value after redesign is slightly lower than before redesign and improved by 13%. Thus, the implementation of both design for X tools at the conceptual design stage did optimize the proposed design and all the objectives were achieved.

5.2 Complexity

Throughout the completion of this project, few difficulties have slowed down the progress. One of them was the restricted access to the nursing home because of the pandemic Covid-19 that is currently spike, especially for those who belong to the high-risk group. Due to that, the flow of this project was up to the data collection and analysis phase where the effectiveness of disposable diapers in a nursing home (objective 1) can only be done using questionnaires, consequently, cannot be completed through interview sessions. Likewise, the implementation of DFMEA can only be achieved through online discussion with the caregivers and users since it is an analytical technique used by a product design team plus it is a team process. Hence, the tasks were supposed to complete on time while being more independent relatively to usual work setting. Moreover, the product is specially designed for Muslims and must comply with Shariah, so the functionality of the product must meet the requirements in terms of materials used and how to use it. Since the development of this product excludes fabrication thus it is difficult to identify the product is Shariah compliance or not. Therefore, future work is needed to ensure the development of female hygienic urinal device is successful and marketable.

5.3 Sustainability

Based on the improvement of the proposed product, Design for Environment (DFE) has been implemented. Thus, it was expected that the product should be sustained in the future. By utilizing recyclable material to fabricate the product, the end of life of the material should be better and increase the life span of the product. As a result, better overall productivity and functionality of the product are achieved through an improved design and manufacturability. Sustainable manufacturing has been the most crucial factor for engineers to address as it is a requirement and a responsibility to the industry.

5.4 Life-long Learning

The female hygienic urinal device will give a big impact on the community especially bedridden users and their caregivers. It is low cost since the product is reusable and can lessen the caregiver’s burden due to frequent diapers exchanged. The importance of DFMEA is seen to be effective in optimizing a product before the fabrication process is carried out. The concurrent concept used in the process of developing this product is efficient and cost-saving since it is a preventive action. Repairing and resolving damage usually cost a lot of money. Besides, developing a new product is a lifelong learning phase as improvement always be made to improve the product performance. In general, from this project, students will be able to exhibit the abilities and knowledge they have gained theoretically during their studies. Few soft skills which are very beneficial also can be developed throughout the completion of this project. For instance, students could benefit from the discussion session done with nursing home’s representative where communication skills can be enhanced. This project provides an opportunity for students to make judgments and apply what they've studied about methodologies, tools, and approaches to a real-world issue similar to how a professional would encounter when performing work after graduating.

5.5 Basic Entrepreneurship

The product can be utilized in various sectors such as hospitals and nursing homes. Besides, it can be used by bedridden patient that stayed at home. The product is Muslim friendly since it was developed mainly to meet Shariah compliance and fill in the gaps of the existing product. Therefore, the commercialization of the product increased due to its uniqueness.

5.6 Recommendation

For future recommendations, the design must include simulation to test, iterate and validate the design through Computational Fluid Dynamic (CFD) software. This is to ensure that the product can function well without any failures in the future such as backflow of the urine and the washing phase need to fulfil the requirement for Muslims. Next, fabrication of the product is needed as it can be tested on real users and improvements can be made in terms of material used. Thus, it is suggested to scale down the size of the product and proceed with the vacuum casting process. This is to foresee the material appearance and texture with a shorter time. Then, the fabrication of the product can proceed with the original size. Besides, mold for the product is recommended to be printed using 3D printing.

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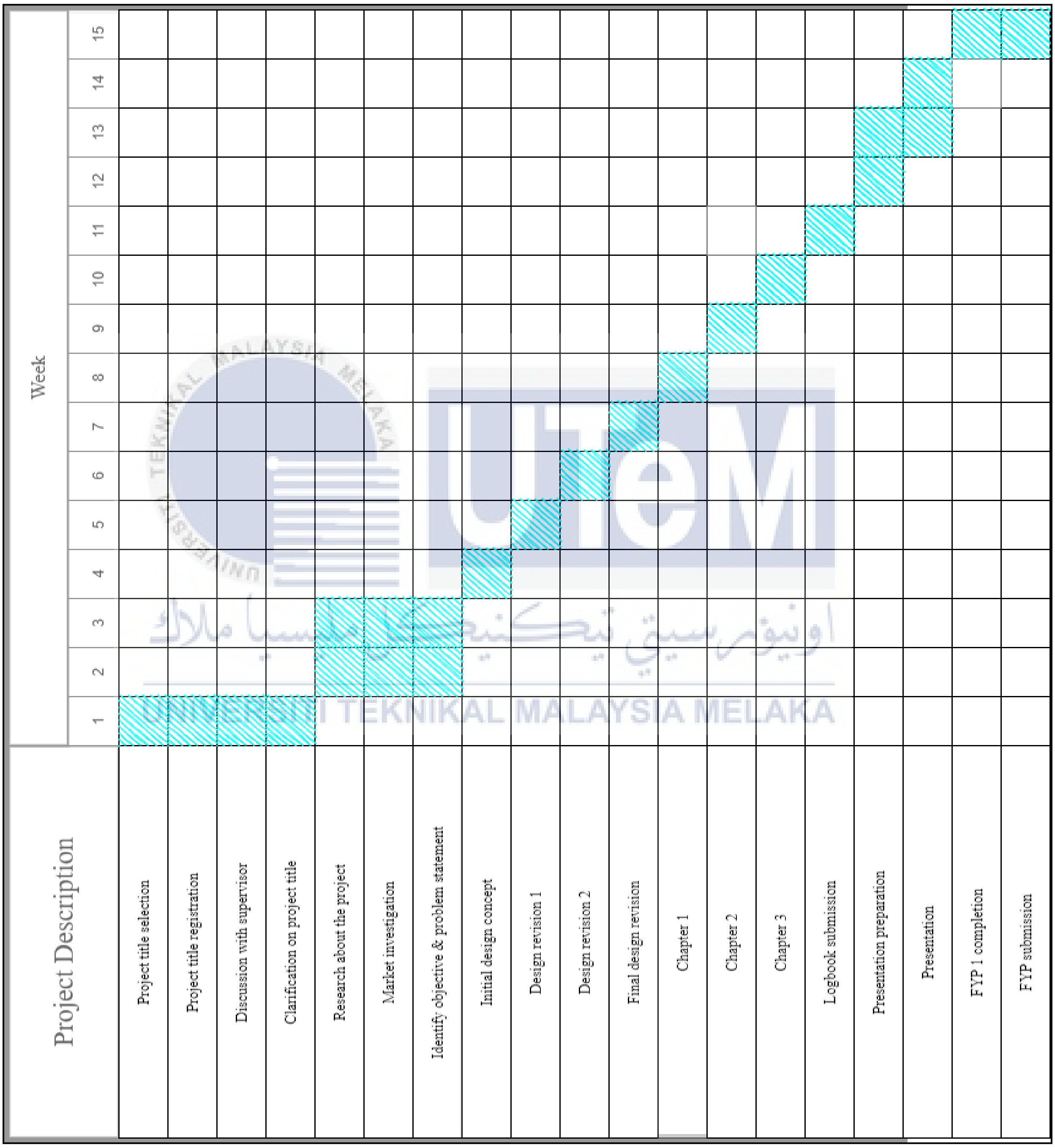
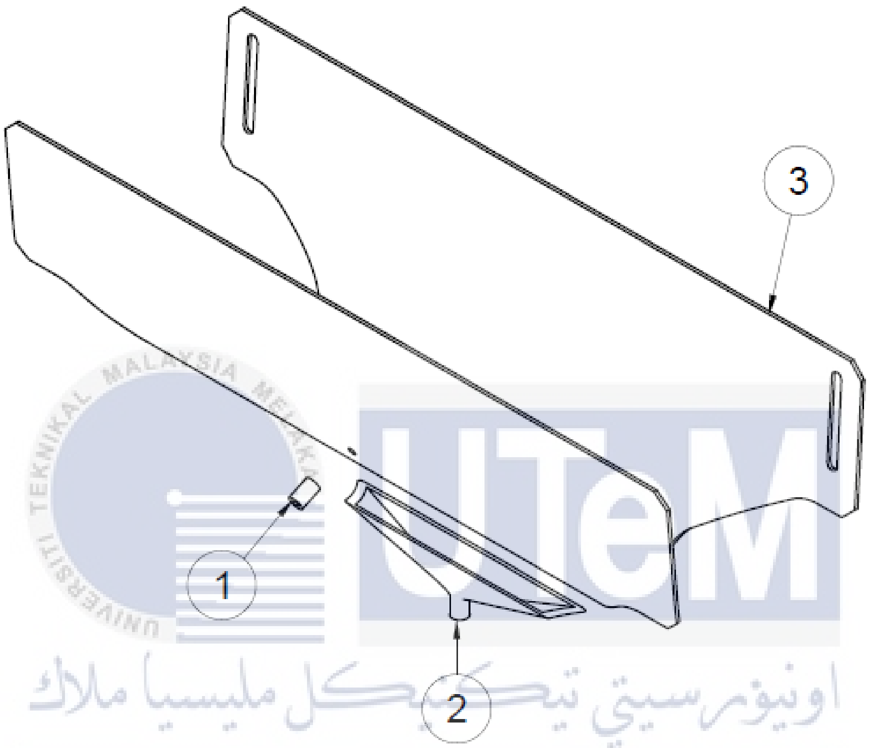
APPENDICES

APPENDICES A – Gantt Chart of FYP 1



APPENDICES C – Drawing Parts



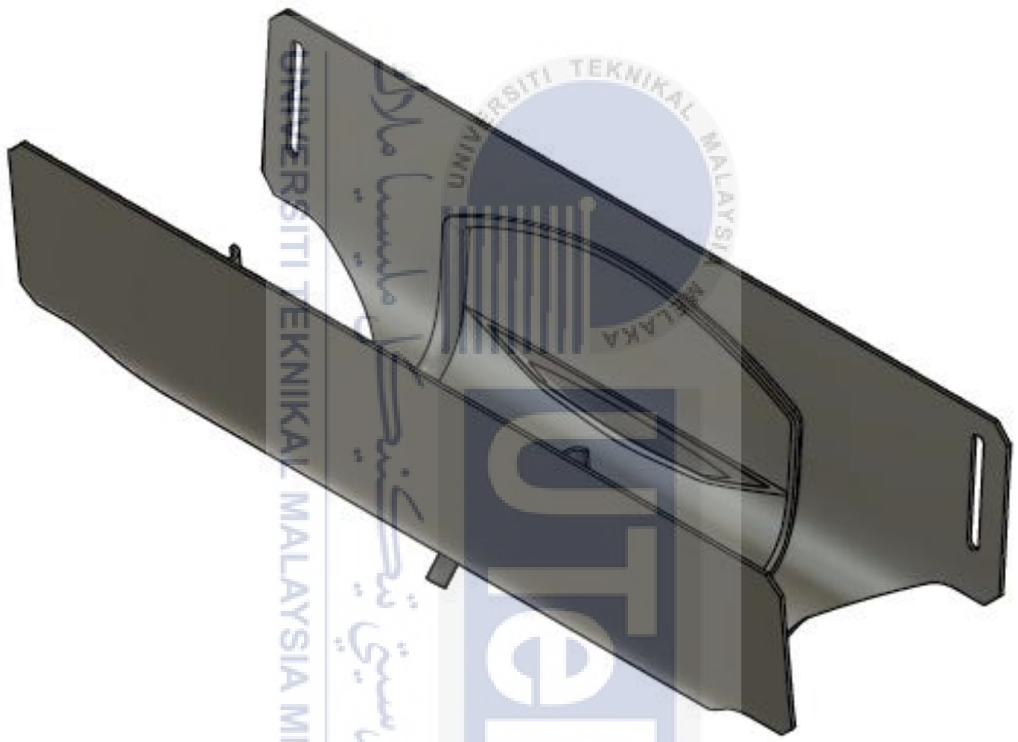
Bill of material

Item	Part name	Material	Qty
1	Washing system	PUL fabric	1
2	Urinal flow housing	Polypropylene	1
3	Body frame	Polypropylene	1

Drawing by: ADILA FAZLIANA	Date: 30/8/2021	Title: FEMALE HYGIENIC URINAL DEVICE (before optimization)
Checked by: PROF HAMBALI	Date: 30/8/2021	
Approved by: PROF HAMBALI	Date: 30/8/2021	DWG No. 1

Size: A4	Unit: mm	Scale: 1:8	Sheet: 1 OF 1

Rev.



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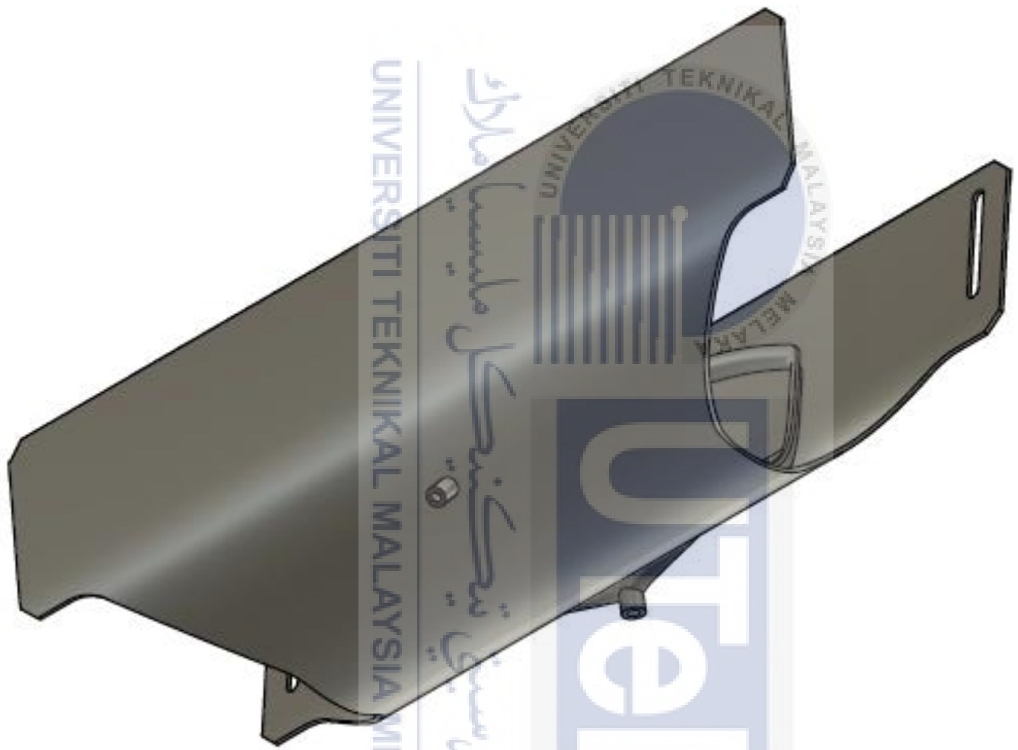
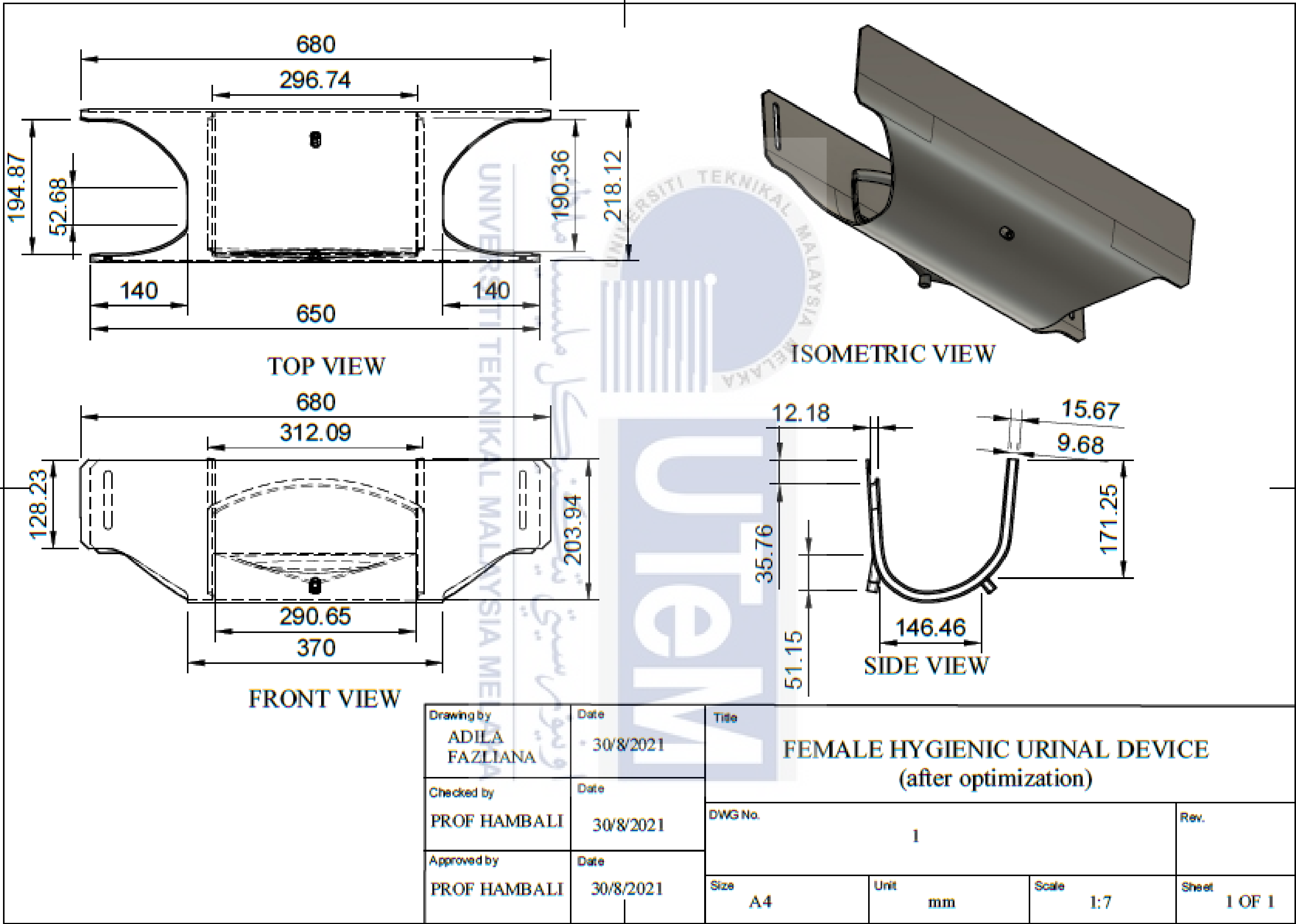
Checked by	Date	DWG No.			Rev.
PROF HAMBALI	30/8/2021	1			
Approved by	Date	Size	Unit	Scale	Sheet
PROF HAMBALI	30/8/2021	A4	mm	1:4	1 OF 1



Drawing by	Date	Title			
ADILA FAZLIANA	30/8/2021	FEMALE HYGIENIC URINAL DEVICE (after optimization)			
Checked by: PROF HAMBALI	Date: 30/8/2021	DWG No.: 1			Rev.
Approved by: PROF HAMBALI	Date: 30/8/2021	Size: A4	Unit: mm	Scale: 1:4	Sheet: 1 OF 1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52.68
190.36
218.12
140
140
650
TOP VIEW
680
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128.23
203.94
290.65
370
FRONT VIEW
ISOMETRIC VIEW
12.18
15.67
9.68
171.25
35.76
51.15
146.46
SIDE VIEW
Drawing by
ADILA FAZLIANA
Date
30/8/2021
Checked by
PROF HAMBALI
Date
30/8/2021
Approved by
PROF HAMBALI
Date
30/8/2021
Title
FEMALE HYGIENIC URINAL DEVICE
(after optimization)
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Rev.
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Unit
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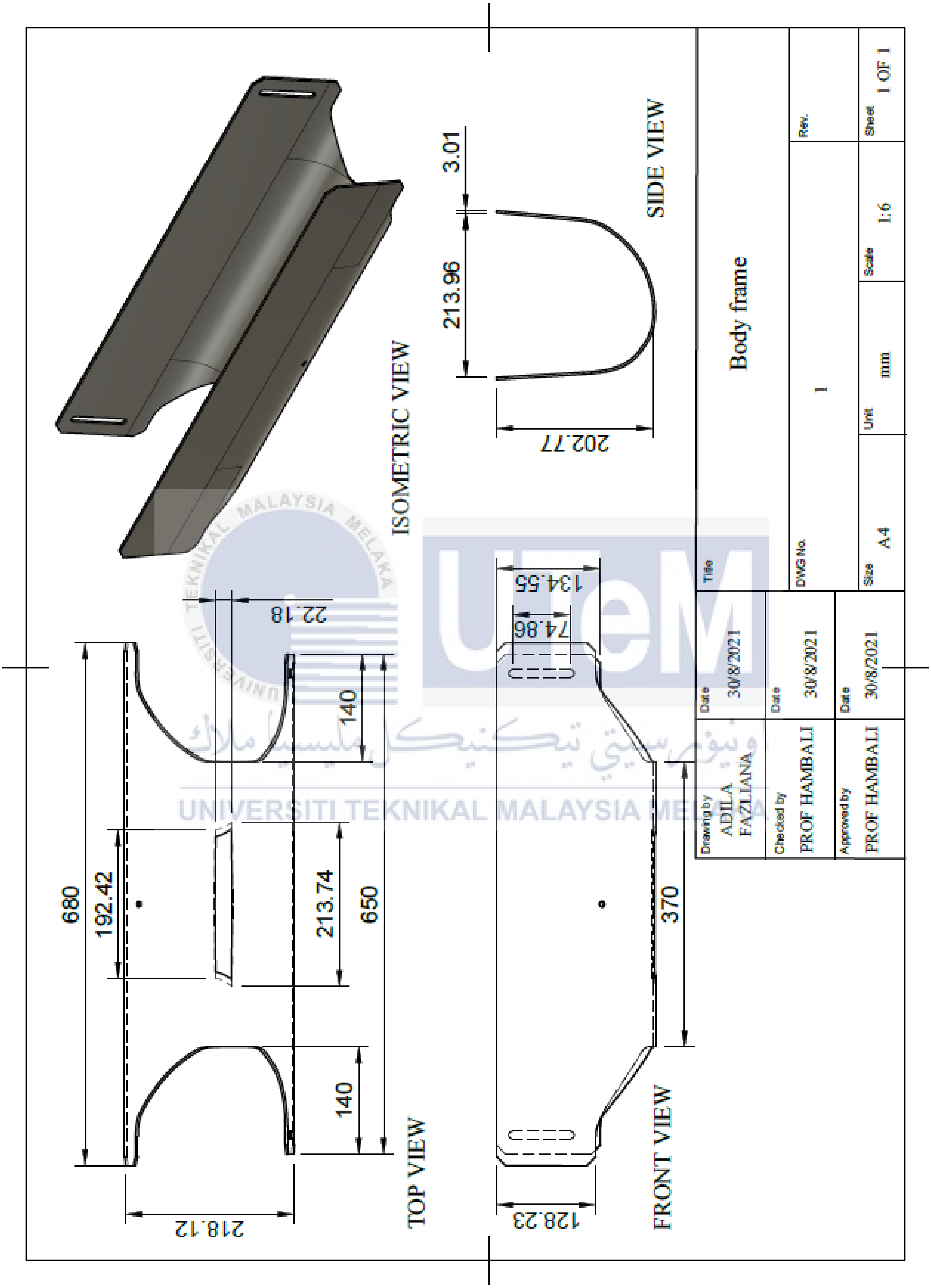
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650
140
140
218.12
22.18
FRONT VIEW
134.55
74.86
370
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Body frame
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Rev.
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1 OF 1
Drawing by
ADILA FAZLIANA
Date
30/8/2021
Checked by
PROF HAMBALI
Date
30/8/2021
Approved by
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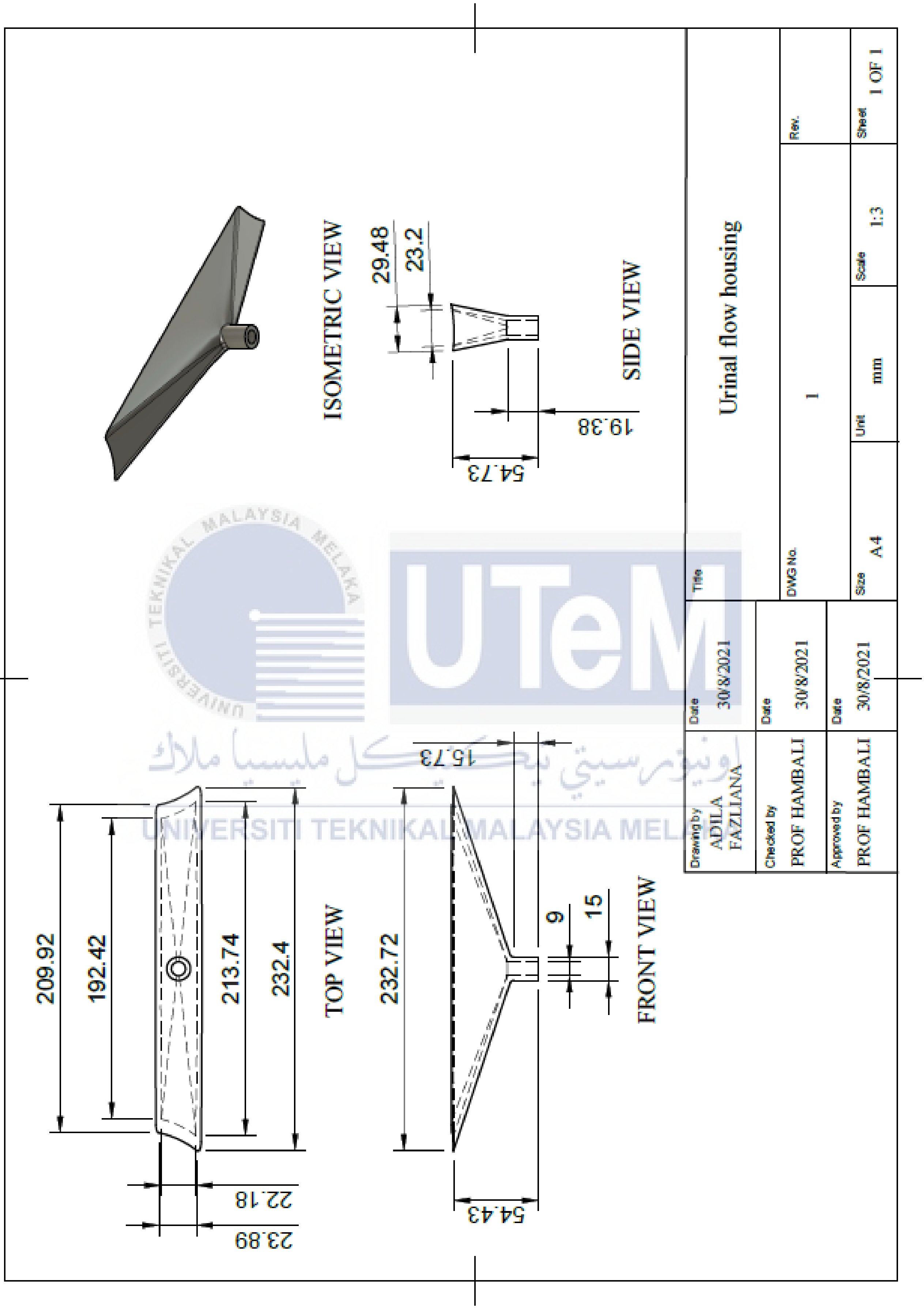
Date
30/8/2021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SIDE VIEW
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192.42
213.74
232.4
TOP VIEW
22.18
23.89
232.72
15.73
9
15
54.43
FRONT VIEW
Title
Urinal flow housing
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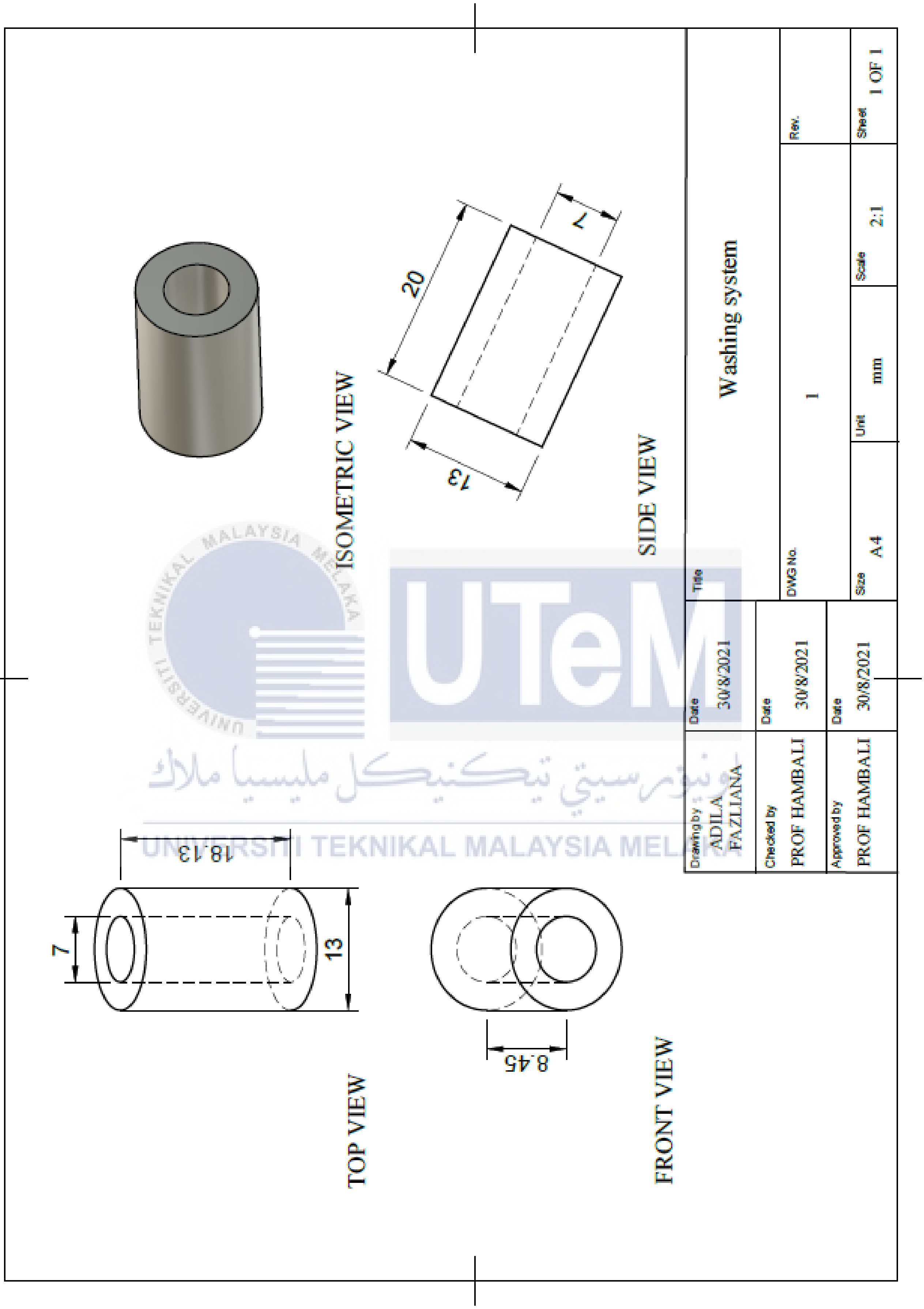
Rev.
Size
A4
Unit
mm
Scale
1:3
Sheet
1 OF 1
Drawing by
ADILA FAZLIANA
Date
30/8/2021
Checked by
PROF HAMBALI
Date
30/8/2021
Approved by
PROF HAMBALI
Date
30/8/2021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7
13
SIDE VIEW
18.13
7
13
TOP VIEW
8.45
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Rev.
Size
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Unit
mm
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Sheet
1 OF 1
Drawing by
ADILA FAZLIANA
Date
30/8/2021
Checked by
PROF HAMBALI
Date
30/8/2021
Approved by
PROF HAMBALI
Date
30/8/2021

APPENDICES D – Survey Form (example)

FINAL YEAR PROJECT SURVEY QUESTIONNAIRE

This survey is about 'THE EFFECT OF DISPOSABLE DIAPER USAGE AMONG FEMALE ELDERLYS IN ELDERS HOME CARE CENTRE'. This questionnaire is designed to collect data in order to complete bachelor's degree final year project. All the information that been given will be used for academic purpose only. All your honesty, time and contribution will be appreciated. Thank you.

This questionnaire consists of THREE (3) sections, which are Section A, Section B and Section C. Section A consists of demographic information of the respondents while Section B consists of questions related to the project. Section C consists of technical specifications of proposed design.

Tinjauan ini adalah mengenai 'KESAN PENGGUNAAN LAMPIN TERHADAP ORANG-ORANG TUA (PEREMPUAN) DI ELDERS HOME CARE CENTRE. Soal selidik ini dilakukan untuk mengumpulkan data bagi menyelesaikan projek tahun akhir ijazah sarjana muda. Semua maklumat yang diberikan hanya akan digunakan untuk tujuan akademik sahaja. Semua kejujuran, masa yang diberikan serta sumbangan anda amatlah dihargai. Terima kasih.

Soal selidik ini terdiri daripada TIGA (3) bahagian, iaitu Bahagian A, Bahagian B dan Bahagian C. Bahagian A terdiri daripada maklumat demografi responden manakala Bahagian B terdiri daripada soalan yang berkaitan dengan projek. Bahagian C terdiri daripada soalan berkenaan spesifikasi teknikal reka bentuk yang dicadangkan.

Section A

1. Gender / *Jantina*

☐ Male / *Lelaki* ☐ Female / *Perempuan*

2. Age / *Umur*

☐ 16 – 25 ☐ 26 – 35 ☐ 36 – 45 ☐ 46 – 55 Others / *Lain-lain*: _____

Section B

1. Who usually wear diapers?
Siapakah yang sering memakai lampin pakai buang?

☐ Bedridden patient */pesakit terbaring* ☐ Patient with Alzheimer's disease */pesakit Alzheimer* Others: ___________ *Lain-lain*

2. What type of diapers that usually been used?
Apakah jenis lampin yang sering digunakan?



☐ With tabs / *pelekat* ☐ Pull up / *tarikan* ☐ Cloth diapers / *lampin kain*

3. How do they wear diapers?
Bagaimanakah seseorang itu memakai lampin?

☐ With help / *dengan bantuan* ☐ Without help / *tanpa bantuan*

4. How many times do they change diapers per day?
Berapa kali seseorang itu menukar lampin dalam masa satu hari?

☐ 1 – 2 times */kali* ☐ 3 – 4 times */kali* ☐ 5 and above */kali*

5. How much cost spent to buy diapers per person monthly?
Berapakah kos yang diperuntukan untuk membeli lampin bagi seseorang dalam masa sebulan?

☐ < RM 200 ☐ between RM 201 – RM400 */antara* ☐ > RM 401

6. Have the current diapers cause any skin irritation?
Pernahkah lampin yang sedia ada ini menimbulkan iritasi kulit?

☐ Yes / *Ya* ☐ No / *Tidak*

7. What is the other problem with current diapers?
Apakah masalah lain yang ada di lampin sedia ada?

Please state the problem:
Sila nyatakan masalah tersebut:

____

____

____

____

8. If reusable diapers are used, what do you think the benefits?
Jika lampin kitar semula digunakan, apakah kesan positif yang mungkin terjadi?

☐ Environmentally friendly
Mesra alam

☐ More hygienic
Tahap kebersihan tinggi

☐ Reduce skin irritation
Mengurangkan iritasi kulit

In your opinion, please state other benefits:
Pada pendapat anda, sila nyatakan kesan positif yang lain

____

____

____

9. If reusable diapers are used, what do you think the drawbacks?
Jika lampin kitar semula digunakan, apakah kesan negatif yang mungkin terjadi?

☐ Inconvenient for the user
Pengguna tidak selesa

☐ Less hygienic
Tahap kebersihan rendah

☐ Caregiver has extra works
Penjaga mempunyai lebih banyak kerja

☐ Expensive
Mahal

In your opinion, please state other consequences:
Pada pendapat anda, sila nyatakan kesan negatif yang lain

____

____

____

____

Section C

1. The urine in diapers should be discharged and stored into the urine bag.
Air kencing di dalam lampin haruslah dikumpul ke dalam beg urin.

Strongly disagree / *Sangat tidak setuju*	Disagree / *Tidak setuju*	Moderate / *Sederhana*	Agree / *Setuju*	Strongly agree / *Sangat setuju*
1	2	3	4	5

2. The diapers should be equipped with washing system.
Lampin haruslah dilengkapi dengan sistem pembasuhan sendiri.

Strongly disagree / *Sangat tidak setuju*	Disagree / *Tidak setuju*	Moderate / *Sederhana*	Agree / *Setuju*	Strongly agree / *Sangat setuju*
1	2	3	4	5

3. The material of the diapers should be easily wash.
   Lampin perlulah diperbuat dari bahan yang mudah dibasuh.

Strongly disagree / *Sangat tidak setuju*	Disagree / *Tidak setuju*	Moderate / *Sederhana*	Agree / *Setuju*	Strongly agree / *Sangat setuju*
1	2	3	4	5