DESIGN AND DVELOPMENT OF TABLE NAPKIN FOLDING MACHINE

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering Technology (Product Design) (Hons.)

by

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2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN A FOOTSTEP POWER GENERATION**

SESI PENGAJIAN: **2016/2017 Semester 1**

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I hereby, declared this report entitled “Design and Development of Table Napkin Folding Machine” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor in Engineering Manufacturing Technology (Product design) (Hons.). The member of the supervisory is as follow:

……..

Umi Hayati Binti Ahmad

ABSTRAK

Kertas ini melaporkan mekanisme dan fabrikasi mesin yang boleh melipat kain napkin yang digunakan dalam industry perhotelan. Ideanya adalah untuk melipat napkin meja dengan bentuk yang dikehendaki dalam masa yang singkat. Mesin in menggunakan mekanisme seperti gear dan aci untuk berfungsi. Aci berfungsi dengan dipusingkan megikut arah jam untuk memberi elemen mesin membuat lipatan dan bergerak. Tujuan utama mesin lipat kain napkin meja ini adalah untuk melipat kain napkin meja dalam kuantiti yang banyak di dalam masa yang singkat. Selain itu, ianya juga untuk mengelakkan saiz tak terpiawai dilipat napkin meja. Borang kaji selidik telah diedarkan kepada 30 orang pengguna untuk memilih reka bentuk yang terbaik dan sesuai untuk mesin ini. Idea sistem rekaan ini diekstrak daripada mesin lipat baju yang ada di dunia pada masa kini.

Kata kunci
Prototaip lengkap; Mesin melipat napkin meja; Saiz napkin yang telah dilipat; Gear dan aci;

ABSTRACT

This paper is explaining the design and development of table napkin folding machine mechanism and fabrication that can fold a table napkin in hospitality industry. The idea is to fold the table napkin with the desired pattern in a short time. This machine is using gears and shaft as the mechanism to function. Shaft is rotate in clockwise so the machine element can fold the table napkin. Main purpose of this table napkin folding machine is to fold a large quantity of table napkins in a short time. Besides, it also to prevent the unstandardized size of folded table napkin. A survey has been conduct to 30 random respondents to decide the best and suitable design for this machine. The idea of fabricated system is extracted from cloth folding machine that exits in world nowadays.

Keywords

Complete prototype; Table napkin, Folded size; Gears and shaft;

DEDICATIONS

This report is dedicated to all people that hold me dear. Thank you for your continuous support during my vital educational years. Without their consent, understanding and most of all love, the completion of this final year project would not have been possible.

To my beloved parents,

My sibling,

My supportive friends,

and my supervisor,
Umi Hayati Binti Ahmad.

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I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. A special gratitude I give to my final year project manager, Mrs. Umi Hayati Binti Ahmad whose contribution in stimulating suggestions and encouragement helped me to coordinate my project especially in writing this report.

Furthermore, I would also like to acknowledge with much appreciation the crucial role of the staff of related workshop, who gave the permission to use all required equipment and the necessary materials to complete the project of Design and Development of Table Napkin. Special thanks to my classmates and friends who help me to regarding the machine element fabrication and gave suggestion about the task. Last but not least, I have to appreciate the guidance given by other supervisor as well as the panels especially in our project presentation that has improved our presentation skills thanks to their comment and advices.

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CHAPTER 1
INTRODUCTION

1.0 Background of Study

There are several shape and sizes of table napkin that were used in different occasions. The shape of napkins used are usually square. Though table napkins are varying in size, they are commonly found in the following size; 16 inches, 18 inches, 20 inches and 21 inches. 22-26 inches are considering as the large napkin which is typically used for formal occasions, multiple course and meals. The larger napkin allows easier napkin folding presentations and laying across the entire lap while dining (Roberts, 1999). The material of the table napkins usually is a high-thread-count, linen or linen-cotton mix damask.

In order to reduce the time consuming and get a standard size of folded napkins, this machine only fold the easiest part of the napkins without considering the arts. The gears and shaft were used to make the machine works. As we know the function of gear is to transmit the motion of the machine besides can increase speed, increase force or change direction. Every type gear will be studied to determine which gear is suitable for this machine to functional well. Apart from that, in order to do the simulation and analysis the machine elements that were used in the machine, SolidWorks software was being used.

1.1 Problem Statements

Before this the table napkins were folded by the workers manually which is this conventional method is consume more time to complete the task. Each worker that need to fold the table napkins are not able to do the other task because the table napkins was hard to fold and take times. In hospitality industry, the total of table napkins used for each meal usually in a large quantity. Therefore, a machine is needed for this task to be complete in a short time. Besides, the workers have different kind of skills to fold the table napkins. This will make the folded size table napkins different between workers. Thus, a table napkin folding machine will prevent this problem to be happened in the future.

1.2 Objectives

The objectives for this project are:

i. To design a table napkin folding machine.

ii. To produce a functional table napkin folding machine that can reduce time consume and get a standard size of folded table napkin.

1.3 Scope

The scope is set as a border of this project to clarify the area of a study that would be cover in this report and which is not. The limitation of this report is included as:

i. The standard size of table napkin that will be used in this project is within the range of 9-10 inches square. This range of size were used for dessert such as beverage and cocktail. Different size of napkin is used based on the occasions.

ii. This machine will only fold one pattern of table napkin without considering the arts.

iii. This machine can only be used at hotel or in hospitality industry.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Folding machine is basically a machine that can fold an object such as papers, fabrics, plastics and many more using the machine element that were used in the machine. As production field is growing the development of machine continues to develop. This chapter will be continuously carried to study the past and current of research work. Some important issues and data have to be studied, reviewed, determined and applied for the project which is "Design and Development of Table Napkins Folding Machine". There are previous researches on folding machine which is using different machine elements, mechanical movements, method, and experiment design to obtain the folded table napkins. Furthermore, this chapter will be including the types of folding machine, type of machine element used and the mechanical movement in the machine.

2.1 Folding Machine

There are many types of folding machine in this world. For example, folding machine for fabric, paper, plastic and many more. These machine are using the same concept for the folding motion. The mechanical movement will be studied in each folding machine.

2.1.1 Fabric Folding Machine

Table napkins and cloth folding machine were also included in the fabric folding machine. This is because the material for the table napkins and cloth are a little bit similar which is both are using fabric. The first folding machine that will be discussed is “Photovoltaic Powered T-shirt Folding Machine”. This is an automatic motor controlled t-shirt folding machine powered by a photovoltaic system. Photovoltaic (PV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors.

Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid, such as Solar Energy Industries Association (2014). Gomesh, Daut, Kumaran, Irwanto, Irwan and Fitra (2013, p. 313) state that “this folding machine used four DC motors to control the motion of the folding part.” The DC motor are attached to the folding motion and rotates according to a program which uses microcontroller.

There are many fabric folding machine that had already exists such as Laundroid. Laundroid is the name of the laundry folding robot that being created by Japan-based Seven Dreamers. The refrigerator-sized machine is the “first in the world to automatically fold and separate laundry”. The CEO of this company, Shin Sakane said, the robot uses image-recognition algorithms to tell what kind of clothing its handling and to fold it appropriately. Segan (2016) state that Laundroid takes 3 between 10 minutes to fold one piece of laundry at a moment. They are not 100% neat, but they are folded, by machine.

Figure 2.1: A Demonstration of Laundroid

2.1.2 Plastic Folding Machine

Plastic folding machine are used to fold a box with a plastic. This process also called wrapping process. Bag folding are also one of the plastic folding process. High speed bag-folding and packaging machine particularly designed to handle sheet or flat plastic materials, although other equivalent sheet materials may be processed, such as are used for plastic bags.

This machine is to mutually fold the cut paper to the face-cloth paper, which is put into the box becoming the economic drawing style box face-cloth paper. This plastic folding machines are equipped with high quality micro process control with digital display. These machine are widely used for center and bottom sealed pouch by folding process at a high speed.

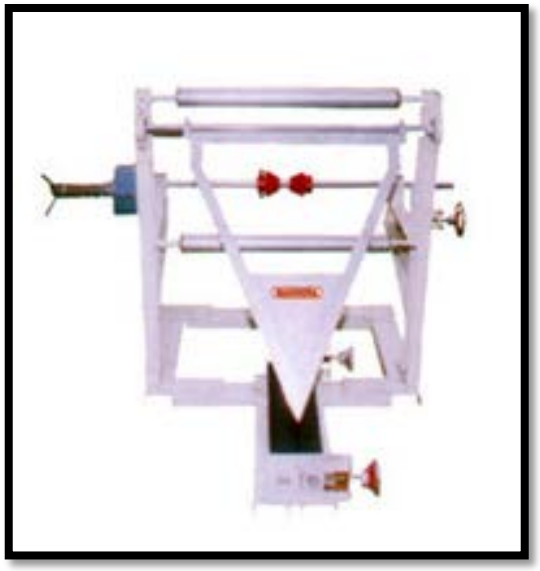


Figure 2.2: Plastic Folding Machine

2.1.3 Paper Folding Machine

Paper folding machines help speed up productivity in the office. Besides, it also can be helpful in banks, print shops, schools or any place of business that processes and mails a variety of documents and letters. Therefore, it can cut down on time spent manually for folding mailings and documents with a paper folding machine. It is a perfect-time saving tools.

These machine can fold various type of paper, low-volume or high-volume paper. The operational speed indicates how many sheets of paper can be folded within an hour's time. A paper folder that folds up to 1,800 sheets per hour is considered low-volume, while a paper-folding machine that folds up to 10,300 sheets per hour is considered high-volume (*Paper-Folding Machines,* 2016). Most paper folders have multiple folding options, usually offering around four or six selectable settings. Some common folding styles include letter, half, Z-fold, double parallel, gate and church.

Figure 2.3: Paper Folding Machine

2.2 Mechanism in the Machine

2.2.1 Fabric Folding Machine

A folding machine including a feeding unit feeds the sheets form a stack to a folding station. At the folding station an intermediate portion of each sheet is pushed by a pushing unit between two counter-rotating rollers to be folded in half. The feeding unit, the pushing unit and the rollers are driven by independent motors and controlled by a programmed control unit.

Usually there will be DC motor that will convert direct current electrical power into mechanical power for the folding motion. The DC motor consists of two permanent magnets and also two windings. The brushes and the commutator power the coil. Magnetic polarity of the electromagnet will change. And also the winded direction of the two magnet windings will be reversed. So it will make one

electromagnet to be north and another will be south. The basic of a DC motor can be seen in the Figure 2.4.

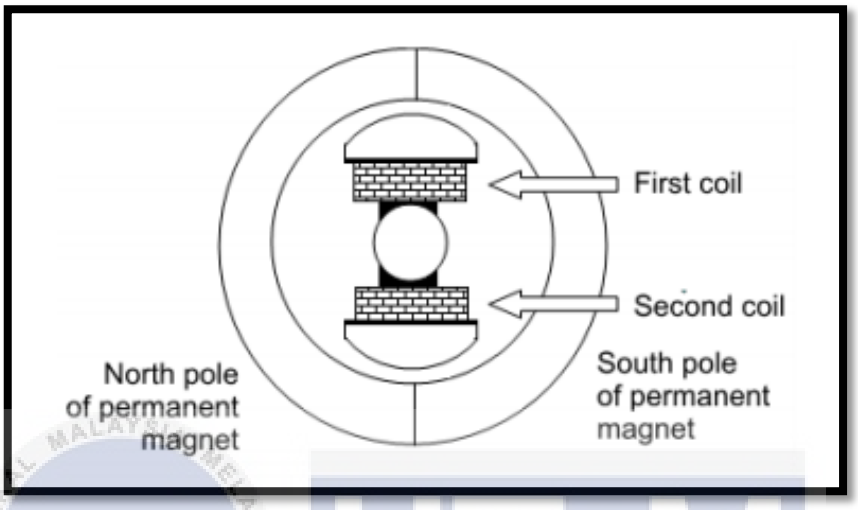


Figure 2.4: Basic of DC Motor

For this fabric folding machine, a 200rpm 12V DC gear motor has been used to lift up the folding material. The difference between normal DC motor and DC gear motor is, DC gear motor can hold a position without drifting, Gomesh, Daut, Kumaran, Irwanto, Irwan and Fitra (2013, p. 315). DC gear motor can rotate and return accurately to the wanted position according the program that has been added in the microcontroller.

Figure 2.5: Microcontroller

The microcontroller controls the overall motion of the folding. The overall system is powered by a photovoltaic system. A microcontroller is a small computer (SoC) on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals ('Microcontroller', 2009). Microcontrollers are designed for embedded applications.

2.2.2 Plastic Folding Machine

An automatic, variable speed, plastic-bag-folding machine which takes flat plastic bags, rolls, folds, flattens and packages the bags. The machine consists of a conveyor belt assembly and fed by the discharge of a plastic-bag-making machine which feeds the bags into rolling, folding and multi-bag packaging sections, synchronized by a pneumatic control system.

Because of the inherent speed capability involved in the positive mechanical, moving pin action used to remove the bags from the rolling section in the previous machine, had some limitations which the present invention is directed

to overcome. As a matter of comparison, the prior machine handled bags at speeds of sixty bags per minute while the present invention has been run at a speed of over a hundred-and-twenty bags per minute.

They had improved the time taken for the machine to complete the task. This is because the present invention utilizes a different, improved multi-bag packaging section which includes two separate bag collection sections with a mechanical diverter which allows the final packaging to be carried on independently of the collection function, further enhancing the speed handling capability of the machine.

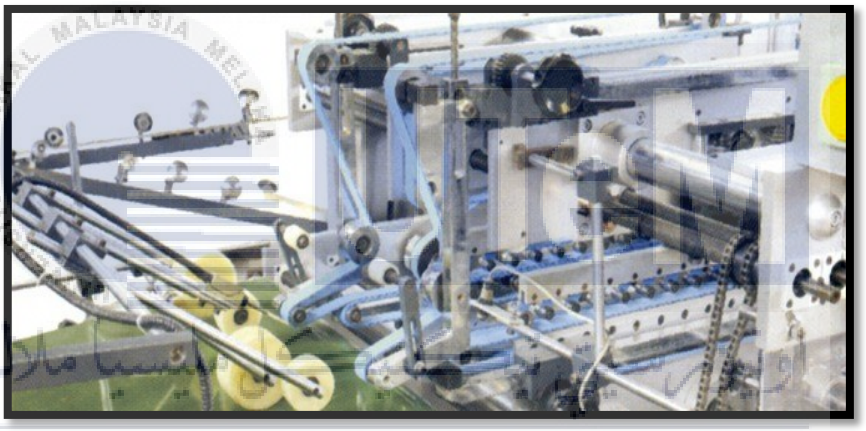


Figure 2.6: Mechanism in Plastic Folding Machine

2.2.3 Paper Folding Machine

A paper-folding machine with a plurality of folding rollers, which form a folding station in pairs and the distances between whose axes can be set to different folding gap widths corresponding to the paper thickness to be processed and the number of layers of paper passing through the individual folding stations, as well as with mechanical or electronic feed limiters, which are arranged in front of the

individual folding stations and can be set individually to different feed lengths (Mathias, 1992).

A first folding nip for executing fold the first paper and a second folding nip for executing fold the second paper. The rollers are engaged to each other by gears and rotated by a single electric motor for moving the sheet material. A pocket is formed upstream of the first folding nip in the housing for receiving the sheet of paper to stop its forward progress. The sheet of paper is continued to be fed by the take-in nip so that it folds into the first folding nip which draws the now once folded paper from the first pocket. The housing is formed in two articulated parts as is the frame so that the housing can be opened.

Three of the rollers which define the take-in and second folding nips are connected to one part of the frame so that when the housing is opened these rollers are separated from the other roller. The housing and frame are designed to open on a plane which is near a tangential plane passing through the first folding nip. When the housing is opened the rollers and the pockets are exposed for removing paper that might have jammed in the folding machine.

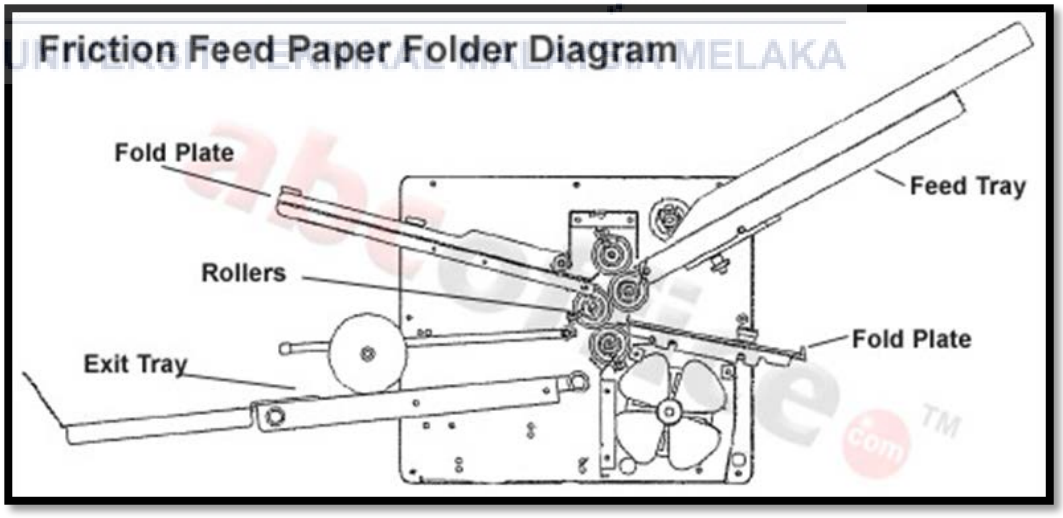


Figure 2.7: Mechanism in Paper Folding Machine

2.3 Main Components

Some research has been done for determine the suitable machine element that will be used in this machine. Inside this machine, there will be gears and shaft for the mechanical movement.

2.3.1 Type of Gear

Gears are used to transmit power and rotating or reciprocating motion from one machine part to another. Gear is very compact which is also allow short center distance and require less space. They are also quiet in operation if they are a good quality gears. Besides, it also has a very high efficiency which is very useful in transmitting motion. It can be used to transmit a very large power.

The main advantage of gear drive is that it transmits same velocity ratio between the gears and have a very good reliable service. They will have long life if properly designed, lubricated and operate in a clean environment. However, gear needs accurate location and alignment. It also need intensive care where good lubrication and clean operating conditions needed.

2.3.1.1 Spur Gear

As for this project, spur gear was chosen because it can be transmitting power between two parallel shaft and have teeth that is parallel to one axis which is easy to manufacture and low cost. Beside have high speed and high load application in all types of trains, it also has the highest efficiency and excellent precision rating compare to others gear. The spur gears have

two different number of teeth which is 18 teeth and 10 teeth. The gears were being arrange as a train gear.

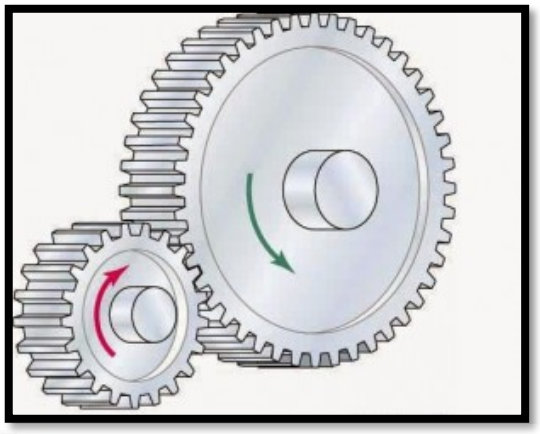
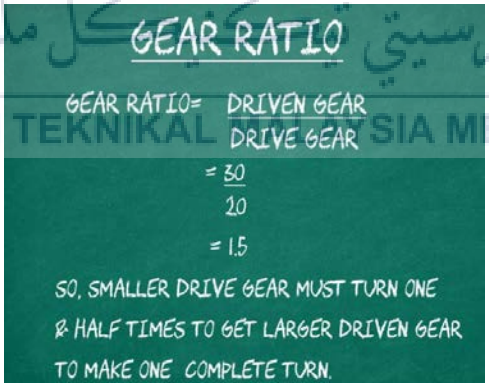


Figure 2.8: Spur Gear

Calculation of the Gear Train

As for this project, an 18 teeth and 10 teeth gear has been used.



$$\boldsymbol{Gear\ Ratio} = \frac{\mathbf{18}}{\mathbf{10}}$$

$$= \mathbf{1.8}$$

So, smaller drive gear must turn 1.8 to get larger driven gear to make one complete turn.

Speed Calculation = S1 × T1 = S2 × T2.

S1 refers to the rotational speed of the drive gear, T1 refers to the teeth in the drive gear, and S2 and T2 to the speed and teeth of the driven gear.

As for the calculation, 40 rpm has been taken as the rpm for human to rotate the shaft using their hand.

40 rpm x 10 = S2 x 18

S2 = 22.22. rpm

2.3.1.2 Helical Gear

There are many types of other gear such as helical gear, bevel gear, spur gear, worm and wheel (worm gear) and the last one, rack and pinion. Helical gear gives a smooth operation as it results in gradual gear engagement. Next, it also could connect parallel or non-parallel shafts and have higher thrust loads from teeth reaction force. Efficiency of helical gear is less because helical gear trains have sliding contacts between the teeth which in turns produce axial thrust of gear shafts and generate more heat. So, more power will loss and the gear became less efficiency.

Figure 2.9: Helical Gear

2.3.1.3 Bevel Gear

Bevel gear are used to transmit motion between shafts with intersecting center lines. This gear makes it possible to change the operating angle. Differing of the number of teeth (effectively diameter) on each wheel allows mechanical advantage to be changed. The intersecting angle is normally 90 degrees but may be high as 180 degrees. The teeth may be straight or helical. The two gear have conical surfaces.

Figure 2.10: Bevel Gear

2.3.1.4 Worm and Wheel

The worm rotates against the wheel, and the screw face pushes on the teeth of the wheel. Worm and wheel have a very low transmission ratio. A worm gear can have a massive reduction ratio with little effort. A worm gear is used when to increase torque or greatly reduce speed. This type of gear usually used in power steering systems, presses, rolling mills. However, the worm gear materials are expensive. Worm drives also have high power losses and they produce a lot of heat.

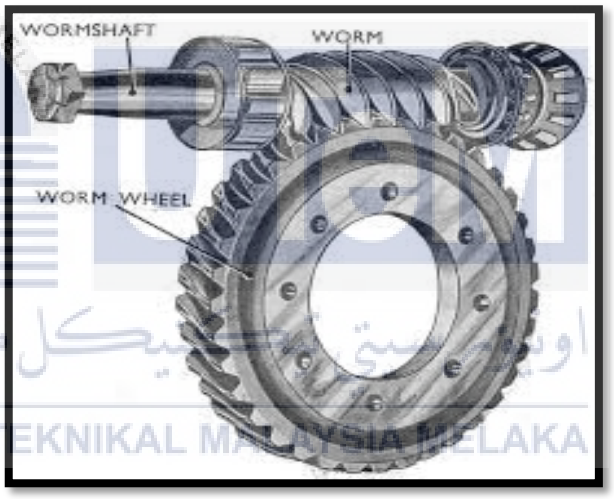


Figure 2.11: Worm and Wheel (Worm gear)

2.3.1.5 Rack and Pinion

Rack and pinion is a pair of gears which converts the rotational motion into linear motion. It is the easiest way to convert rotation motion into linear motion. Rack and pinion is used in the vehicle steering. Without a functional rack and pinion, your ride can't travel in a straight line. Rack

and pinion gives easier and more compact control over the vehicle. The rack and pinion can only work with certain levels of friction. Too much friction and the mechanism will wear more than usual and will require more force to operate. Due to the friction, it is under a constant wear, possibly needing replacement after a certain time.

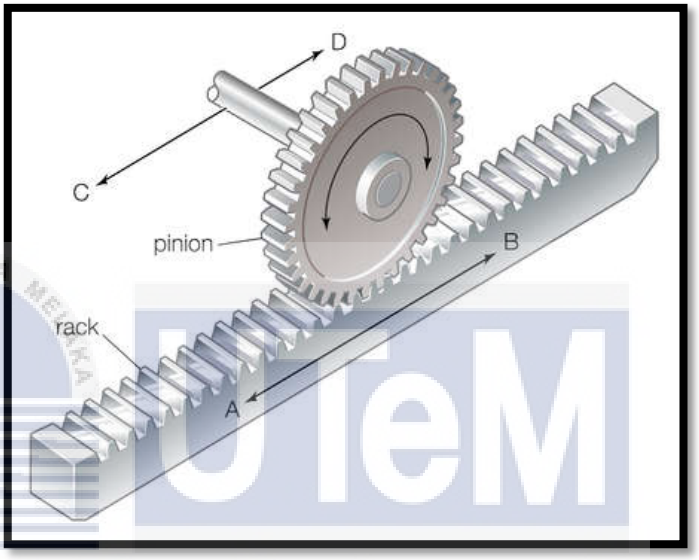


Figure 2.12: Rack and Pinion

2.4 Material of Table Napkin

Table napkin have a variety of size, style, shapes and also material. Each material has its own characteristic but the most common fabric that used to make a table napkin is linen.

2.4.1 Linen

Linen is a textile made from the fibers of the flax plant which grows all over the Mediterranean region and Central Asia. Flax is a tall, reed-like plant, with long fibers which make it easy to spin into thread. Linen is one of the first fibers that people made into string and cloth. The texture of linen is more like cotton but in a lightweight. Because of linen texture absorbs well and it washes clean, people more prefer linen as a table napkin. Linen is just nicer with more elegant look.

Figure 2.13: Linen Table Napkin

2.4.2 Lightweight Cotton

Lightweight cotton fabrics work well for blouses, dresses and tops as they are easily fold and sewn. Cotton is more comfortable, soft hand and has a hydrophilic property. With its good breathability, lightweight cotton not only has

a high retention of color, but for prints well. Although lightweight, cotton remains strong due to the mercerization process that also improves a cotton's luster.

Figure 2.14: Cotton Table Napkin

2.5 Types of Table Napkins Folding

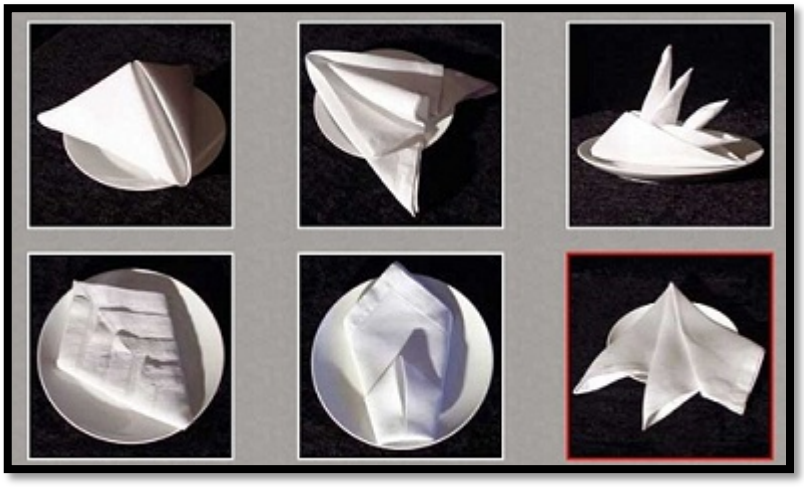


Figure 2.15: Example of Table Napkins Fold

There are many types of table napkins fold in hospitality industry. Although most people don't really think about it, napkin folding is a form of art. It may not be as deeply appreciated as paper origami, but it is a type of origami. With that being said, this is a type of art that every dinner host needs to learn.

Figure 2.16: Pyramid Napkin Fold

This classy napkin folding technique is simple, fast, and can be made easily with most napkins. If the napkin being used is thin and flops easily then iron it with light starch prior to folding and it will turn out perfect.

This table napkin folding machine is supposed to fold this kind of table napkin but unfortunately, there were some problems that we faced in doing the prototype. The problems were being discuss in Chapter 5.

CHAPTER 3
METHODOLOGY

3.0 Introduction

Methodology is theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge ('Methodology', 2016). This chapter help in understanding the methods by explaining more detail about the research process. This chapter explain about the methods that is used in completing the table napkin folding machine prototype. Apart from that, this chapter also will explain about phases that involve which is conceptual design phase, engineering design phase and lastly, simulation and analysis phase.

3.1 Project Planning

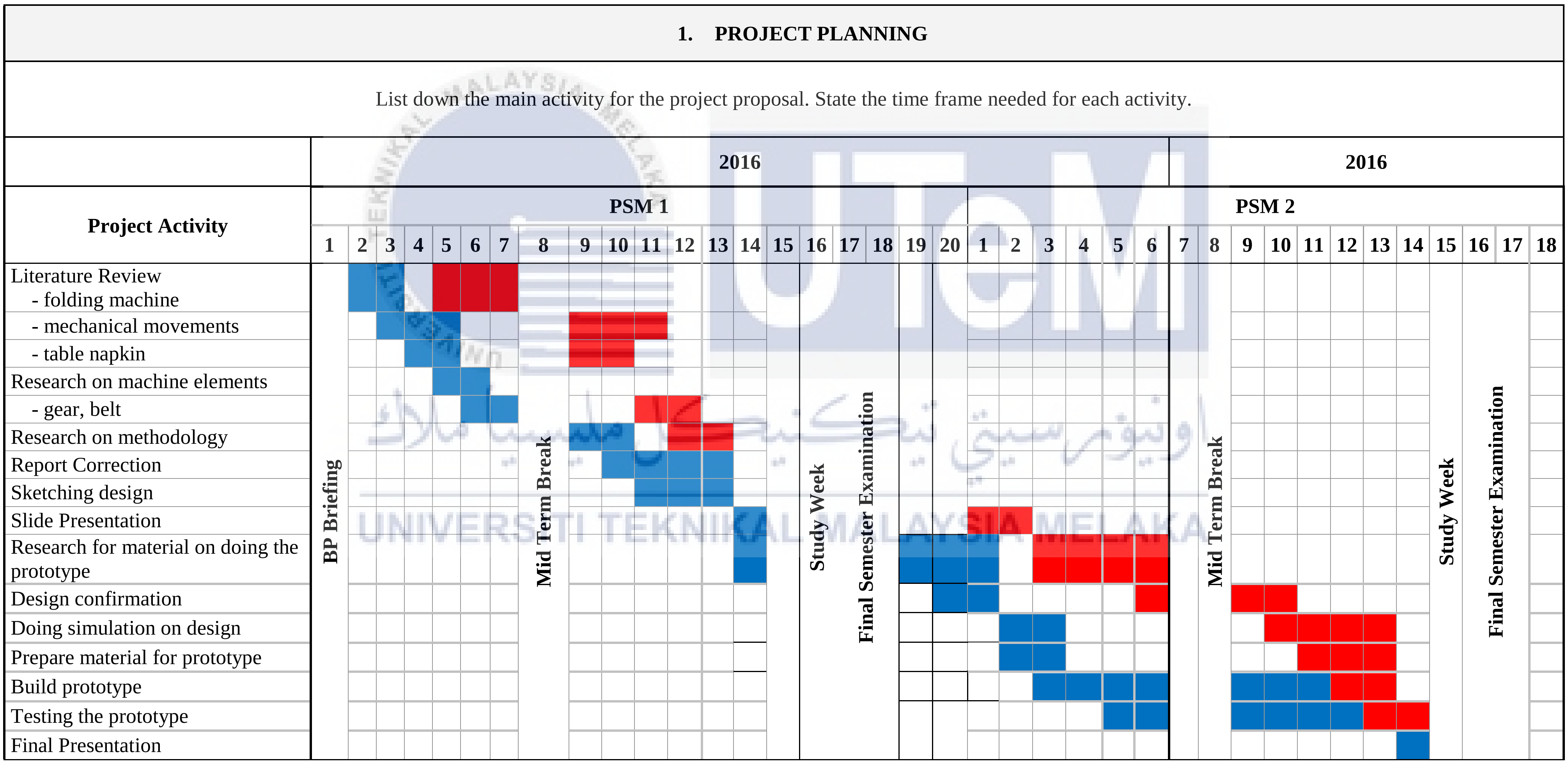
First and the foremast, this stage is used to collect all information about this project. All the information about the hardware and software that will be used for this project are listed. Literature studies and schedule are used in this phase to gather the information as guideline for this project. Besides, journal, research paper and text book also has been used in literature review. The research of project related consists of the objectives, methodology and results to understand the process and functions of the project. Furthermore the flowchart of this method also provided to show the process in planning stage.

3.1.1 Gantt Chart

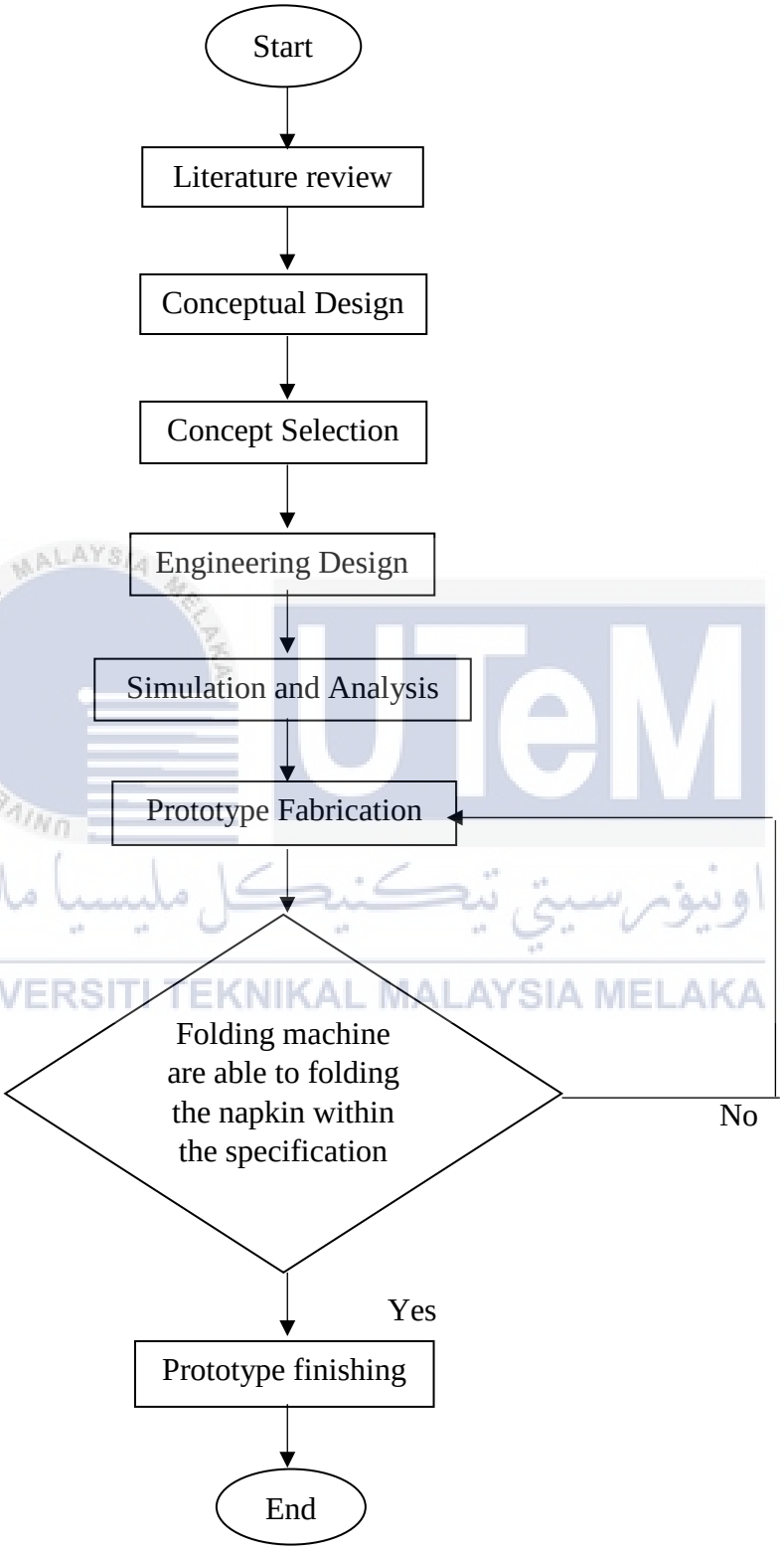
Actual

Planning

Table 3.1: Gantt Chart of Project Planning



3.1.2 Process Flow Chart



3.2 Product Planning and Identifying Customer Needs (initial survey)

Design and development of table napkin folding machine goes with the concept of the existing child restraint system product in the market. The product that need to be design and modify must be functional for all to use it in the hospitality industry.

In this project, for the concept survey the questionnaires were distributed to 30 random people who is going to use the machine in their daily life. The objective of distributing the questionnaire was to obtaining the information about the problem that people faced when folding the table napkins especially in a large quantity. The finding stated that people are more likely want a product that is cheap but in high quality. This also means the caregiver prefer the product is safe, easy to use, and give benefits to people when using it.

3.3 Data Collected

During concept survey, from the questionnaire collected at social media and restaurant for many people in there are in random age. From the questionnaire, most of them said they wanted to fold the table napkin in a short time and use an efficient method to fold the table napkins. Questionnaire that had been conduct involve of 30 random people who is in hospitality industry that going to use the machine.

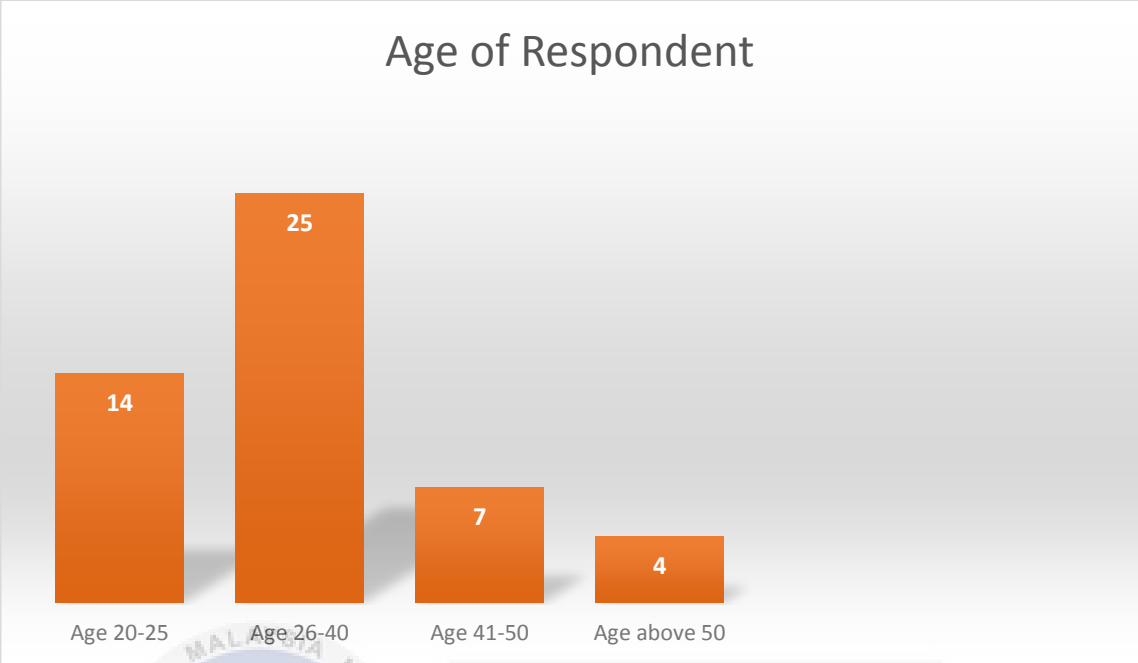


Figure 3.1: Respondent Age

3.4 Concept

As for this project, the concept designs are created in order to produce a design that is suitable with the problem involve and meet the objective. It is important to study about the machine element that involve in order to determine what the product function really are and find out how it performs. Sometimes the constraint will exist in producing the concept design. Besides that, the concept design includes two minor concepts which are concept screening and concept selection.

3.4.1 Customer Needs

Table 3.2: Customer Needs

Customer needs	Need statements
I need a portable machine that can fold table napkins.	A machine that is small in size.
I do not have enough time.	A machine that is can reduce the time of folding the table napkins.
I need a folding machine that easy to use.	Simple design of table napkin folding machine.
I need a folding machine that safe to use.	Folding machine that easy and safe to handle.

The table above shows the data from the respondent of the customer need that are being transfer to the need statement. The information is being recorded from the respondent of the questionnaire. The questionnaire of this project are been attached at the appendix. From this table also shown that the need statement is needed to give the solution to what customer need.

3.4.2 Customer Requirement

Table 3.3: Customer requirement

Customer Requirements	Need Statements
Easy to use	• Easy to install
Functionality	• Lightweight
Manufacturing ease	• Low complexity of part (simple shape)
Durability	• Longevity and comfort

The customer requirement is needed to collect the data that customer need for the product. With this data, we can get the solution for the product specification that need to be design due to the requirement. The table shows the need statement that we must considered when making the specification of the design.

3.4.3 House of Quality

In QFD, the ability to find the problem is important to succeed in product design. We must consider the right time and the right person to ask the right question.

To establish the link to the customer, QFD are used to form engineering requirements that can be used as measurable replacement for qualitative customer needs. It is also used to make clear the relationships between engineering requirements and customer needs, to form specification by make the target values on each engineering requirements, and lastly record the expected technical difficulty.

Table 3.4: Engineering characteristic

		Engineering Characteristic					
Improvement Direction							
Units			mm				kg
Customer Requirements	**Importance Weight Factor**	design	Size	Less Energy	Tolerance	Quality of Materials	Weight
Depend how often the unit is use.	3	7	5	5	7	2	1
Depend on the size of the unit	4	5	4	1	3	1	5
Not easy to broke.	6	4	4	1	5	7	3
Good type materials use.	5	6	1	2	6	7	6
Easy to installed	7	3	5	6	2	2	2
To smooth the process	1	6	6	7	4	3	4
Affordable	2	2	2	4	3	5	4
Raw score		**126**	**105**	**92**	**117**	**114**	**97**
Relative Weight %		**19.4**	**16.1**	**14.1**	**18**	**17.5**	**14.9**
Rank Order		**1**	**4**	**6**	**2**	**3**	**5**

*note: Strong = 7 Average = 4 Weak = 1

3.5 Sketching

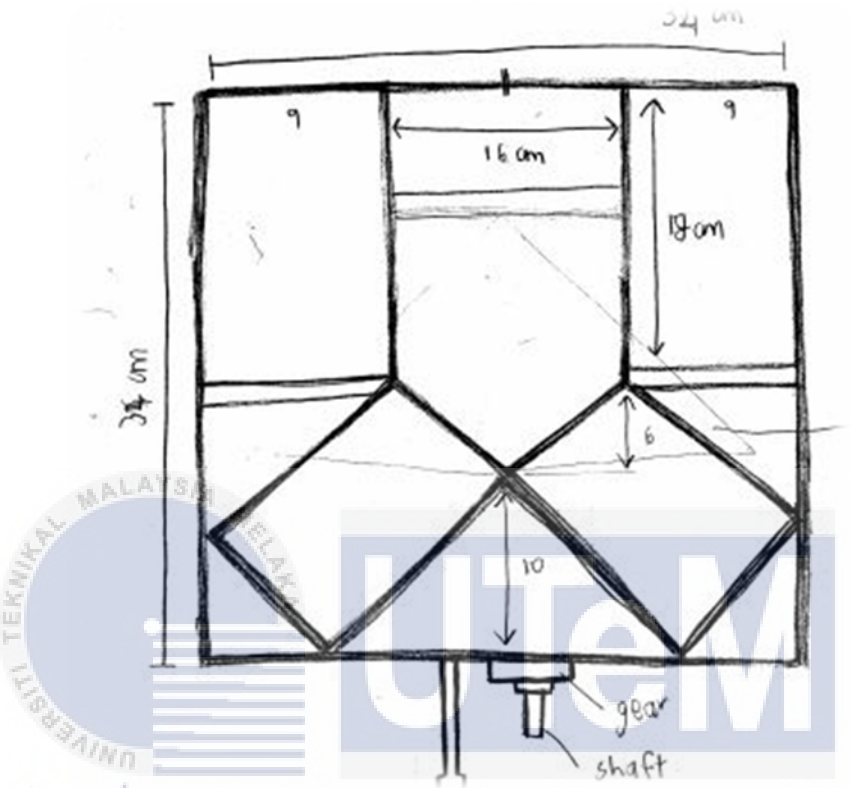


Figure 3.2: Sketch Concept 1

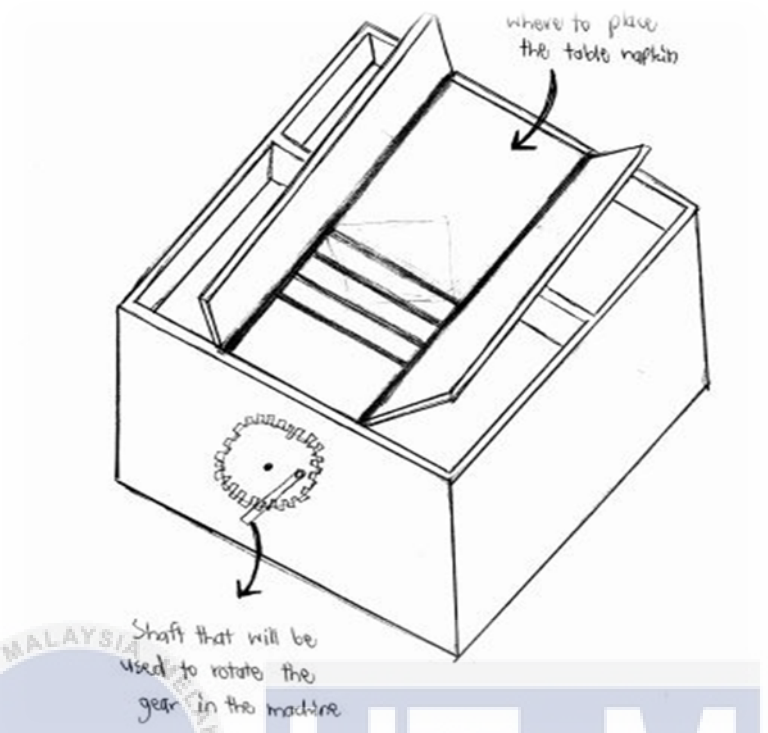


Figure 3.3: Sketch Concept 2

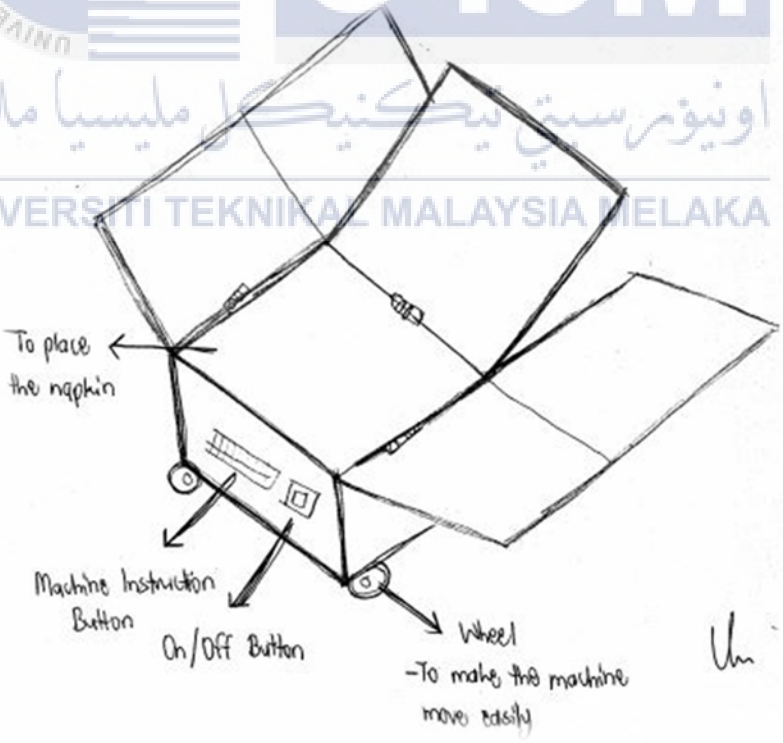


Figure 3.4: Sketch Concept 3

3.6 Conceptual Design

Conceptual design stages are where in the beginning the design and concept were studied from the problems that is faced by the people in the hospitality industry. As for this project, 3 or 4 designs will be creating in order to produce a design that is suitable with the problem involve and meet the objective. It is important to study about the current design in order to determine what the product function really are and find out how it performs. After the conceptual design have been decide, then we can proceed to next phase which is sketching the design. Various sketching will be sketch in order to choose the best one.

3.7 Concept Selection

In concept selection, concept screening method will be used which is it was based on the method developing by the late Stuart Pugh in the 1980s and is often called Pugh concept selection (Pugh, 1990). The purposes of this stage are to minimize the design concept quickly and to improve the concepts.

3.7.1 Concept Screening

The goal of concept screening is to narrow down a concept into a manageable, promising set for an evaluation and, eventually, concept selection. One of the options for concept screening process is to use Pugh's method or also called decision matrix method.

Pugh's method procedure:

1. Prepare the evaluation criteria from the list of customer requirements, customer and company constraints.
2. Prepare the matrix listing all the evaluation criteria in the first column, and the remaining concept or alternative in the other columns.
3. Set a datum (reference).
4. Select a concept to evaluate: better (+), similar (s) and less (-). Add the up for each concept.

Each option of design is examining through selection criteria as measurement to measure its overall score relative to the optional idea. If one option scores much higher, then this is clearly likely to be the best choice. However, before rejecting other options, it is good to consider how the idea could be improving the overall system.

Table 3.5: The Design Concept

				DESIGN CONCEPT		
ROW	CRITERIA	WEIGHTS	1	2	3	
1	Easy to use	10	+	-	+	
2	Light weight	6	S	+	S	
3	Easy to attach	7	+	-	+	
4	Easy to maintain	4	-	+	-	
5	Long life	6	S	S	S	
6	Anti-corrosion	10	+	S	+	
7	Streamlined	5	+	S	+	
8	Eco-friendly	2	0	-	0	D
9	easy to detach	2	-	-	-	A
10	Consistent of flow	8	+	0	+	T
11	Not easy to broke	7	+	-	+	U
12	Portable	10	+	+	+	M
13	The height can be adjustable	8	-	S	+	
14	Easy to setup	9	+	0	+	
15	Easy to get the stock	10	S	S	S	
16	Comfort to use	7	-	+	+	
17	Child easy to move	6	+	-	+	
18	Aerodynamic	10	S	S	S	
	Total +		9	4	11	
	Total -		4	6	2	
	Total 0		1	2	1	
	Overall score		4	1	8	
	Weighted overall score	127				

3.8 Materials

3.8.1 Material for Component

The materials that will be used for this machine is plywood for the majority of the chassis body and gears. There were two types of plywood which is 9 mm and 6 mm. Gears and shaft were also made from wood. The gears were made from a 9 mm plywood. This is because to easier the rotation process between the shaft and gears. Besides, to connect the gears to the upper part of the folding machine, frame wood is being used. Other material that being used is stainless steel where the hinge is made from it. 4 mm screw were also being used as for the fastener. This material will be used for the real product.

3.8.1.1 Materials Selection

i. Plywood

Plywood is an engineered wood from the family of manufactured boards which includes medium-density fiberboard (MDF) and particle board (chipboard). Plywood is used for a wide range of structural, interior and exterior applications - from formwork through to internal paneling.

ii. Stainless steel

Stainless steel is more popular used in water, for example water and sewage treatment, water tubing and hot water sinks. For other general component that suitable used this material is like spring, fastener and wire. This are approving that stainless steel are suitable use in this unit because it gave the better hardness.

3.9 Product Specification

3.9.1 Technical Specification

- Dimensions: length: 336 mm, width: 331 mm, height: 120 mm
- Mass: Weight: 500 g
- Appearance: natural
- Packaging: one set
- High stability

3.10 Bill of Material

Table 3.6: The Bill of Material

No.	Material	Unit	Quantity	Unit per Cost (RM)
1.	Plywood 9 mm	Kg	1	10.00
2.	Plywood 6 mm	Kg	1	7.00
3.	Frame wood	Kg	1	2.30
4.	4 mm screw	Kg	15	4.00
5.	Washer	Kg	15	
6.	Nut	Kg	15	
7.	Shaft	Kg	1	2.00
8.	Wooden gears	Kg	5	50.00

3.11 3D Design

The selected design sketched was transferred to solid modeling and engineering drawing using SolidWorks. The sketching design that has been chosen will be draw in the software with the actual dimensions. Computer Aided Design (CAD) are being use for making the 3D design table napkin folding machine. SolidWorks 2014 was being use for this types of CAD software for this project. SolidWorks 2014 software helps an engineer to design a complex or even simple product. Most of people in the engineer field are using SolidWorks 2014 to draw and design the product or any part of it. The SolidWorks 2014 is the design software that also will help an engineer to reduce the time of modification process. This is because the software itself have a very good features to do the complex drawing compare to others.

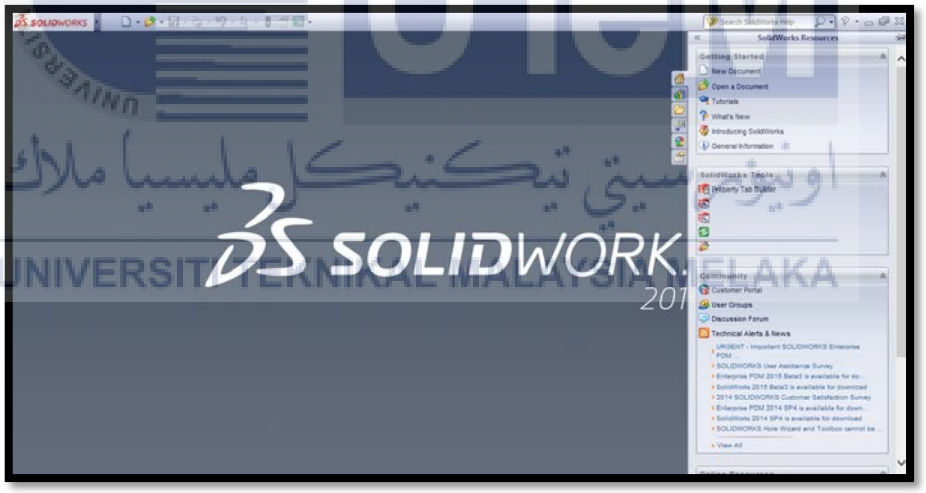


Figure 3.5: SolidWorks Software

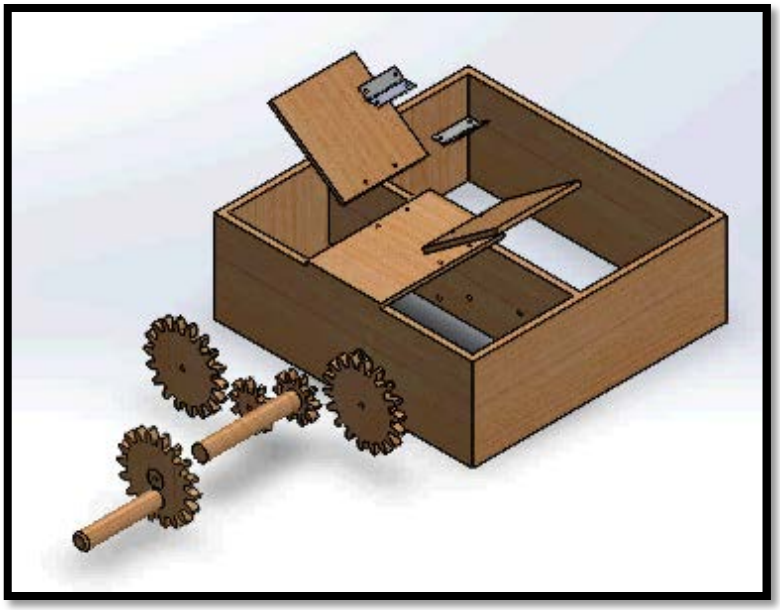


Figure 3.6: Folding Machine Assembly in Isometric View

From the sketch selected, the design was being made using the SolidWorks 2014. The figure shows the early concept that are being transfer from the sketching to the CAD software to making the 3D model. After the concept are transferred, the 3D model was being touch up to make it more attractive to the user. In this concept I had chosen the simple concept because sometimes it is best to test the market first.

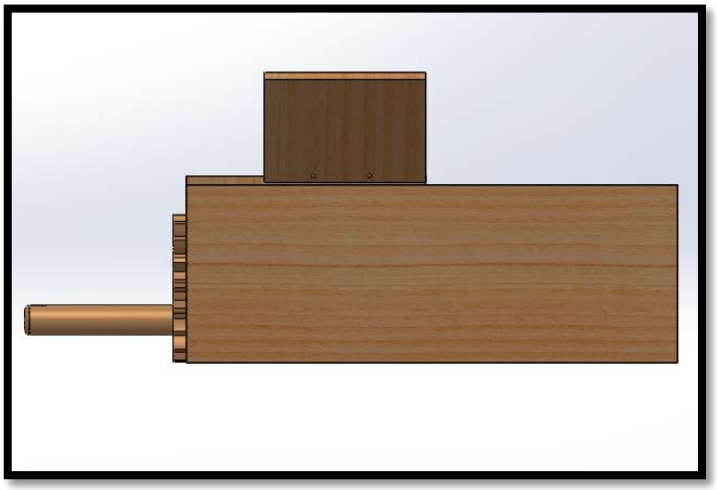


Figure 3.7: Left View of the Product

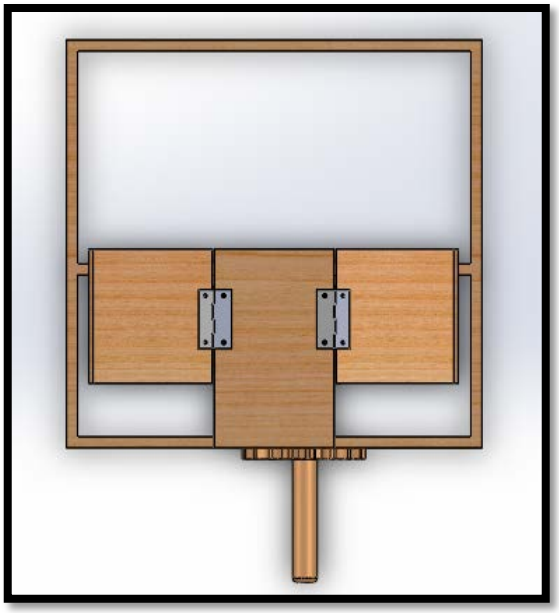


Figure 3.8: Top View of the Product

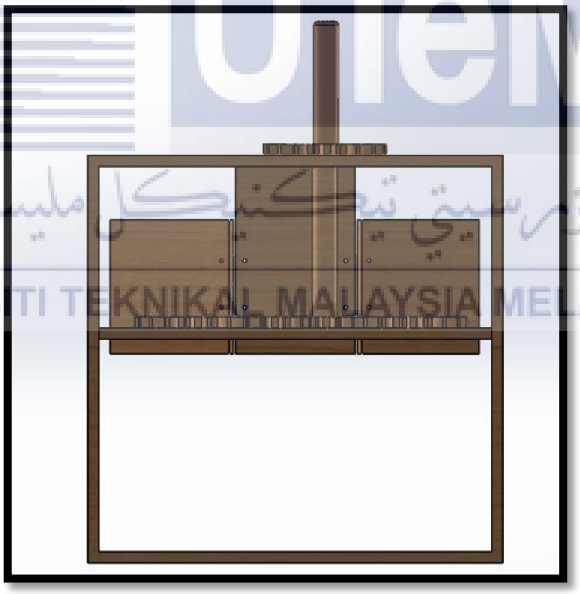


Figure 3.9: Bottom View of the Product

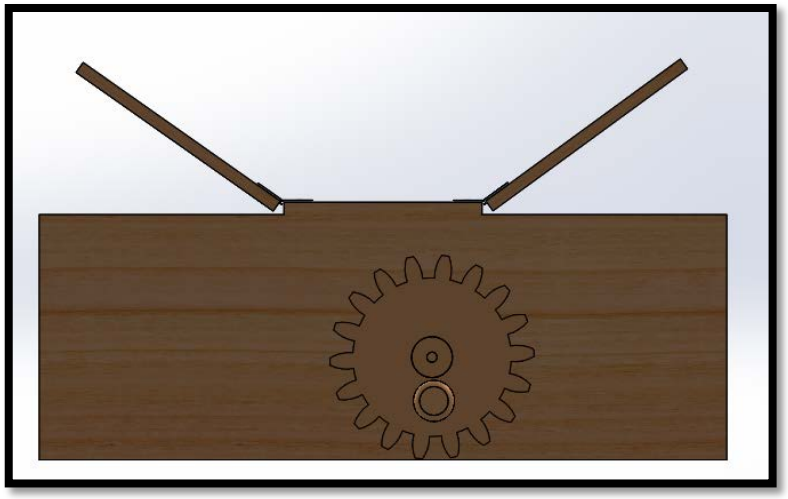


Figure 3.10: Front View of the Product

3.12 Simulation and Analysis

Simulation and analysis is supporting the studies of the project and help to predict the design is success or not. Simulations are very popular in the manufacturing and automotive industry. In order to test the part, product or design, simulation are needed to avoid the unwanted spent cost. Only when the design team is satisfied then the automobile will perform of a prototype or the actual product. As for this project, the part will be simulating first in the SolidWorks software which is 2014 version. In this software, the stress and strain of each part will be known. As for the analysis, ANSYS software was used to know the stress and friction at each of the teeth gears by using static structural analysis.

3.13 Prototype Fabrication

Before proceed to the prototype fabrication, the design that have been drawn must be fulfill with the correct dimensions. If the design has no error and the simulation is success, the process will be continuing to the prototype fabrication. In this stage, all the machine element will be placed together inside the machine properly until the machine can be functional to complete the task.

In making the prototype, if a limited-function prototype fails, we know exactly what failed and failed first. An advantage of a prototype is that we can watch and observe the behavior of our device in a realistic condition. Where and what is the problem that we faced. The simulations cannot provide the same learning insight that a prototype can generate. Also, prototypes are easier to make the customers and people believe how the projects will work whether its success or not.

Apart from that, prototypes also have its own limitation which is the cost. It is important to make the prototype functional but there will be pros and cons in doing the prototype. The problems that students faced will be the one of the learning process for them to success.

CHAPTER 4
RESULT AND DISCUSSION

4.0 Introduction

This chapter discuss about the effectiveness of the system depending on the experiments done at the previous chapter. The effectiveness of the system will focus on three features that are flexibility, adaptability and reliability. Discussion of the experimental results will also be included in this chapter.

4.1 Questionnaire Result

During the process of making this product, the questionnaire had been delivered to 30 random persons that will used these machine to get the data for modifying the existing product. The result of this survey had been collected to choose the best design for making the new product or modifying the existing product from the customer need.

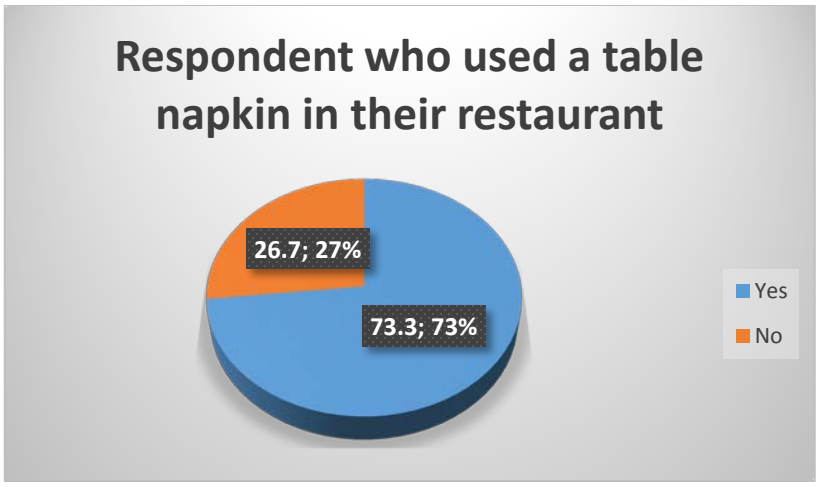


Figure 4.1: Pie Chart for Who Used a Table Napkin in Their Restaurant

From this pie chart, it shows that 73% of the respondent used a table napkin in their restaurant. From this data, respondent that used the table napkin in their restaurant will likely give the feedback based on their experience than the respondent who do not used the table napkin. The bar graph below also shows the result of the material of the table napkin that being used by the respondent.

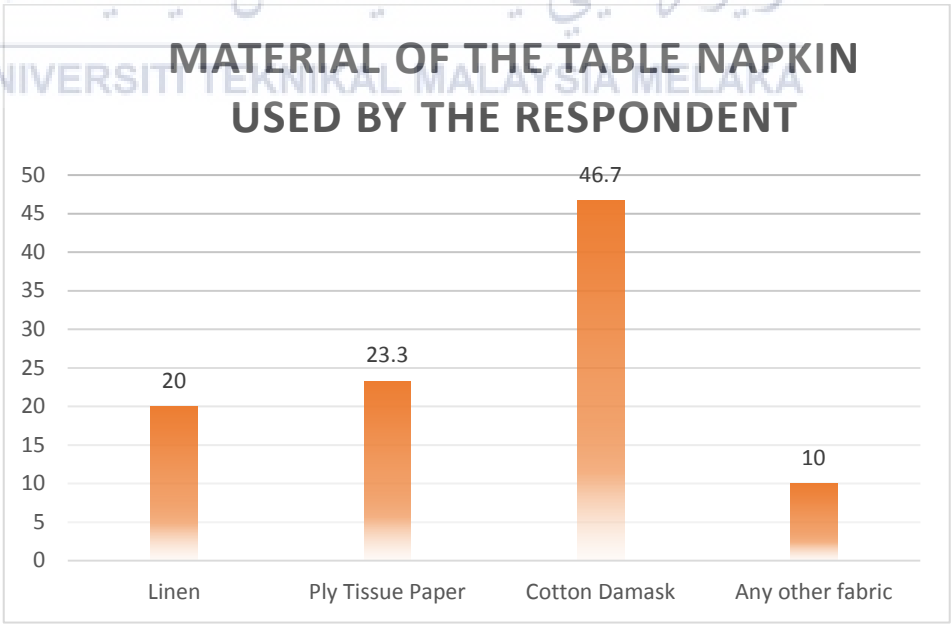


Figure 4.2: Bar Graph for Material of the Table Napkin Used

In addition, student also been asking for the problems that respondent faced when folding the table napkin. Most of the respondent state that they having a problem in folding the table napkin. The pie chart below shows that the time taken for respondent in folding the table napkin. 33.3% of them state that they used more than 10 minutes in folding one of the table napkin. Respondent that take 5-7 minutes in folding the table napkin is 26.7%.

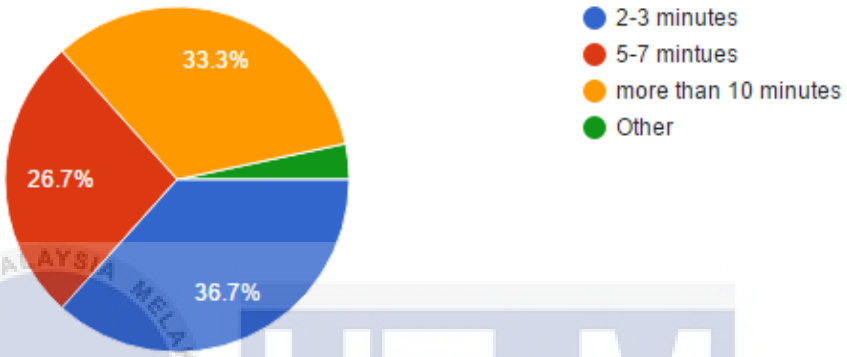


Figure 4.3: Pie Chart for the Time Taken for Respondent to Fold the Table Napkin

Beside, student also ask about the most important reason when choosing a product. Half of the respondent which is 46.7% choose function as the most important factor in choosing a product. This shows that respondent prefer functional product compare to the appearance, price, quality or safety.

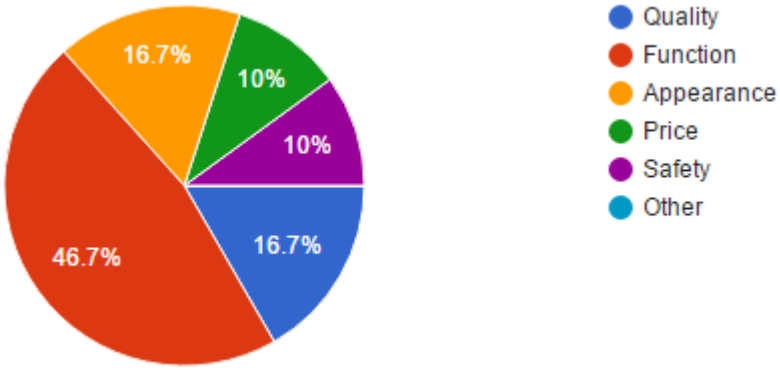


Figure 4.4: Factor that Respondent Consider the Most When Choosing a Product

4.2 3D CAD Drawing

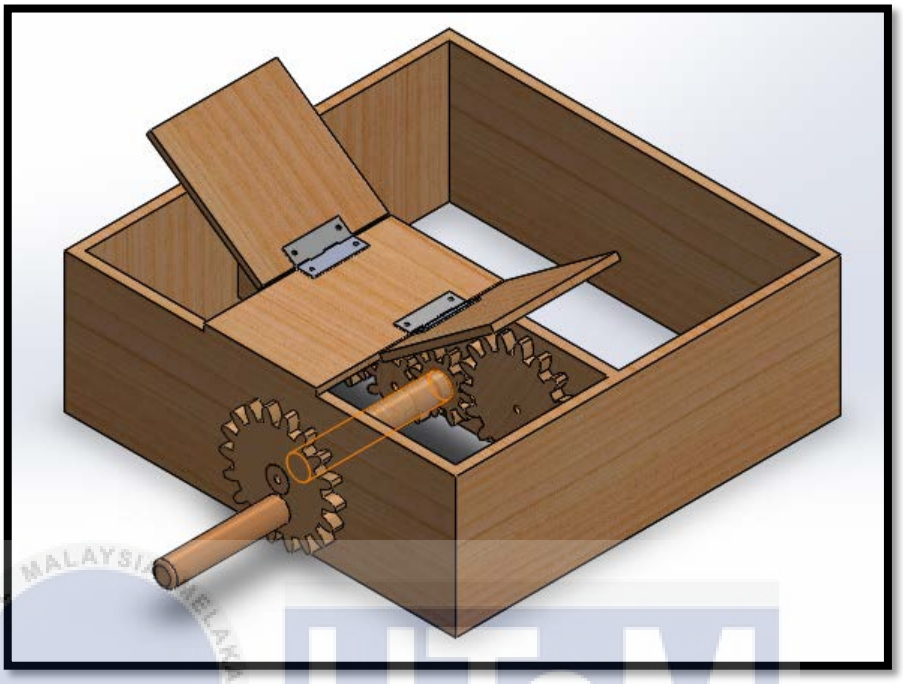


Figure 4.5: 3D Drawing Product with Assembly

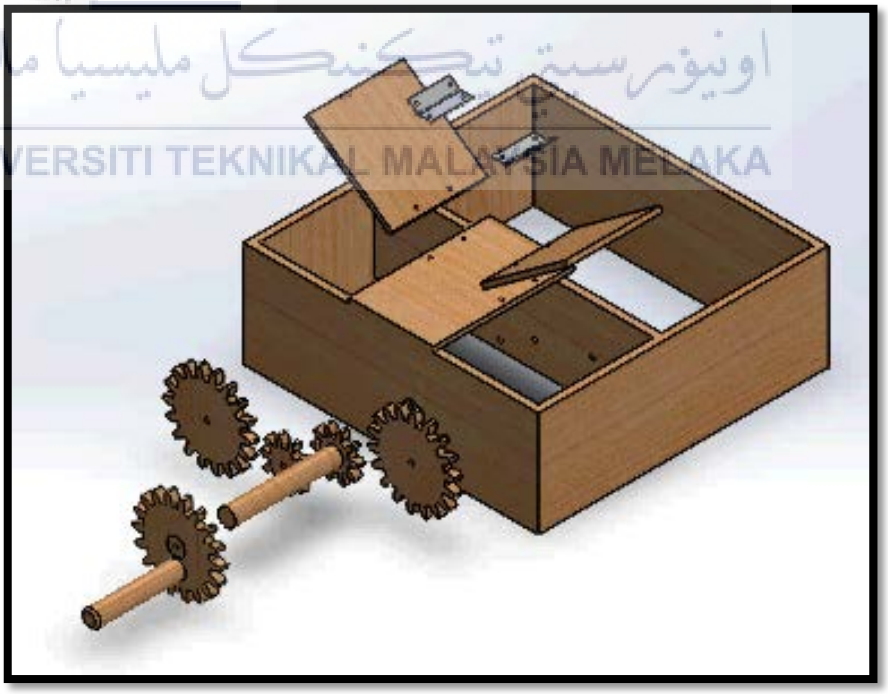


Figure 4.6: 3D Drawing Exploded View of the Product

4.3 Bill of Material (BOM) – For Part

Table 4.1: Bill of Material for Part

Part No.	Part Name	Description	Quantity
1	18 teeth gear	Two of them is to rotate the shaft and one is to hold the shaft form moving along when rotate.	3
2	10 teeth gear	As a gear train with the 18 teeth gear as the mechanism	2
3	Folding part	To fold the table napkin	1
4	Shaft	To connect the gears and the handle	1
5	Handle	To rotate the mechanism	1
6	Connecting Rod	To connect the gear and the folding part	2
7	Hinge	To connect the folding part together	2
8	Sponge	To connect the connecting rod and the gears	2
9	Set of Screw, Washer and Nut, Nail	To attached the gears to the frame of the machine	6

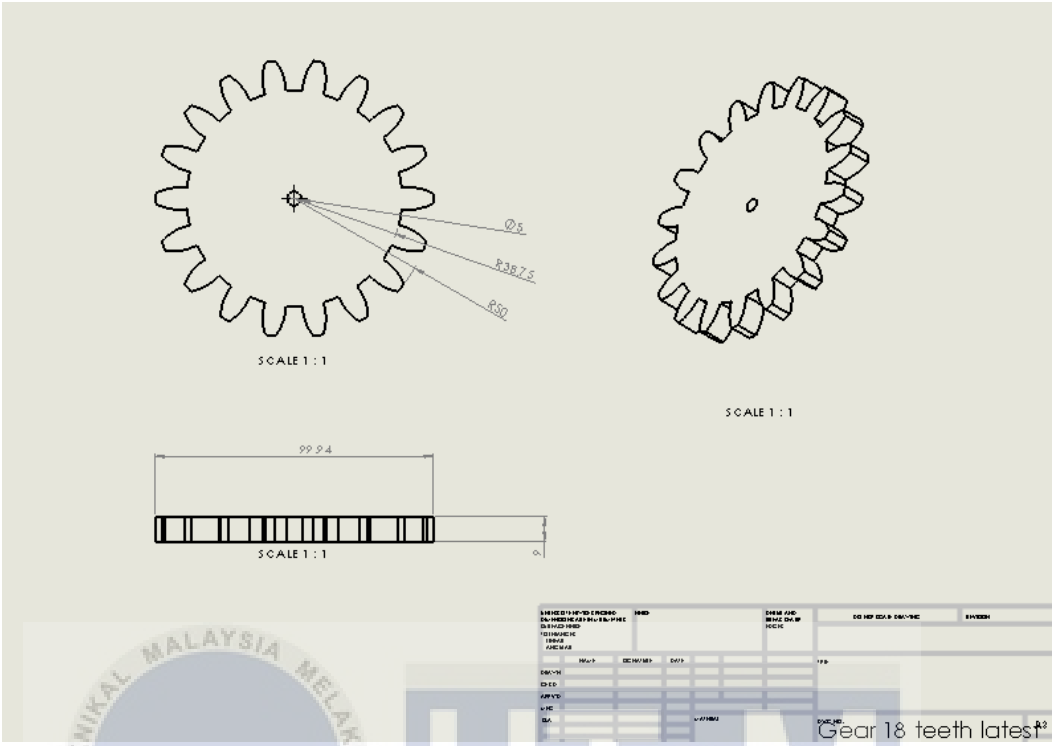


Figure 4.7: Drawing for 18 teeth gear

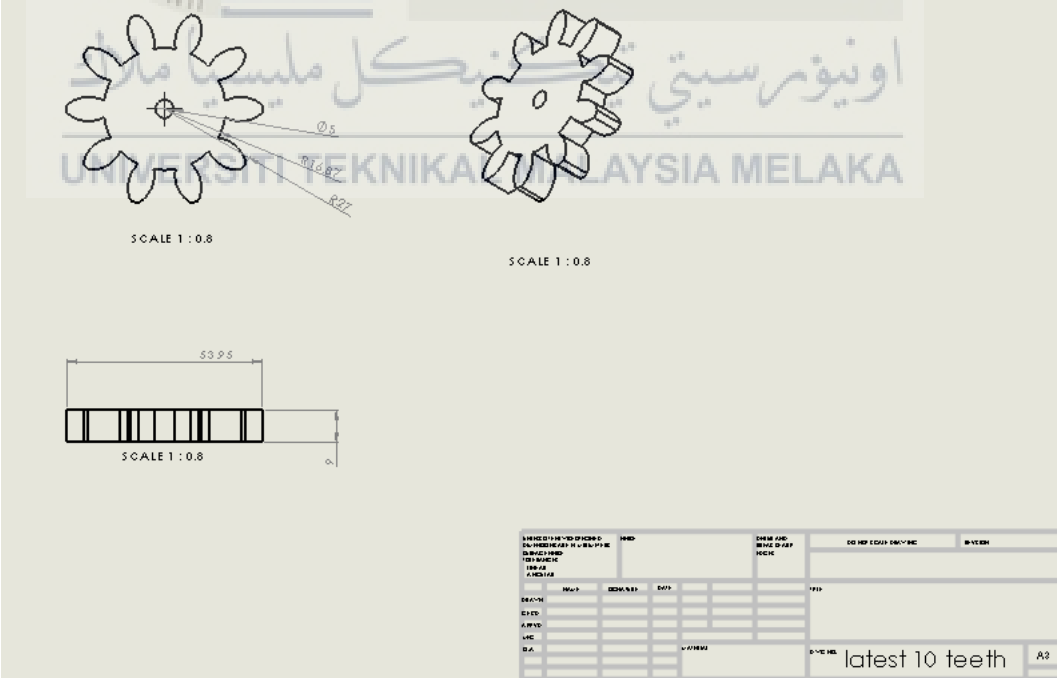


Figure 4.8: Drawing for 10 teeth gear

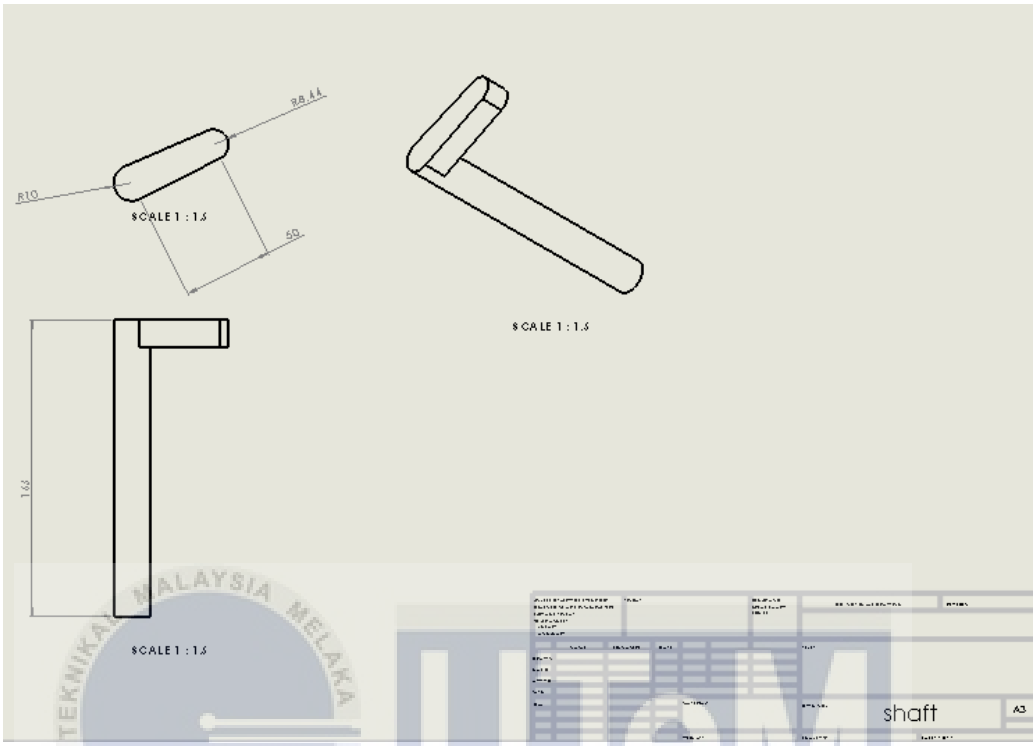


Figure 4.9: Drawing for Shaft

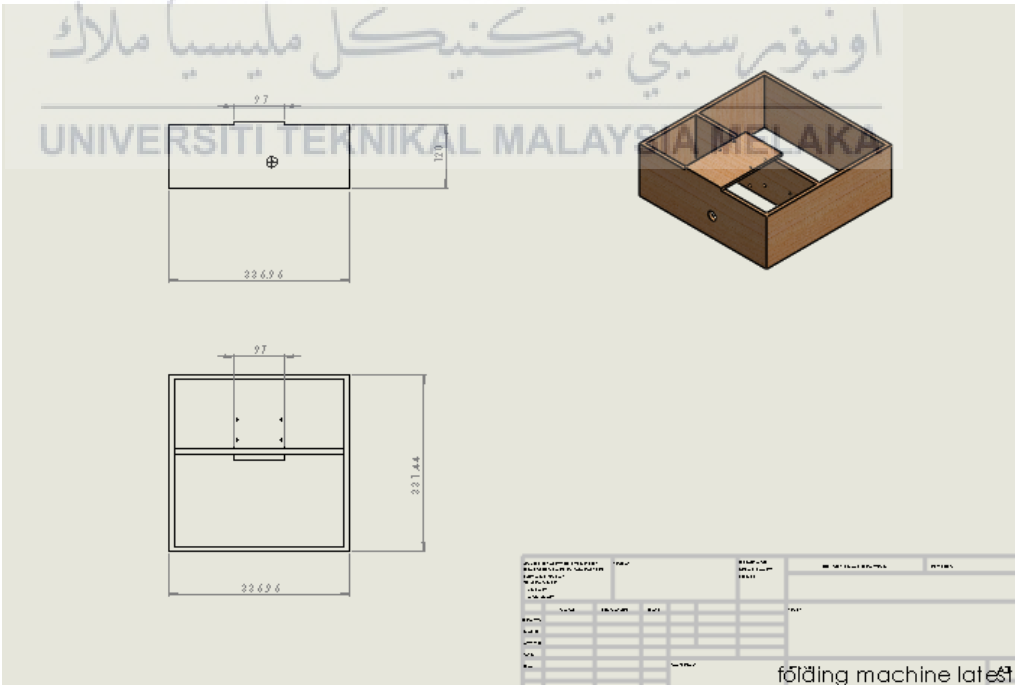


Figure 4.10: Drawing for Folding Part

4.4 Manufacturing Process

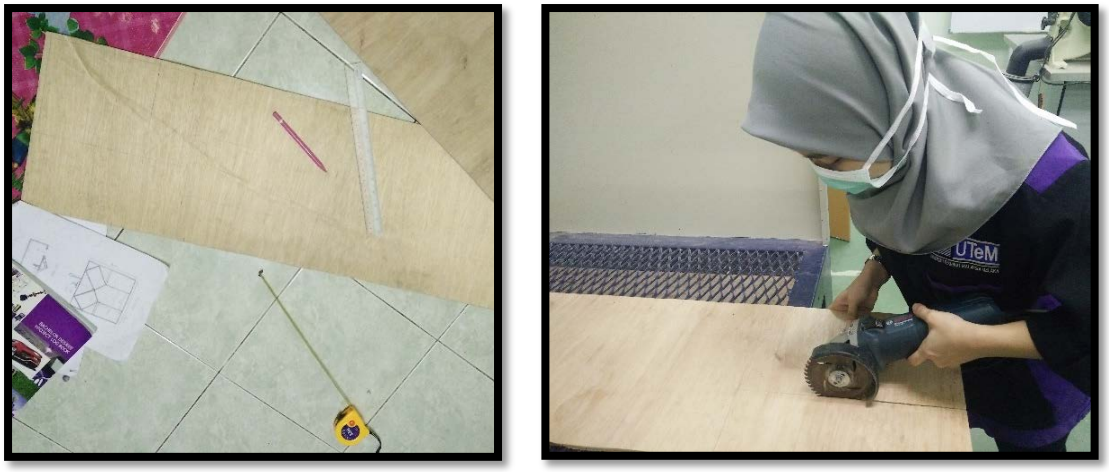


Figure 4.11: Plywood being cut

Firstly, the plywood has been measured before being cut using a hand grinder. The figures above shows the process was been done in JTKP laboratory.

Figure 4.12: Gears being made

The gears were also being cut using a hand grinder at the hardware shop. The gear template was being download in the internet to get the accurate shape and the actual size of the gears. Every teeth of the gears were cut properly to make sure the teeth can fit to each other.

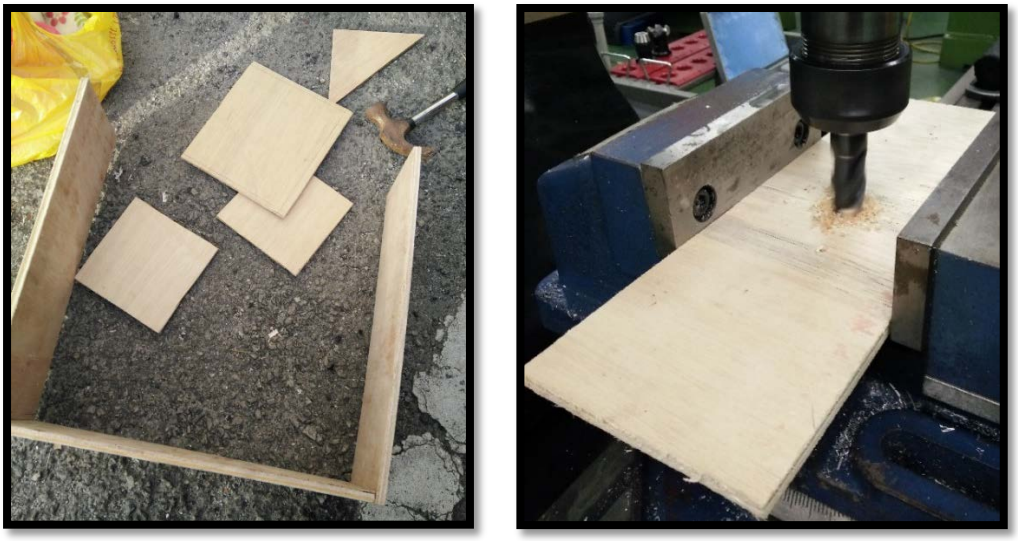


Figure 4.13: Assemble the frame machine

The plywood that has been cut is assembled together to make the machine frame. One side of the frame was being drilled using a 20 mm end mill to insert the shaft later.

Figure 4.14: Gears were assemble to the machine

The gears were assembled as a gear train with the 4 mm screw, washer and nut. The shaft that connect the gear and the handle together were assembled to justify the rotation of the gear train is smooth or not.

4.5 Manufacturing to Selling Cost

Every product that had been design is been proposed to be sell. I had making some statement of cost and calculation that important for marketing this product which is table napkin folding machine. This cost stamen can being change depend on the demand of supplier and the marketing level on that time.

Table 4.2: Manufacturing to Selling Cost

Bil.	TYPE OF COST	COST OF MONEY (RM)
1.	Manufacturing Cost	RM 102.30
2.	Wage Cost	RM 20.00
3.	Selling Cost	RM 120.00

CHAPTER 5
CONCLUSION

5.0 Introduction

This chapter discusses about the conclusion and some suggestions for future work to further improve the development of the system. It also stresses the importance and potential application from the research output.

5.1 Summary of Project

5.1.1 Summary of Project

Based on this project, this thesis presented the development of table napkin folding machine. This system is presented the new way of folding the table napkins using a conventional method. This was also being prove by the static structural studied of simulation.

5.2 Achievement of Research Objectives

Upon completion of this project, a fully functional low cost table napkin folding machine was successfully developed. The project was being done in less than RM102.30 which achieved the cost saving for this project prominently. From this project, student

also had able to study about the various way of folding the table napkins in hospitality industry. With this, student had able to design a table napkin folding machine which can only fold one specific pattern. Next, from the result of the design, student had able to fabricate the prototype of table napkin folding machine with the characteristic that suitable for the user based on the data that had been collected form the questionnaire. Based on the above statement, it can be concluded that all the objective of this project was successfully accomplished.

5.3 Significance of Project

The significance in this research is mainly to increase flexibility and adaptability of the vision to reduce the time taken for folding the table napkins in a large quantity. A different point of view was exploited especially in hospitality industry for marketing this product.

5.4 Problems Faced During Project

Despite the system is being shown great accuracy in all aspects, there are still problems occur in completing this project. One of them is student have a limited time in doing this final year project because of others subject project meanwhile focusing in study during this progress. Besides, student also find it is hard to spend large amount of money for this project. Furthermore, this project need the energy from men since it required an ability to cut and drill the plywood. So student had to ask a help from my male classmates and technician. Student also faced a problem in assembled the gear and shaft. The gears were not rotate smoothly since the teeth are manually cut by a wood cutter. This problem was being solve by rubbing the teeth gear surface using a sand paper. The connecting rod take a long time to process because the diameter of the 18 teeth gear is too small and cannot support the length of the connecting rod.

5.5 Recommendation

This part of the report is important because it is based on the observation to improve and upgrade the system to be much better in future. The system can be upgrading by using the best material that is more suitable for this system such as steel or plastic. This is because steel and plastic is easier to handle compare to plywood. Besides, steel is more elastic and can withstand more force more than plywood.

Apart from that, it can make the system much better if the gears are made from steel or using plastic in 3D printer. With this, the mechanism inside the machine will give smooth rotation to produce the better output. Furthermore, the system can be studied for lowing it cost. So that we can produce more of this product by the little usage of money.

In addition, the connecting rod must be equal to the diameter of the gear so that the folding part can move downwards smoothly without any collision with other components. Last but not least, the system must be more attractive and ergonomic, so that the user can do their task more efficiently. In addition, in order to attract people to use the product, the shape of the design must be more attractive.

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APPENDICES