A PRELIMINARY DESIGN OF PORTABLE PINEAPPLE PEELER: AN ERGONOMICS APPROACH

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated to my beloved family

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Abstract

This study is about designing a pineapple peeler using ergonomics technique in order to avoid or minimize the chance of developing Musculoskeletal Disorders (MSD) among pineapple peeler workers. MSD happens due to the product or tools that is not ergonomics. MSD starts to develop when a workers is doing a job repeatedly. Working tools that is not ergonomics combining with the repeated movement will results in MSD to develop and resulting pain in a long term period. There is two objectives for this study. The first objectives of this study is to design a portable pineapple peeler with ergonomics approach using Solidworks. The preliminary design will be design using Solidworks. The second objectives is to simulate the designed pineapple peeler using Algor. This is to analyze the for affecting the peeler when it is motion. In gathering the data needed for this study, questionnaire will be used to obtain information from the workers about the problems that they face when using their working tools. All the questions asked will be related to ergonomics concepts. Then the answers will be analyzed so that it will be used to design a pineapple peeler that have less problems against the workers from ergonomics point of view. The design stage will take two stages. The first one is based on literature review and the second stage will be based on the answers from the questionnaire. Basically the first design will be refined and improved in the second stage. The improve design will be analyzed using Algor to evaluate the force distribution on the critical part of the pineapple peeler when it is used by the workers. The force distribution will affect the human body and resulting in MSD. The usage of ergonomics in producing a product will helps to save life. The MSD will effect people in long term period and before they know it, it has gotten worst. Thus, the improved design of the pineapple peeler will minimize and reduce the risk of having MSD among pineapple peeler workers.

Abstrak

Kajian ini adalah mengenai mereka bentuk pengupas nenas mudah alih menggunakan pendekatan ergonomik demi mengurangkan risiko menghidapi Musculoskeletal Disorders (MSD) di kalangan pekerja pengupas nenas. MSD berlaku disebabkan oleh produk atau alatan bekerja yang tidak ergonomik. MSD bermula apabila seseorang pekerja melakukan sesuatu pergerakan secara berulangan. Alatan bekerja yang tidak ergonomik ditambah pula dengan pergerakan berulang akan membawa kepada kesakitan yang berpanjangan. Kajian ini akan mempunyai dua objektif. Objektif pertama adalah mereka bentuk pengupas nenas mudah alih dengan menggunakan Solidworks. Rekabentuk awal akan menggunakan Solidworks. Objektif kedua adalah mensimulasikan penggunaan pengupas nenas mudah alih yang telah direkabentuk. Ini adalah untuk mengkaji tentang daya yang bertindak ke atas pengupas nenas semasa ia digunakan. Dalam mengumpulkan data untuk kajian ini, borang soal selidik akan digunakan untuk mendapatkan maklumat daripada para pekerja berkenaan masalah yang mereka hadapi semasa bekerja. Semua soalan yang diajukan adalah berkaitan mengenai ergonomik. Kemudian, jawapan mereka akan dikaji untuk menghasilkan sebuah pengupas nenas yang memberikan kurang masalah kepada para pekerja dari sudut ergonomik. Proses merekabentuk akan melalui dua peringkat. Peringkat pertama rekabentuk akan berdasarkan kepada teori dan kajian yang telah dilakukan sebelum ini manakala peringkat kedua akan berdasarkan kepada jawapan daripada borang soal selidik. Secara mudahnya, rekabentuk peringkat pertama akan ditambah baik pada peringkat kedua. Rekabentuk yang telah ditambah baik akan dianalisis menggunakan Algor untuk menentukan taburan dan tindakbalas daya pada bahagian kritikal pengupas nenas semasa ia digunakan. Penggunaan ergonomik dalam merekabentuk produk akan menyelamatkan nyawa. MSD akan member kesan kepada masyarakat dalam jangka masa panjang dan sebelum mereka ketahui, ia telah menjadi teruk. Sehubungan dengan itu, pengupas nenas yang direkabentukan akan meminimumkan dan mengurangkan risiko untuk mendapat MSD dikalangan pekerja mengupas nenas.

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LIST OF ABBREVIATIONS

CTDs	Cumulative trauma disorders
MSD	Musculoskeletal disorders
N	Newton
SME	Small and medium enteprise
RSIs	Repetitive strain injury
RMI	Repetitive movement injury
RP	Rapid prototype

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Malaysia is one of the countries that has a lot of varieties of fruits. These fruits sometimes gives advantages in term of profit. Usually in Malaysia, fruits become one of the nations top export goods. One of the main fruits that has been exported for many years is pineapple.

The pineapple had become one of the items that generate profit to the country. It grow to become an industry in Malaysia. Small and medium enterprise (SME) is the business that actually correlated with the pineapple. Pineapple business has become a vital business in Malaysia and it has emerged ever since and has developed a small town into a big one in regards of the pineapple business. For example, Pekan Nenas Johor has developed due to the pineapple business. The business involved the local residents and since the business is small, the processing process is done manually by the workers. Manual process of peeling is by using bare hand and knife. Just like peeling pineapple at home.

The pineapple skin is thick and a person needs a lot of force and muscle usage to peel a pineapple. Peeling the pineapple skin is the most crucial part when processing a pineapple . For SME, this process is known to be a repetitive task since the workers will peel a lot of pineapples for a working period . In ergonomics, repetitive works actually causing a disease that we called musculoskeletal disorder (MSD). The MSD will affect the workers that the job specification involving repetitive movement. As we know, the peeling process involved the upper body of a person thus making the body vulnerable to back pain

and other MSD symptoms. For workers that repeatedly peel the pineapple, the most infected part would be the hand or known as the carpal. Gripping the tools or knife to peel and also the force experienced by the hand due to the effect of cutting force will eventually resulting in pain around the hand area.

Since the work is repetitive and it is been done frequently, this will effect the workers health. In long terms, the body part might not be able to function well according to its use. For example, the hand that is used for peeling, it is been subjected to the same force and the same area that is affected will result in severe damage. Common peeler such that for potato also gives affect to the user such as wrist pain. This is just for small fruit and domestic use that is at home and just for kitchen usage. Imagine using the same peeler for a pineapple. With much bigger force, much bigger size, so it tends to produce much more pain when doing the work. Even for domestic use we would feel the pain. How about the repetitive work that maybe reach about eight hours a day. Of course it will give effect that is much worse than daily kitchen work. When this happened, it will effect the workers' health and finally affect the company as well. The company will loss worker that's having a health problem. This means more work but less workers. This will cause the work to be delayed and worst causing bottleneck. Besides that, the company might have to pay compensation for the workers. If one worker it is ok, but if it affects many workers, it can affect the company's profit.

In order to overcome this problem, the ergonomics design can be used. This project will emphasizes on the use of ergonomics approach in designing a pineapple peeler. Nowadays, ergonomics has becomes an essential tools or knowledge in overcome MSD. This is because ergonomics has been proven to solve work related problems. In the peeling process case, ergonomics design will be used in order to find the right design and the right peeling style or work orientation for the workers since nowadays peeling fashion came across a lot of work related problems or in other words, ergonomics will help to ease the pain among the workers. This can be done by accommodating the ergonomics and also the efficiency of a peeler. Thus resulting in less pain and injury but more productivity.

Furthermore, this can benefit the company because the manual peeling method that is using hand and knife can be changed to a much faster way.

1.2 PROBLEM STATEMENT

This project is to solve the musculoskeletal problems among workers who manually peel the pineapple. Currently, there are very few studies have been done for such a function. We are going to design a pineapple peeler that will do this by adapting the ergonomics criteria. By doing this, we are going to tackle some of the problems associated with the musculoskeletal disorders. Other problems are not tackled in the duration of this project.

1.3 PROJECT OBJECTIVES

The objectives of this study are:

1. To design a portable pineapple peeler with ergonomics approach using Solidworks.
2. To simulate the designed pineapple peeler using Algor.

1.4 PROJECT SCOPES

Without yet considering unforeseeable problems that might crop up later, these are the exclusions and the things known but not attempted to solve:

1. To developed pineapple peeler is only prototype and it is not readily functional as a commercial product.

1.5 THESIS ORGANIZATION

This thesis is been divided into five chapters and every chapter has its' own sub topics. The first chapter discusses about the introduction of the whole project idea. It also explains about the pineapple peeling process and the association of ergonomics as well as the importance of ergonomics when commanding a work . Brief explanation about pineapple in Malaysia is also included. Also included in the first chapter is the problem statement. The problem statement explain the problem faces when peeling process and also the limitations when doing this project. Not forgetting the scope as well as the project objectives.

In chapter two, literature review according to the terms involve with the project is done. Terms such as ergonomics, peeler and pineapple are among the main subject for this chapter. The explanation is based on the usage of ergonomics and it's connection to work. Also the importance of ergonomics as well as the brief history of pineapple and peeler and also the current and past research about the terms associated with the projects. The sources for this chapter are books, journal article, websites and newspaper articles.

Chapter three explains the methodology of the research. Methods on how the project is conducted will be explained and presented in this chapter. The method used will be focused on how the data is gathered through questionnaire. The principle of designing the questionnaire is also discussed in this chapter. The objective of the questionnaire will be further discussed in this chapter. The questionnaire will be based on the pilot questionnaire design at the early stage of the project.

In chapter four, data from the project will be analyzed and evaluated. Data will be gathered and discussed thoroughly. Data collected will be processed using Microsoft Excel (Microsoft) to determine the best approach for the design according to the information from the questionnaire and from the ergonomics approach. The discussion on the data will led to the designing of the pineapple peeler. The design will be based on two stages. The first one is based on the literature review while the second stage will account the answer

from respondents as well as the respondents answers. After that, simulation using Algor software will take place. The analyze will be on the critical parts that are affected by the force subjected to a certain part by the user.

The final chapter discusses the objective of the project is either achieved or not. Besides that, suggestion on how to improve the project and its' product will be pointed out. Furthermore , all the problems that happen during this project will be briefly explained and also will be included with solution to the problem.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses about the previous researches that have been done about the related issues with this project. Definition of each term will also be included. Ergonomics, musculoskeletal disorders, pineapple and pineapple peeler are among the interested terms in this chapter. The source of the review are extracted from journal, article and books. Literature review is done to provide information about previous research and the relevant that can help to smoothly run this project.

2.2 ERGONOMICS

2.2.1 HISTORY OF ERGONOMICS

In the early 1900's, the production of industry was still largely dependent on human power/motion and ergonomic concepts were developing to improve worker productivity. Scientific Management, a method that improved worker efficiency by improving the job process, became popular. After World War II, the focus of concern expanded to include worker safety as well as productivity. Research began in a variety of areas such as:

- Muscle force required to perform manual tasks
- Compressive low back disk force when lifting
- Cardiovascular response when performing heavy labor

- Perceived maximum load that can be carried, pushed or pulled

Areas of knowledge that involved human behavior and attributes (i.e., decision making process, organization design, human perception relative to design) became known as cognitive ergonomics or human factors. Areas of knowledge that involved physical aspects of the workplace and human abilities such as force required to lift, vibration and reaches became known as industrial ergonomics or ergonomics. (http://www.ergoweb.com/resources/reference/history.cfm)

It seems like ergonomics has been around for many years and it has been improved without we realizing it. This is because at that time we were not actually using ergonomics as the standard terms but actually after the gathering in England that has give birth to the ergonomics field.

According to Lehto and Buck (2008), the field got it's name in summer of 1949 when a group of interests individuals assembled in Oxford, England to discuss the topic of human performance. The group consists of anatomists, physiologists, psychologists, industrial medical officer, industrial hygienists, design engineers, work study engineers, architects, illuminating engineers, and anyone who is concerned some aspect of human performance. Then it is decided that they would coin new word ergonomics, which couples ergos, the greek word for work and momos, meaning natural laws. Some time later, the term human factors was coined in U.S for a society of similar purpose.

Through this, we can say that ergonomics also happens to be the human factors. Human factors focused more on the human itself. When doing a certain job like lifting a box, all aspects of the human body will be inspected. This is to determine whether the job that has been given is actually causing pain to the worker. If it is, then solution has to be done in order to minimize or reduce the health effect among workers. Human factors also related to the bone, muscle and the biomechanics of human body. By observing the human movement and how they work, we can actually design a job that is fit for someone. That is according to the terms ergonomics itself that is fitting the job to the workers. The most

important aspects of ergonomics is how to design work and workplace that is safe for workers. If we can design workplace that is safe for workers, then it will be good for the workers and the company. Besides that, if the workeres is having health problem due to the workplace environment and the work itself, the company have to pay compensation to the workers. This will burden the company as the have to pay money and subsequently losing their workers in term of working hands. This is actually because of musculoskeletal disorders (MSD).

2.2.2 ERGONOMICS DEFINITION

"Ergonomics (or human factors) is the scientific discipline concerned with the understanding or interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance" (Helander, 2006). By the definition, we can concluded that ergonomics is actually a science discipline to obtain working environment that is fit for people to work. It is also making the job to be fit to the worker. That is why it is stated in definition that ergonomics is also designing jobs and work related material. Meaning that we are trying to create a job that basically does not effect the human health. Figure 2.1 shows a person who is using the computer as working tools. Besides that it's also shows the position that the person is sitting and how the body reaction towards the working tools. The chair that the workers sitting on gives the body posture and this will show the position that will give MSD. In figure 2.2, it shows the real position that the workers should be according to ergonomics principle. It shows the seat angle and back cover that the chair should be designed. The chair design also gives the knee angle 90 degrees bend in order to support the legs. Besides that, the chair also focus on the viewing angle and the viewing distance that the workers should have in order to prevent MSD.

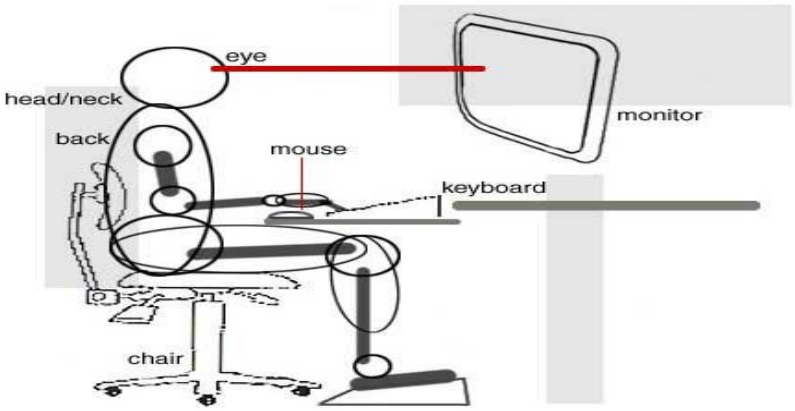

Figure 2.1: Person with computer as working tools

Source: www.medicaldistribution.com/mac2009

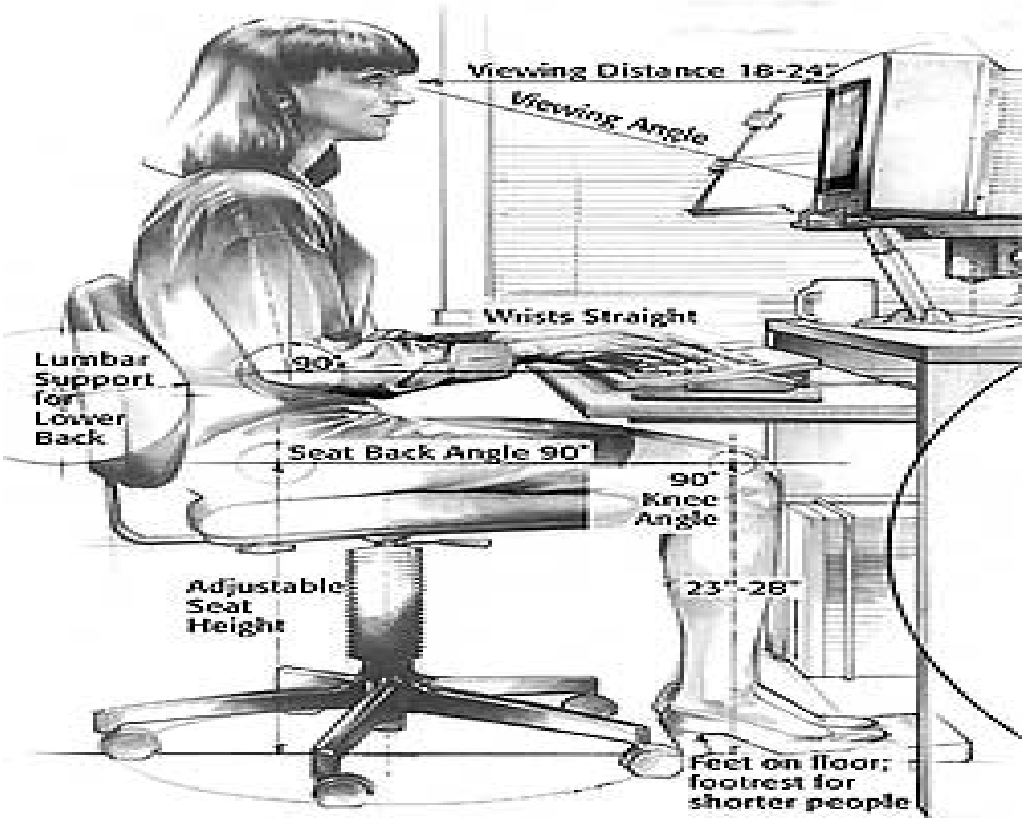

Figure 2.2: Real person with ergonomics position

Source: (http://www.ergoweb.com/resources/reference/history.cfm/April2009)

Statistics from the Ministry Human Resources Malaysia stating that in 1997, 86589 cases of accidents has been reported but in 1998 the cases reported had decline to 53339. Although there is a declination in the cases, we must always beware and try to take responsibility in avoiding such accidents from happening. It is also stated that the accidents happened basically because of the workplace is not ergonomics and consists of to many people in doing a job at the same time whereas the schedule for work has not been resolve carefully. Table 2.1 shows the recent studies on ergonomics.

Table 2.1: Recent studies on ergonomics

Year	Title	Author	Content
2000	Ergonomics definition	The ergonomics society	Ergonomics is a science of matching the design of tools, systems, equipment and the environment to the needs of the people who use them. It is the process of accommodating the job to the person- not the person to the job
2006	Kodak's ergonomics design for people at work	S.N.Cenghalur, S.H. Rodgers, and T.E.Bernard	Ergonomics is a multidisciplinary activity striving to assemble information on people's capacities and capabilities and to use that information in designing jobs, products, workplaces and equipment
2008	Introduction to human factors and ergonomics for engineers	M.R.Lehto and J.R. Buck	Ergonomics is the study of people at work

From the previous research, an ergonomics is trying to improve the existing design products that are being used right now. Accommodating for the pineapple peeler, the

product in the market needs to be changed in terms of design so that it can be more ergonomics and much more easy to use. By this, we can improve the performance of the workers and enhance the efficiency of the workers so that the productivity can be increased besides avoiding injury among the workers.

2.2.3 PRINCIPLE OF ERGONOMICS

In ergonomics, there are principles that must be followed in order to design the work that can be fit to the worker. The principles are safety, comfort, ease of use, productivity/ performance and aesthetics (Dul and Weerdmesster, 2001).

The first one is safety. Safety is very important since it is an element that everyone is looking for when performing a task. Ergonomics promote safety in designing the task for a worker. Job that is safe is relevant and practical to be used in the world. This is because the safety of the workers is guaranteed. Safety also includes the working environment and also the working tools. For working environment, a safe environment is very important. This is because workers can concentrate more on their task rather than thinking about their safety. Besides that, risky job environment like underground tunnel, undersea exploration and many more required high level of safety. That is for the workers to feel safe. For working tools, they need to be safe to be handle. That is why a lot of tools that move around is been equipped with safety measurements. Some tools for example the lathe machine is equipped with emergency stop button and also automatic emergency stop button. The emergency stop button is important in case something bad happen and the machine needs to stop immediately.

Comfort is also one of ergonomics principle. Comfort is known to be one of most desired criteria in designing a product. Everyone in the world wants the comfort in performing task. Working in a comfort environment tends to motivate the workers to work hard. Furthermore, it can relax the workers and release the stress that can cause ergonomics failure among the workers. Working accessories like chair, work bench, tooling apparatus are also need to be comfortable to be used. If the workers needs to adjust the chair for a

certain period of time before starting the work, this will cost the time of productivity for the company. Ergonomics principle tends to provoke comfort in working area. For example, a certain of the body needs to be in the comfort zone in order for the workers to do work. For an office workers that use computer, the spine needs to be in the comfort zone in order for them to operate in front of the computer for a long time. That is why the backrest of a chair usually been equipped with soft material to dampen the back of the body.

The third principle is ease of use. The ease of use usually related with the working accessories and tooling equipment. There are a lot of working accessories that associated with jobs. Different type of job required different type of working accessories. But one thing that is the same for all the accessories is the fact that it needs to be ease of use. Easy to say that it is easy to be use. Tools that is easy to be handle will enhance the efficiency of a worker. Imagine a handle bar that is hard to grip. This tends to make the user to make adjustment in order to adjust themselves to the working tool. Tools that is hard to use will make the task perform not ergonomics. This is because the workers will feel the stress that come from the difficulty of using the tools and also from the task perform itself. Besides that, tool that is not easy to be used will cause musculoskeletal disorders (MSD). MSD That is way it is important to make tools and working accessories to be ease to use.

Productivity and performance is also one of the ergonomics principle. Productivity is correlated with performance. If a performance of a worker is good, so as the productivity. We can say the performance is directly proportional to the productivity. Performance of a workers lies within the working aspects including the ergonomics itself. In order to produce productivity and performance, ergonomics will design job that will be fit to the workers according to the basic needs. This is important because if a worker like his or her job, then the productivity will be high, thus stimulate the potential in a person. Ergonomics will enhance the workers potential in doing the work and also manipulating the potential to increase the productivity of a worker. Ergonomics create conducive environment for working thus making the workers feels happy about their job. Besides that, performance and productivity is also vital in a company. The company's reputation will be based on the workers performance that will reflect the strength of a company.

The final one is aesthetics. Aesthetics of beauty is commonly about things like clothes, cars and many more. Everyone like things that is beautiful. Due to the fact beautiful thing is wanted in the world, ergonomics implement this part for the needs to produce jobs that can be fit to the workers. Although beauty is subjective, but it enhance a person's performance. Aesthetics values or beauty are usually associated with tools that is related to the job. Even chair needs to be aesthetics in order for it to be sold as well as to be liked. Making the workplace full of aesthetics value will cause the workers feels less stress when doing the job. It can also be thought as psychology measure in attracting ones' interest. For example, workers that work with computer, they need to have desktop or workplace that have aesthetics values. The attraction is more concentrated to the work by this way. Besides that, the shape of the tools also called aesthetics. Sometimes, we can see that many shape for a mouse or casing of a CPU. This is due to the aesthetics value that the designer use in designing.

The five principle in ergonomics is the core for every work that is designed according to ergonomics. Combining the principle in a single task will ensure that the worker will produce a good result in their work. Ergonomics design will prevent work related disease such as MSD and many more in working area. Through research that has been done, the principle is well known to be effective in solving problems of ergonomics at work. Table 2.2 shows recent studies on ergonomics.

Table 2.2: Recent studies on ergonomics at work

Year	Title	Author	Content
2002	Does ergonomic equal safety	Jonathan Tyson	Revise the connection of ergonomics and safety,
2006	Ergonomics experiment for thumb keyboard design	Xiong Yunfei	Study on how to improve the already made products, implement ergonomics principle on the product.
2007	The effects of job performance on effectiveness	Ermin Yahya	Evaluate performance on effectiveness, teamworking benefits of improving performance
2007	Ergonomics: Making the job fit	Laura Hill	Ergonomics usage in designing jobs for workers.
2008	Vibration reduction of pneumatic percussive rivet tools: Mechanical and ergonomic design approaches	John C Cherng, Mahmut Eksioglu, Kamal Kizilaslan	Solve ergonomics problem using Taguchi method, increase workers performance using ergonomics principle.

Solving work related problems using ergonomics can benefits the employer and the employee as well. This is because both sides are connected to each other. From the ergonomics study, we can say that the design must be according to the ergonomics principle. This is important so that we can reduce the problems that is related to the workers that happen due to design that is not ergonomics. This means the pineapple peeler must be comfortable and easy to use. Thus increasing the productivity of the workers.

2.2.4 MUSCULOSKELETAL DISORDERS (MSD)

Musculoskeletal disorder means a broad range of conditions of varying degree associated with the upper extremities (hand and arm) such as inflammation or trauma mostly of the tendon, muscle-tendon junction or surrounding tissue; inflammation of tissue of the hand, compression of the peripheral nerves serving the upper limb, and include temporary fatigue, stiffness of the muscles comparable to that unaccustomed exertion. (Prichett, 2004)

The MSD is actually a class of disorders that basically amount of wear and tear on the tissue surrounding the human joints. Every joints in the body can potentially affect , but the lower back and the upper limbs are the areas of most concern. MSD also occur because of having the repetitive work and also lifting. This causes fatigue and failure among the human tissue (Macleod, 2006). This means that working style that involve movement and repetitive work are potentially causing MSD. This is because the body is doing the same task the same way and the affected area would be the same. When an area is been subjected to the same force everyday, the area would become less efficient due to the fatigue experience by the body. For example, the hand when it is subjected to the same force every day will become weak. A person might also experience pain and also soreness around the effected area.

MSD cases has been reported through out the year. This means, the worker is gradually been attacked by this disease. MSD can affect a workers productivity and efficiency. This is because when a worker is having MSD, this means he or she has to take a leave in order to recover from MSD. But through out the year, thousand of workers have been infected by this disease. The worst case scenario would be the company would have to pay compensation to the workers. Macleaod (2006) also stated that the commoms MSD symptoms are:

1. Cumulative trauma disorders (CTDs)
2. Repetitive Strain Injuries (RSIs)
3. Occupational overuse symptoms

The disease stated has shown that working causes pain at all body parts. Although it can be treated, but if it repeatedly occurs at the same point and causing the amount of pain to be multiplying, then solutions must be find to reduce the pain. The MSD is a common disease in ergonomics and have been studied for years to overcome it. But the reality is different, workers are relatively hooked up to this problem at the workplace.

From Chengular (2006), around the same time, formal expectations were established about the programs and the processes that would be used to focus on proactively improving workplace environment and concomitantly reducing the risk of musculoskeletal disorders. In order to meet this, company's performance standard encompass the following basic tenets:

1. Employees should receive training in basic ergonomics principle. The aspects covered in the training depend on the work environment they have.

2. Employees whose activities impact the work environment (e.g,engineers, supervisors, maintenance groups, and health and safety professional) should receive in depth training commensurate with their activities.

3. Newly designed or modified workplace, processes, and equipment should meet established ergonomics or human factors guidelines.

4. A continuous improvement process should be used to reduce fatigue and human error, as well as the risk of injury associated with the existing workplaces, processes or equipment.

5. Affected employees should be involved in the planning and implementation of changes of workplace, equipment, or processes.

6. Reports or work related injuries and illness should be followed up with root cause analyses, and the workplace, process, or equipment should be modified accordingly.

The standard was basically for the company to practice so that ergonomics environment can be created and also that the workers are actually aware of ergonomics factors and what they can do to prevent MSD. This can also prevent further losses to the company not to mention they had to pay compensation to the workers if anything bad happen to them. A company needs to implement ergonomics working environment so that every worker will feel safe. This is important because environment that is not ergonomics can cause un expected injury. This situation will affect the productivity of workers and finally affecting the company in terms of profit. Experienced worker is not easy to find and the guidelines can reduce the stakes or risk that a company has to bear about losing experienced workers. Many companies nowadays are trying to implement an ergonomics working environments because it can increase the effectiveness of workers and also encourage the workers to work hard. Besides that, this will show that the company actually care about their employee. MSD among workers has been the top issues that is currently being discusses around the world. Due to the concern for the workers, such guidelines are needed. MSD rate around the world nowadays is high. Due to the lack of awareness among the workers itself that cause such situation to occur.

Figure 2.3 shows the area that is infected by pain when the workers are having MSD. The back pain is the most critical area and this will affect the workers performance. This phenomena happens due to the repetitive works that the workers involve. In figure 2.4, it shows the area of the spine that is most affected. The area near the hips is most likely to injure if MSD happens.

Figure 2.3: Infected area of pain when workers are having MSD

Source: http://www.ergoweb.com/resources/reference/history.cfm

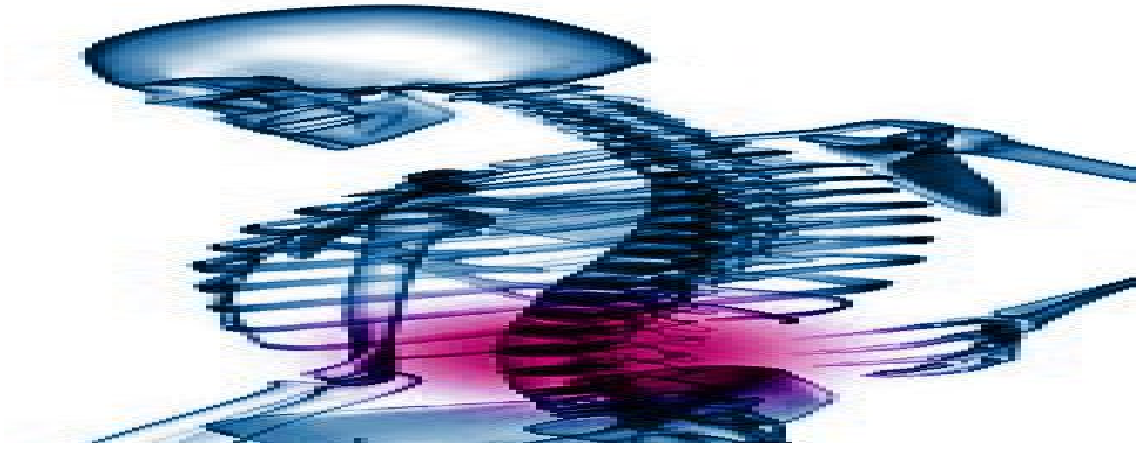

Figure 2.4: The area near the hips is most likely to injured if MSD happens.

Source: http://www.ergoweb.com/resources/reference/history.cfm

Table 2.3: Recent Study on Musculoskeletal disorder (MSD)

Year	Title	Author	Content
2007	Posture and muscle activity of pregnant woman during computer work and effect of an ergonomic desk board attachment	Genevieve A. Dumas, Tegan R, Upjohn, Alain Delisle, Karine Charpinteir, Andrew Leger, Andre Plamondon, Erik Salazar, Michael J.McGrath.	Comparing posture and muscle activity in the back and upper extremity of late pregnancy and non pregnant controls. The research also evaluate the effect of concave desk board on the back and upper extremity of woman in late pregnancy.
2008	Force in measurement in field ergonomics research and application	Stephen Bao, Peregrin Spielholz, Ninica Howard, Barbara Silverstein.	Expalin the effect of pulling/pulling, lifting, pinch and power gripping, measure force when performing task.
2007	Posture and muscle activity of pregnant woman during computer work and effect of an ergonomic desk board attachment	Genevieve A. Dumas, Tegan R. Upjohn, Alain Delisle, Karine Charpinteir, Andrew Leger, Andre Plamondon, Erik Salazar, Michael J.McGrath.	Comparing posture and muscle activity in the back and upper extremity of late pregnancy and non pregnant controls. The research also evaluate the effect of concave desk board on the back and upper extremity of woman in late pregnancy.

Table 2.3: Continued

Year	Title	Author	Content
			Properly textured handles increase the feeling of control on a powered tool; handle material with low thermal conductivity may also be desired. 5.Reduce the vibration from the powered hand tool as far as practicable. 6.Avoid gripping requirements in repetitive operations that spread the fingers and thumb apart more than 6.25 cm (2.5in) (Hertzberg,1955). Cylindrical grips should not exceed 5 cm (2in) in diameter (Pheasant and O'neill 1975), with 3.75cm (1.5in) as the preferable size (Ayoub and LoPresti 1971). Hand tools that produce vibrations, require wide grip spans, or repetitively abrade the wrist area during use of particular concern (Greenberg and Chaffin 1977) 7 .For repetitive operations that require finger pinches, keep the forces below 10 newtons (2.2lbf). For gripping actions, keep the

Table 2.3: Continued

Year	Title	Author	Contents
			required forces to 21 newtons (4.81lbf). These represent 20 percent of the isometric strength of the woman.
2007	Posture and muscle activity of pregnant woman during computer work and effect of an ergonomic desk board attachment	Genevieve A.Dumas, Tegan R. Upjohn, Alain Delisle, Karine Charpinteir, Andrew Leger, Andre Plamondon, Erik Salazar, Michael J.McGrath.	Comparing posture and muscle activity in the back and upper extremity of late pregnancy and non pregnant controls. The research also evaluate the effect of concave desk board on the back and upper extremity of woman in late pregnancy.
2008	Force in measurement in field ergonomics research and application	Stephen Bao, Peregrin Spielholz, Ninica Howard, Barbara Silverstein.	Explain the effect of pulling/pulling, lifting, pinch and power gripping, measure force when performing task.
2008	Physiological and perceptual responses in male Chinese workers performing combined manual materials handling tasks	Kai Way Li, Rui-feng Yu, Yang Gao, Rammohan V. Maikala, Hwa-Hwa Tsai.	Study the repeatiting task that the workers experience. The research also considering the effect of time expose to the task perform and the relation to MSD.

Table 2.3 Continued

Year	Title	Author	Contents
2008	Effects of ergonomics-based wafer-handling training on reduction in musculoskeletal disorders among wafer handlers	Hsin-Chieh Wu, Hsieh-Ching Chen, Toly Chen.	MSD effect on workers, Judge whether MSD prevention is worth or not in a certain job area.
2008	Comparing dynamic and stationary standing postures in an assembly task	Kai Way Li, Rui-feng Yu, Yang Gao, Rammohan V. Maikala, Hwa-Hwa Tsai.	Study MSD among factory assembly line workers. Effect of MSD to the productivity

From the previous studies we can say that tools and workplace that are not ergonomics will cause MSD and work-related problems. These problems will effect the workers performance and give bad effect to the employer as well. As we know, the design and work place that are not ergonomics will cause difficulties in terms of moving and performing the task for the workers. For the pineapple peeler, the design should enhance ergonomics principle and helps the workers to use it easily. This is very important so that the design will reduce the cause of injury to the workers.

2.3 PEELING AND MUSCULOSKELETAL DISORDERS

Nowadays, the method of peeling that is well known is by using bare hand and knife to peel of the fruit skin. For a pineapple, the peeling movement require a person to move up and down the hand by applying force to it. As we all know, the pineapple skin is thick and it is not easy to peel the skin off. Due to that, after one pineapple is peeled, a person will feel the pain around the hand and the upper body including the arms. The pain that a person experience is called musculoskeletal disorders (MSD). The MSD that happened due to the repetitive movement is called repetitive movement injury (RMI). There are many other terms, such as overuse disorder, musculoskeletal disorder, work related disorder, repetitive stress or strain and motion injury (Helander, 2006).

Peeling procedure that is for domestic does not tend to provoke MSD. This is because MSD is caused by repetitive movement. This means when the peeling is been done repeatedly, MSD will occur. SMEs are actually among the main group that still practice traditional peeling method. Because of this, a lot of pineapple workers that involve in peeling process are experiencing MSD. When peeling, the hand is been subjected to a force to drive the tools. The part of the hand is repeatedly been subjected to the same force and at the same spot. This will cause fatigue and from time to time, the worker will fell the pain from it.

Besides that, the tools provided for the peeling process is not ergonomics. Workers only provided with a knife and a glove to hold the pineapple. The knife handle is the part where the design is not ergonomics to hold. Changing the design to a more ergonomics handle will comfort the user and reduce MSD problems. Changing the peeling technique from up and down to a cyclic movement like a handle bar rotation will change the hand movement and equally distribute the force around the handle and the hand palm making less force experience around the hand.

2.4 HISTORY OF PINEAPPLE

Ananas comosus is the botanical name of the fruit we know as the pineapple. Native to South America, it was named for its resemblance to a pine cone, the pine cone reference first appearing in print in 1398. The term *pineapple* (or *pinappel* in Middle English) did not appear in print until nearly three centuries later in 1664. Christopher Columbus is credited with discovering the pineapple on the island of Guadeloupe in 1493, although the fruit had long been grown in South America. He called it *piña de Indes* meaning "pine of the Indians." (http://homecooking.about.com/od/foodhistory/a/pineapplehist.htm/April 2009)

Pineapple has been around the face of the earth for a very long period of time. The seed of pineapple itself has been traveled around the globe. This situation contribute to the disperse of the pineapple. That is why we can see that every part of the world has pineapple even in Africa.

In Malaysia, pineapple had come since the invasion on Melaka. The Spaniard and the Portuguese did not only bring cultural and religion, but also pineapple. Attracted by the colour and tasty feature that the fruit have, the local start to grow them. This lead to the spreading of pineapple through out the region of Melayu. Pineapple has become one of the Malaysia's products in terms of business. The government had taken advantage in it by providing small and medium enterprise (SME) capital scheme to start agricultural business that is based on pineapple. Due to that, Pekan Nenas Johor has been dedicated to grow and produce pineapple product such as jams, pineapple juice and many more.

From the outside, the skin of the pineapple has dark green colour and some thorn like leaf. On top of the fruit, there is a crown like figure. Some people recognized it as the trademark for pineapple since it is the only one in the world that have that feature. The skin itself is thick and a lot of force is needed to peel off the skin. The shape of the fruit would be some kind like an oval. After peeling off the skin, a yellow layer of the pineapple skin will reveal. This is the part of the pineapple that you can eat. But before that, we have to cut

of the thorn like skin that is embedded in the yellow skin. After that, the pineapple is ready to be eaten.

There are many types of pineapples. Such common types are Hilo, Kona Sugarleaf, Natal Queen, Pernambuco and many more. The Spanish, Cayenne, and Queen is the most well grow because of it capability to grow at any kind of climate. In Malaysia, it is commercially grow to support the pineapple industries. Pineapple averages' weight is two to four kilograms. Pineapple is also known to grow to 30 to 100 centimeters while the averages diameters would be 12 to 15 centimeters (www.fama.com.my/mac2009).

Pineapple has a lot of nutritional that is good for human. The pineapple fruit has many beneficial effects to the human body. Pineapple contains the protein digesting enzyme mixture called bromelain. This enzyme is natural anti-inflammatory that encourages healing (http://www.healthmad.com/Nutrition/Nutritional-Benefits-of-Pineapple.66001/April_2009). This information shows that the pineapple has a lot of benefits to human. It can also be the source for medicine and suitable for patient that is on a recovery time.

2.5 PINEAPPLE PEELER

A peeler is a metal blade attached to a wooden, metal or plastic handle that is used for peeling certain vegetables, frequently potatoes, and fruits such as apples, pears and many more. There are a lot of peelers in the market that are mainly used to peel fruit skin. Potatoes and apple peelers are very common among the customer. The pineapple peeler however is not commercially sell and still undergo research to improve it. This is mainly because the size of the pineapple itself is big and it is not suitable to be peeled like potatoes and apples. The traditional peeling technique for a pineapple is actually by using knife and bare hand for peeling. This means the hand will be a part of the moving tools that will peel the pineapple.

In history, there are a lot of peeling techniques that have been invented to peel the fruit. The most famous one is Dalson Classic Aussie Peeler. It consists of a plastic handle which extends upwards to support both the base and tip of a partially rotating blade. This type of peeler is also typical of a general fruit and vegetable peeler in Canada. (Ranken, et al 1997.). This technique usually suitable for small fruit. It's difficult to fit it to pineapple. Figure 2.5 shows the potato peeling technique. This is the Dalson classic aussie peeler. Figure 2.6 shows commercial pineapple peeler develop by REITECH Co.

Figure 2.5: Domestic pineapple peeler

Source: www.ecw.com/mac 2009

Figure 2.6: Commercial pineapple peeler

Source: www.reitechco.za/April 2009

In the market, a device called pineapple corer has been designed to peel the pineapple. It uses mechanism of coring the flesh of the pineapple by making hole in the pineapple flesh and take out the remains. By that, it will remove the skin and also the thorn stem as well. But, it will take a thick skin from the outside because of the depth of the thorn stem is deep.

Table 2.4: Recent study on pineapple peeler

Year	Author	Title	Content
1993	Reitech SA	Pineapple peeler machine	Commercial pineapple peeler. Provide 65 to 100 accurately peeled and cored pineapple cylinders of various diameters per minute.
2005	Paul Ochom	Pineapple peeler	Produce a portable pineapple peeler for agricultural sector in Africa. Basically all assumptions of design based on hygiene and fast working procedure. Compared machine peeling and manual hand peeling method.
2008	ADTEC	Pineapple peeler	Pineapple peeler for SME business, capable of peeling over four tons of pineapple a day, Price estimated Rm6000.

The pineapple peeler in the market is using the coring mechanisms. The coring mechanism actually making a hole in the pineapple and taking out the flesh. This will left many flesh from the pineapple at the skin. As we know, the eye of the pineapple is located deep in the pineapple. Using the coring technique will actually cut too deep and not economical. Thus, the design is not only adequate for the ergonomics factors, but also economical to be used.

2.6 MICROSOFT EXCEL

Microsoft Excel is a spreadsheet-application written and distributed by Microsoft for Microsoft Windows and Mac OS X. It features calculation, graphing tools, pivot tables and a macro programming language called VBA (Visual Basic for Applications). It has been the most widely used spreadsheet application available for these platforms since version 5 in 1993.

In this project, the Microsoft excel is used to analyze the data that we get from the questionnaire. The distribution of the answer and the relevant answer that the respondents want for the design will be analyzed using this program. Graph and pie chart are among the answer distribution analysis that will be used.

Using graph, we can see which answer is the best according to the highest value of the graph. Besides that, we can compare which data is relevant according to the ergonomics principle and then design the pineapple peeler properly. Furthermore, the pie chart is use as the same principle of the graph. Using these two features in Microsoft excel can improve the accuracy of the result that we get because we can compare it with one another.

2.7 SOLIDWORKS

In the designing stage, we need a software that can visualize the 3D image of the peeler. Using Solidworks as the platform to develop the design gives a lot of advantage in terms of animation, view and needs to change the design. The animation feature can give basic view of how the design will function. This means we can design the peeler to be ergonomics and according to the respondents needs.

Solidworks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and was developed by Solidworks Corporation and now a subsidiary

of Dassault Systemes, S. A. (Velizy, France). It is currently one of the most popular products in the 3D mechanical CAD market.

This software will be used to design the pineapple peeler. The first stage will be designing the pineapple peeler according to the literature review. After the data from the questionnaire has been analyzed, we will refine the design according to the respondents needs.

2.8 QUESTIONNAIRE

Questionnaire can reach a large number of respondents. This means more data can be obtained and more accurate design steps can be taken. Besides that, the questionnaire is ease of use. This mean the respondents need only a few minutes to complete the questionnaire and then return it to the researcher. It does not required interviewer like interview and efficient it in terms of short time. Furthermore, the questionnaire has low cost advantages compared to interviews. We just needs few hundreds of questionnaire to be distributed and can reach many respondents in just a minute.

Interview is also one of the ways to collect data from people. Interview is different from questionnaire because interview offers a direct interface between interviewer and the respondent. This means the questions asked will be answered based on open-ended question and not close ended question like the questionnaire. Kumar (2005) stated that interview is useful in collecting in depth information. By this the interviewer can collect data by non verbal reactions and not depends on the scale or rating that has been set by the researcher like in the questionnaire.

2.9 LITERATURE REVIEW SUMMMARY

From the literature review, there is a relationship between the MSD, workplace ergonomics and tools design. According to ergonomics, job is designed for people, that is fitting the job to a person. Besides that, ergonomics is also co-related with safety. This is because MSD occurs to the workers often and produce an unsafe environment for the workers. MSD basically relates to the movement of a person. Repetitive movement is among the main source of the MSD. Cumulative trauma disorders and occupational overuse symptoms are also the main source of MSD. In order to prevent MSD, repetitive work is designed to be ergonomics in terms of working procedure and working tools. The tools is designed to be ergonomics to the workers. By doing this, MSD and the risk of injury is reduce.

Nowadays peeling technique are causing MSD among the workers. This is because the existing technique is not ergonomics and injury happened frequently. The traditional peeling technique that is using hand and knife to peel off the pineapple skin is not healthy and also affecting the productivity of a worker. This is because the technique is causing MSD and when the worker is having MSD, the speed of peeling will slow down due to the pain that they experienced. Changing this technique and working tools can reduce this pain.

CHAPTER 3

3.1 INTRODUCTION

The main focus of this chapter is to describe the methodology in achieving the objective of the project. The questionnaire is designed to obtain information to design a pineapple peeler is described thoroughly. Also the design step based on the data collected. Figure 3.1 shows the flow chart for the methodology of the study.

METHODOLOGY FLOW CHART

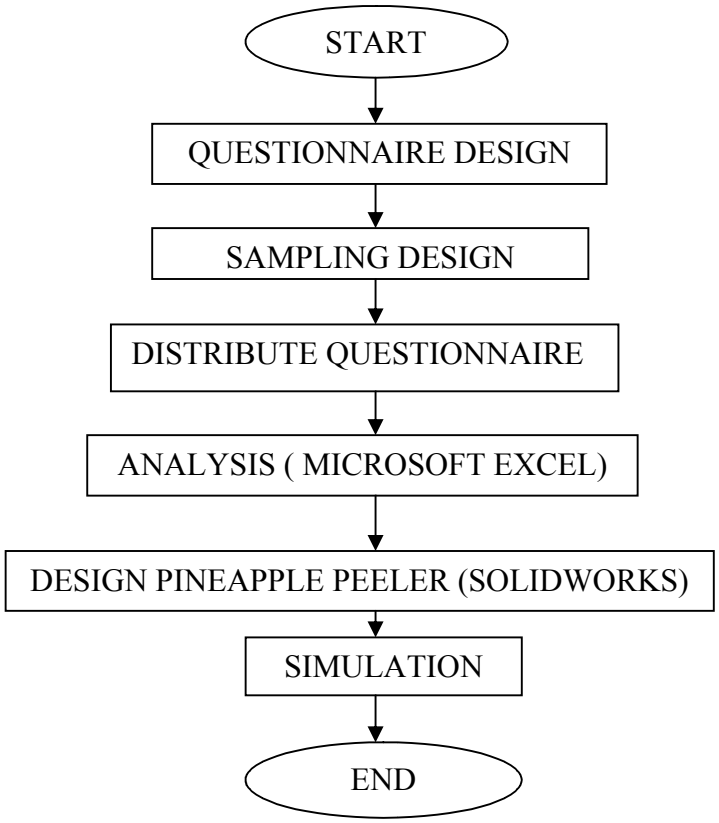

Figure 3.1: Flow chart of methodology

3.2 DATA COLLECTION METHOD

To achieve the objective of the project, data must be collected and analyzed so that reliable information is gathered to achieve the project's objectives. Data collected is very important for this project since the design stage will consider the response from the workers itself. Thus, the appropriate and reliable method to collect data must be implemented in order to obtain accurate reading. There are two types of collecting data from the workers, interviews and questionnaire.

Nemeth (2004) stated that Thomas Malone (1996) considers questionnaires and interviews helpful tools to obtain opinions, attitudes and preferences of those who have experience in a situation such as the hands-on use of experiment. These two methods can be used to obtain data from the workers.

Human factors research relies on the use of questionnaire to collect a variety of data in the development process (Nemeth, 2004). This means that questionnaire is more reliable from the interviews. Few advantages of using questionnaire compared to interviews has been listed by Nemeth(2004) by taking from Salvendy and Carayon (1997): their ease of use, their facility as a tool to collect quantitative data, their relatively low cost and the potential to collect information from any respondents who may be in separate locations and organizations.

3.3 QUESTIONNAIRE DESIGN

The types of information we need to collect from respondents and how best to elicit that information are the two key decisions that must be made early in the design stage (Czaja and Blair, 2005). The before statement state that the questionnaire first must have their needs to be asked. This is because it is important that the question to be straight forward in order to obtain information.

We should also consider whether we will be asking attitude, knowledge, or behavior questions, and determine what type of demographic information we need because their decisions can affect our choice of data collection method (Czaja and Blair, 2005). Demographic data is essential in order to obtain brief description on the respondents education level and the way that they think. This is because everyone has different point of view and opinion about a matter and this will determine what type of answer and analysis that will be appropriate for the project.

3.4 QUESTIONNAIRE SECTION

The questionnaire consists of four section. The first section will gather the demographic details about the respondents including age, gender and many more. The second section will be on working style of the respondents. Third section will focus to obtain data for the respondent's body posture. While the fourth section will gather information about working tools and accessories.

3.4.1 QUESTIONNAIRE JUSTIFICATION

This subsection will justify the project survey questionnaire for each section. The questionnaire is attached in appendix A.

3.4.1.1 RESPONDENTS DETAILS

This part gather information about the respondents general information. This is very important because we wants to know the target age for our product. Besides that, the gender also included to design a product that will accommodate both gender when using it. Table 3.1 shows the justification of each question in part A.

Table 3.1: Respondent details question and justification

PART A: RESPONDENT DETAILS	
Question	Justification
1. Age	To know the respondent's age.
2. Gender	To know the respondent's gender.
3. Hours worked per day	To verify the time expose to working condition.
4. Years in current position	To validate how many years the respondents worked in the same position.

3.4.1.2 WORKING STYLE

Part B will specify on finding the working style of the respondents. This working style will gather information about their daily work routine and whether they involve in repetitive work that can cause MSD. Table 3.2 shows the justification of part B.

Table 3.2: Working style question and justification

PART B: WORKING STYLE	
Question	Justification
5. Work required repetitive movement	To know whether the respondent's work involve repetitive movement.
6. Break needed	To verify that the repetitive work is tiring up the respondent's body.
7. Respondent's job require he/she to move around	To know whether the respondent's job based on a static position or mobile movement.
8. Lifting is required when doing work	To determine the lifting affect the respondent spine or not.
9. Satisfaction against current working tools	To know adjustment has to be made or not on the current working tools.
10. Stretching required	To determine the effect of repetitive movement on the respondent.

3.4.1.3 BODY POSTURE

This part will evaluate the respondents and MSD. The questionnaire will give brief explanation on their current working body posture whether it is contributing to MSD or not. This information is crucial because the MSD are closely related to body posture when working. This part will also tell the period that the respondents being exposed to MSD. Table 3.3 shows the justification for question in part C.

Table 3.3: Body posture question and justification

PART C: BODY POSTURE	
Question	Justification
11. Working position gives back pain	To validate the source of back pain.
12. Stress at the upper body	To determine the main focus of the pain on the body part.
13. Same working position during working hour	To prove that the respondent is practicing the same position during working hour.
14. Sitting position is the best when doing work	To determine the design height and position of working.
15. Body needs to be bend when doing work	To choose the best handling position for the design.
16. Force are being concentrated to the hand when doing work	To design the handle bar and holding position to minimize force acting on the hand.
17. The upper arms needs to be close to the body and not extended outside	To know the effect of the movement on the shoulder and arms.

3.4.1.4 WORKING ACCESSORIES/TOOLS

This part will obtain general information on the respondents currents working tools and accessories. The basic idea of how they want their tools and accessories to be can be collected from this section. This information will give the basic idea of designing the relevant design that fits the workers. Table 3.4 shows the justification for part D.

Table 3.4: Working accessories/tools questions and justification

PART D: WORKING ACCESSORIES/TOOLS	
Question	Justification
18. Tools need to be adjusted to the hand	To design the product to be easily fitted to the workers' hands.
19. The tools handle/spindle is not large enough for you	To design the product's handle/spindle to be easily grip by the workers.
20. The handle/spindle needs to be wrap with material for gripping comfort	To design the product with a comforter or soft material to absorb the force subjected from the workers hand to ease down the pain on the palm.
21. The working material or tools is always position in your reach	To consider the weight, mobility and size of the design.
22. Working tools is causing pain to your body	To make sure the design is ergonomics.
23. Tools is causing discomfort to the body	Considering ease of use concept in the designing .
24. Tools and material needs to be adjusted to fits your height	Considering the working position for the design and the material.
25. Task perform produce vibrations	To evaluate to include moving parts to the design.
26. Task perform are causing discomfort to your body	To know the effect of using the tools.
27. Satisfactions against the current working tools	To know whether the current working tools suits the workers or not.

3.5 SAMPLING DESIGN

The sample for this project will be targeted on the person who uses hand in their work. This because this project will emphasize on the hand tools performance. Thus, choosing the people that use hand in doing work will give accurate result. The most probable sample would be:

1- Lembaga Perindustrian Nanas Malaysia's workers.

3.6 DATA ANALYSIS

Analyzing is important in a project because it will determine the results of the project. The data must be analyzed according to the appropriate method so that the results from the experiment or project can be discussed properly.

For this project, the data is from the questionnaire that has been designed according to the needs of the project. The answer from the questionnaire will determine the design of the project. Each answer from interview and questionnaire will be analyzed according to the ergonomics principles that has been stated in subsection 2.2.3 in chapter 2.

In this stage, Microsoft Excel will be used to analyze the questionnaire's answer. Taking the advantages that has been discussed in section 2.6 in chapter 2 , we can obtain the accurate results by comparing the two method of analyzing. Using graph and pie chart features from the software, answers distribution can be see profoundly.

3.7 DESIGNING

The design stage is the continuation from the analyzing stage. The data that has been analyzed during the analyzing stage is used to construct the design using Solidworks software according to the answer that we get form the respondents.

Several designs will be produced in order to obtain the most suitable design. This is because we can compare it with one another so that the design can be analyzed thoroughly. Besides that, the different shapes and specifications of peelers will helps to boost new ideas on how to improve the design according to the ergonomics principle.

3.7.1 PRELIMINARY DESIGN BASE ON LITERATURE REVIEW

Figure 3.2, 3.4 and 3.5 show the preliminary design of the pineapple peeler based on the literature review.

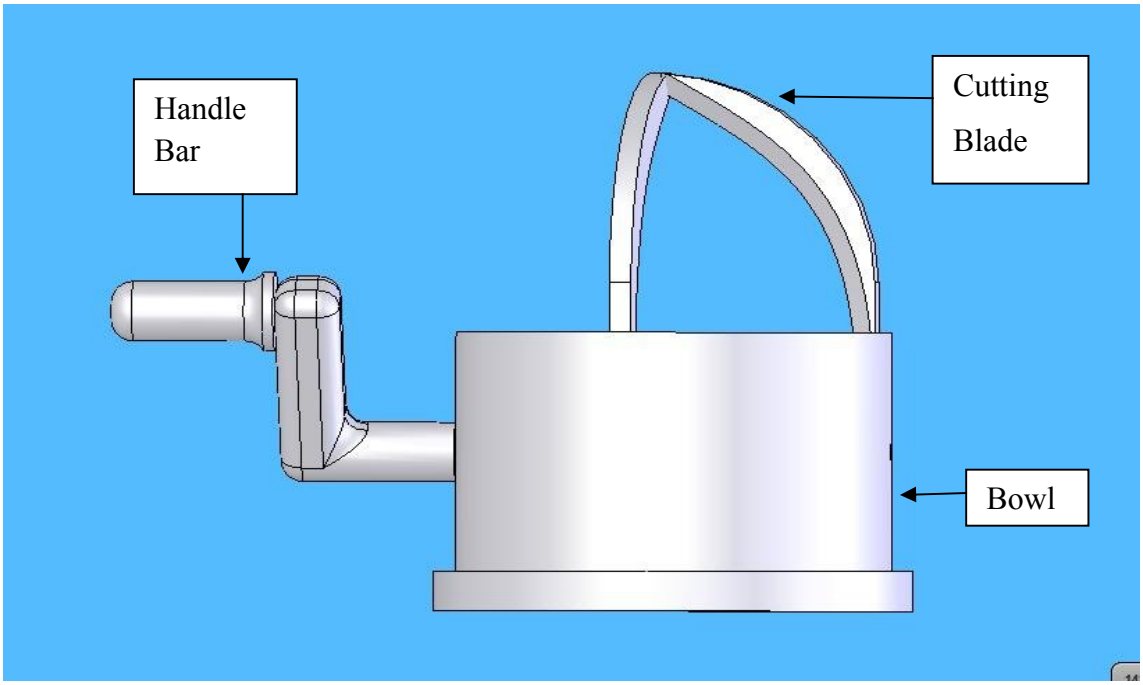

Figure 3.2: Front view

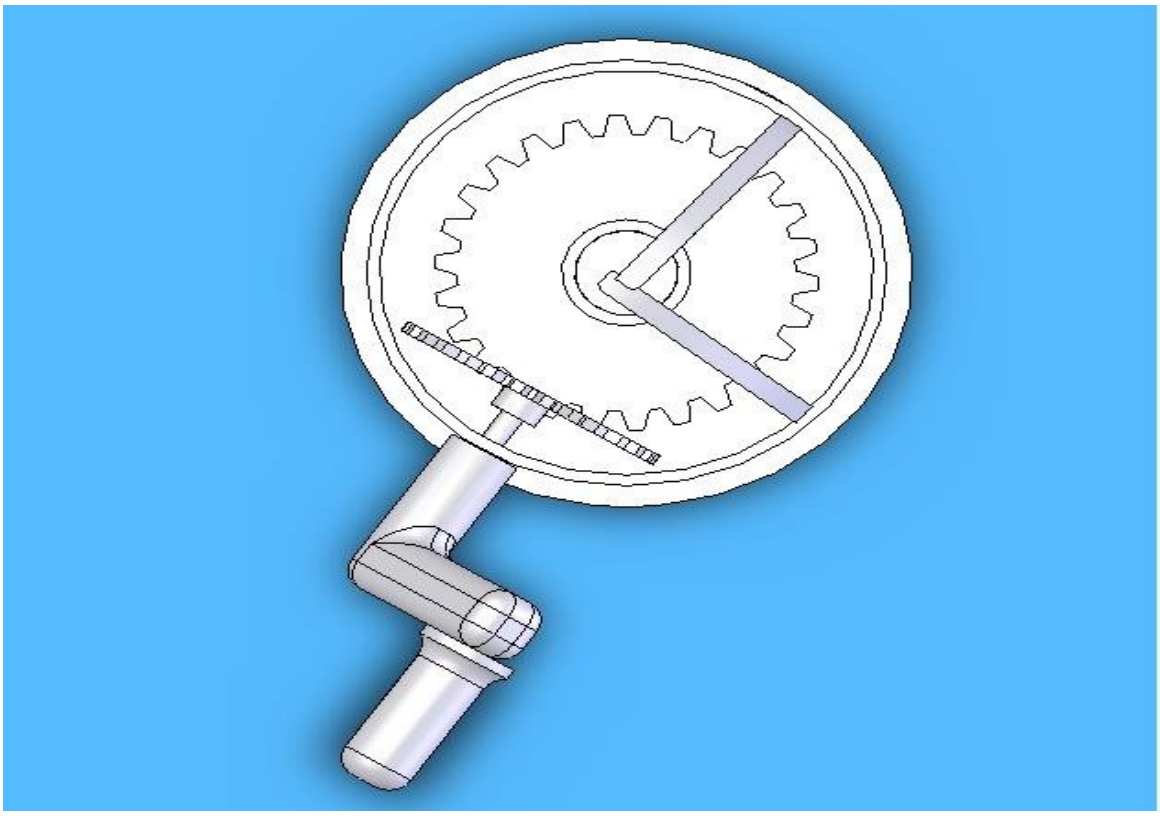

Figure 3.3: Top view

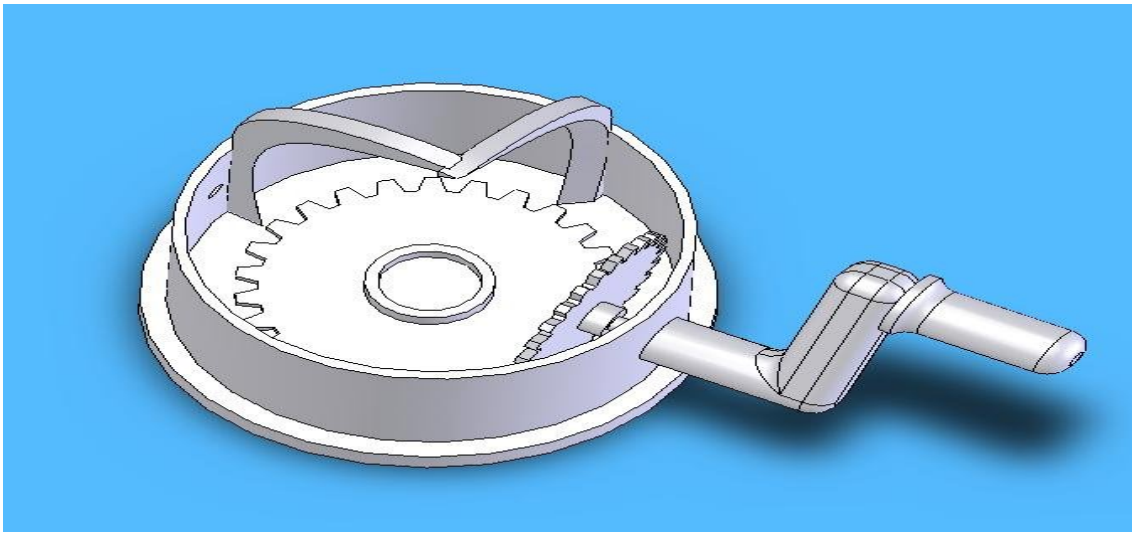

Figure 3.4: Trimetric view

The preliminary design is totally based on the literature review. Below is table 3.5 shows the part and the justifications for the dimension of each part.

Table 3.5: Design justifications

Part	Dimension (mm)	Justifications
Handle bar length	100	Accommodate a person's length. Chengular, N.S., Rodgers, H.S., and Bernard, E. T. 2004. Kodak's Ergonomics Design For People At Work. New Jersey: John Wiley And Sons.
Handle bar diameter	50	The handle bar would accommodate the hand breath of: Male: .88.7mm Female: 77.7mm. Klamkay, J., et al. 2006. International Journal of Industrial Ergonomics 38(2008) 111 118
Handle bar perimeter	15.77	The handle bar perimeter: 15.77mm, this would fit the hand grip of: Male: 20.30mm Female:17.84 Klamkay, J., et al. 2006. International Journal of Industrial Ergonomics 38(2008) 111 118
Bowl height	60	According to the average pineapple's height.
Bowl diameter	180	According to the pineapple's average diameter.

3.8 SIMULATION

In this project, the simulation is to evaluate the critical part of the design that is subjected to the force exerted during movement. Knowing the critical part is important because we need to minimize the force effect and keep the design to be safe for use. Using simulation software, Algor, we can determine the maximum stress the design can hold. Knowing the maximum stress distribution is important so that we can enforce the critical part to withstand such force. The model from Solidworks will be imported to Algor software using .igs compatible mode.

3.9 SUMMARY

For this project, the design will be based on the respondents answer based on the questionnaire. This is important because the design must be based on the respondents view in order to make it ergonomics according to workplace condition. The questionnaire and interview question is design to fit the respondents in real life working condition. Based on the answer we will know what type of design that will fit the respondents. The sample of respondents will be the person who involve in task that is based on hand usage.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter discusses the results on the questionnaire that has been distributed. The answers from the questionnaire will be evaluated to improve the preliminary design for the portable pineapple peeler. The responses will be evaluated using Microsoft Excel to get the distribution of answers. Furthermore, the design will be evaluated thoroughly using Algor software to determine the maximum distribution of force on the pineapple peeler during working. This chapter will be divided into two part. The first one will discuss about the questionnaire that has been distributed. The second part will emphasis on discussing the simulation of the pineapple peeler using Algor software.

4.2 QUESTIONNAIRE ANALYSIS

In this section, the questionnaire that has been distributed will be discussed thoroughly. The answers will be used in improving the preliminary design of the pineapple peeler so that the workers' needs will be accounted for the design in order to avoid and prevent MSD from happening.

4.2.1 Respondent's Age

The first question is about the demographic data which is the age of the respondents. The results show that 70% of respondent's age is in the range of 21-29 years old. 5 % in the range of 30-39 years old while another 5% is in the range of 20 years old. From the answers we know that most of the user are in the range of 21-29 years old. Since the people involve in position of using the pineapple peeler falls in the range of 21-29 years old, the percentage of them developing MSD is quit high. Due to that, we must design the pineapple to be suited the range that most frequent involve so that MSD can be reduced or avoided in the future of their career since they repeatedly doing the same work everyday.

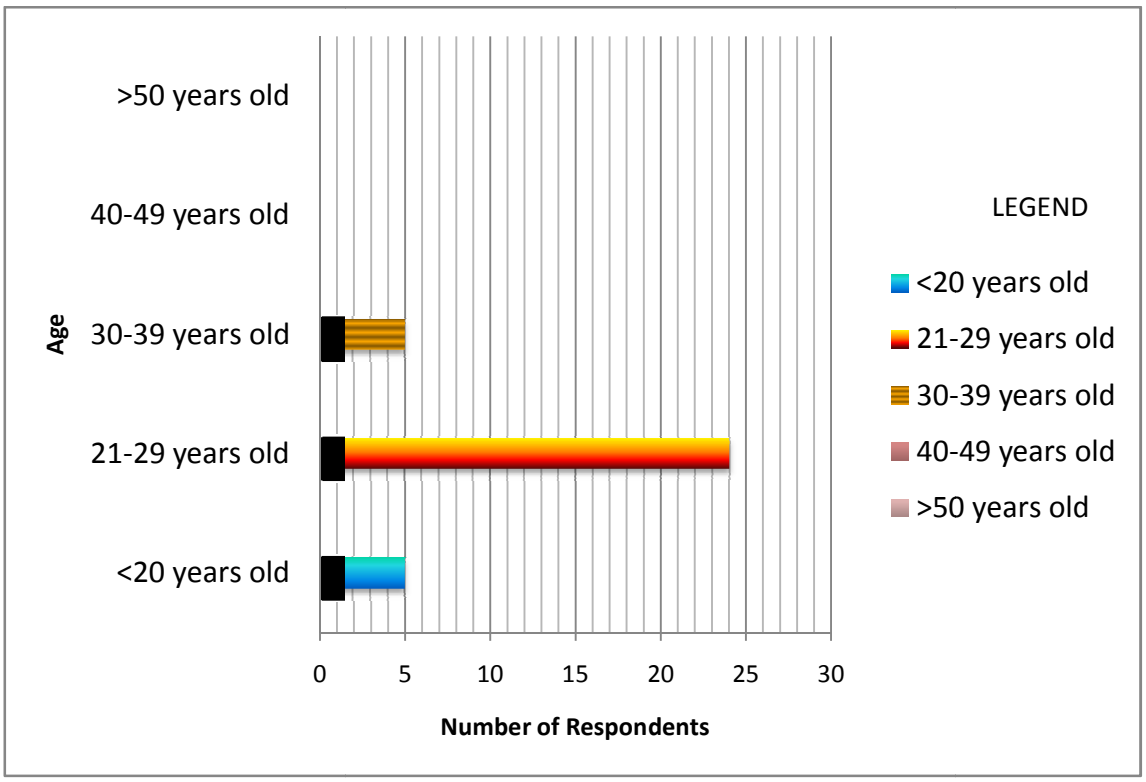

Figure 4.1: Respondent's age

4.2.2 Respondents' Gender

In this question, it shows that 69% of the respondents are male while 31% are female. This means that most of the workers involved in the peeling section are males. Thus, we have to refer to the anthropometry data to know the range of length that is suitable for the design. This is because most workers are male and the body size of male and female is obviously not the same. Basically the design will be most appropriate to be conducted by male rather than female due to the anthropometry data that has been used to design the peeler. Due to that, the maximum force that can be hold by the design should also accounted to be fitted by the gender itself, that is the male. Physiological and perceptual responses in male Chinese workers performing combined manual materials handling tasks (Li.K.W,.et al,200). Below is the chart showing the number of respondents and percentage of the distribution.

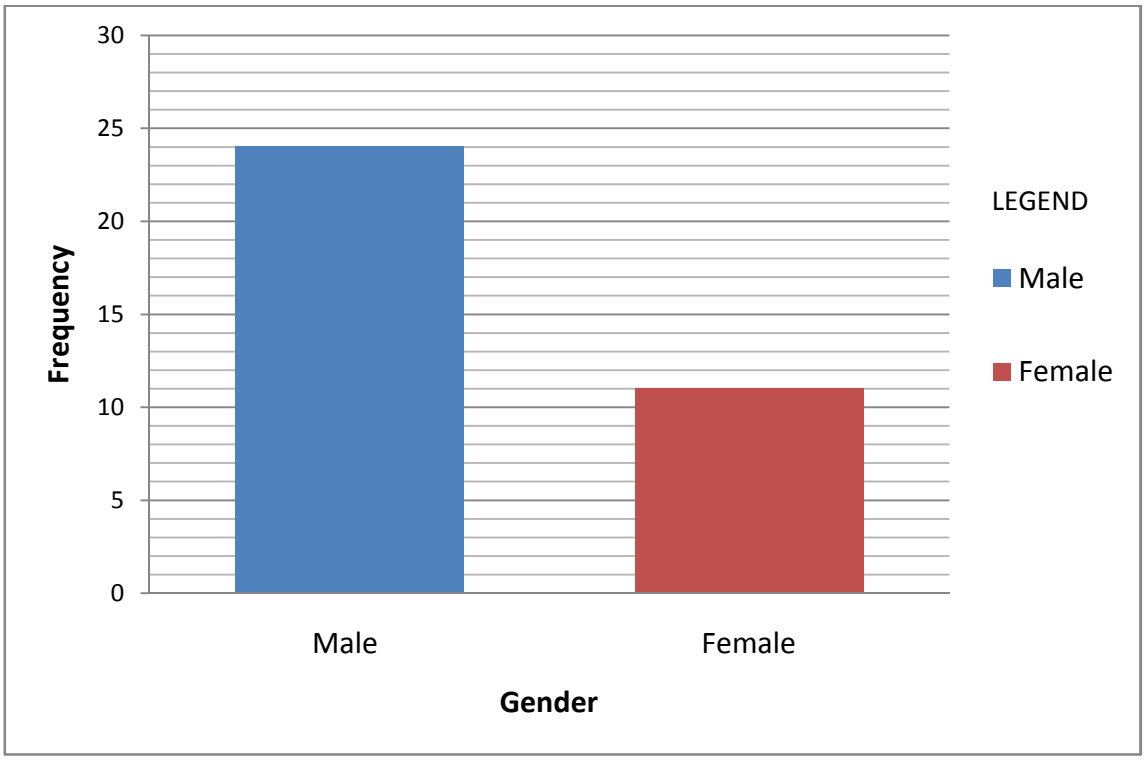

Figure 4.2: Respondents' gender

4.2.3 Respondents' Number of Working Hours in a Day

The third question discusses the number of working hours in a day. From this question, it shows that 61% of the respondents work for 6-9 hours per day. 21 % of respondents work for 4-6 hours while 18% of respondents work for less than 3 hours per day. Since most of the workers experience 7-9 hours of working in a day, the design should not causing discomfort that can cause MSD to the workers. This is because long working hours tends to expose the workers to MSD and eventually increase the chances of developing MSD (Lehto and Buck, 2008). Below is the chart showing the distribution of respondents' working hours.

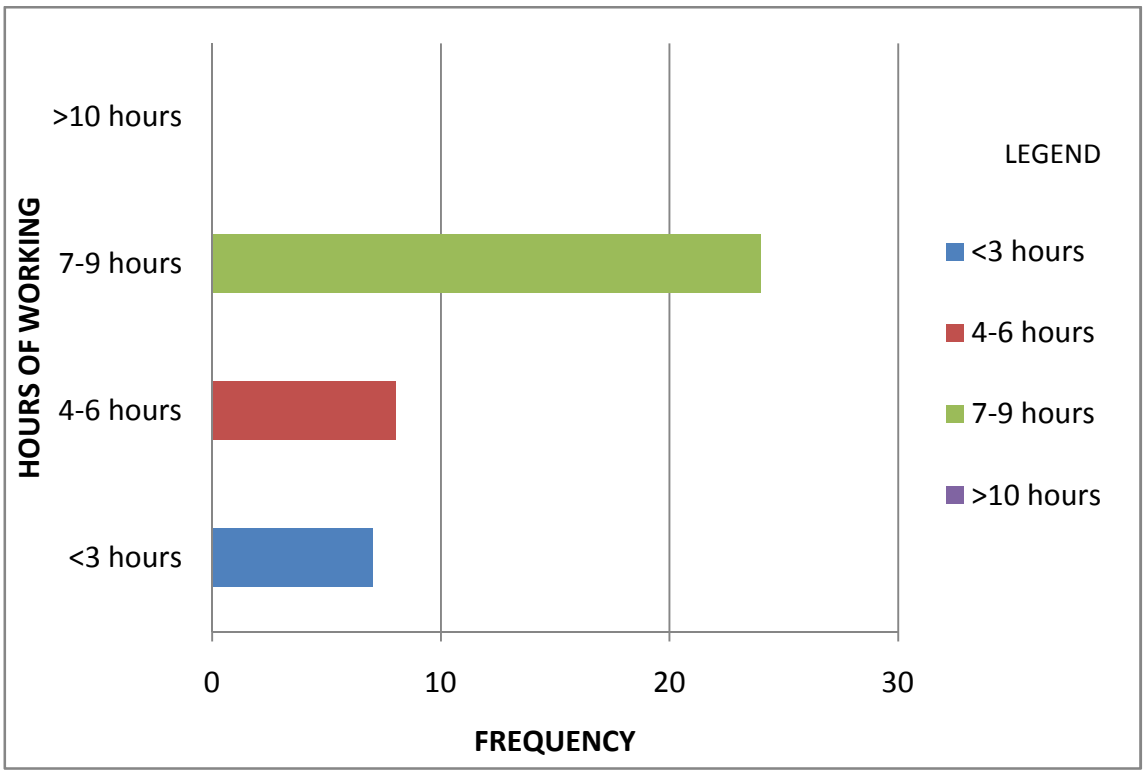

Figure 4.3: Pie chart of percentage of working hours per day

4.2.4 Number of Working Years

The next question is about the number of working years for the respondents. Through this question, we will know how many years the respondents have been exposed to the working hazard especially MSD. The answers show that 40% of the respondents' years of working are two to three years. 29% has been working for less than 1 year. Furthermore, 11% has been working for 4 to 6 years while 11% in more than 10 years and only 9% has been working for 7 to 9 years. From the answers, it shows that the workers have been exposed to the MSD for mostly in any case of 2-3 years. This means that they have developed MSD and actually heading to a way of MSD to becoming more serious. Due to that, designing the peeler according to the ergonomics principle is important in order to stop or reduce the MSD. The pie chart below explains the distribution of answers.

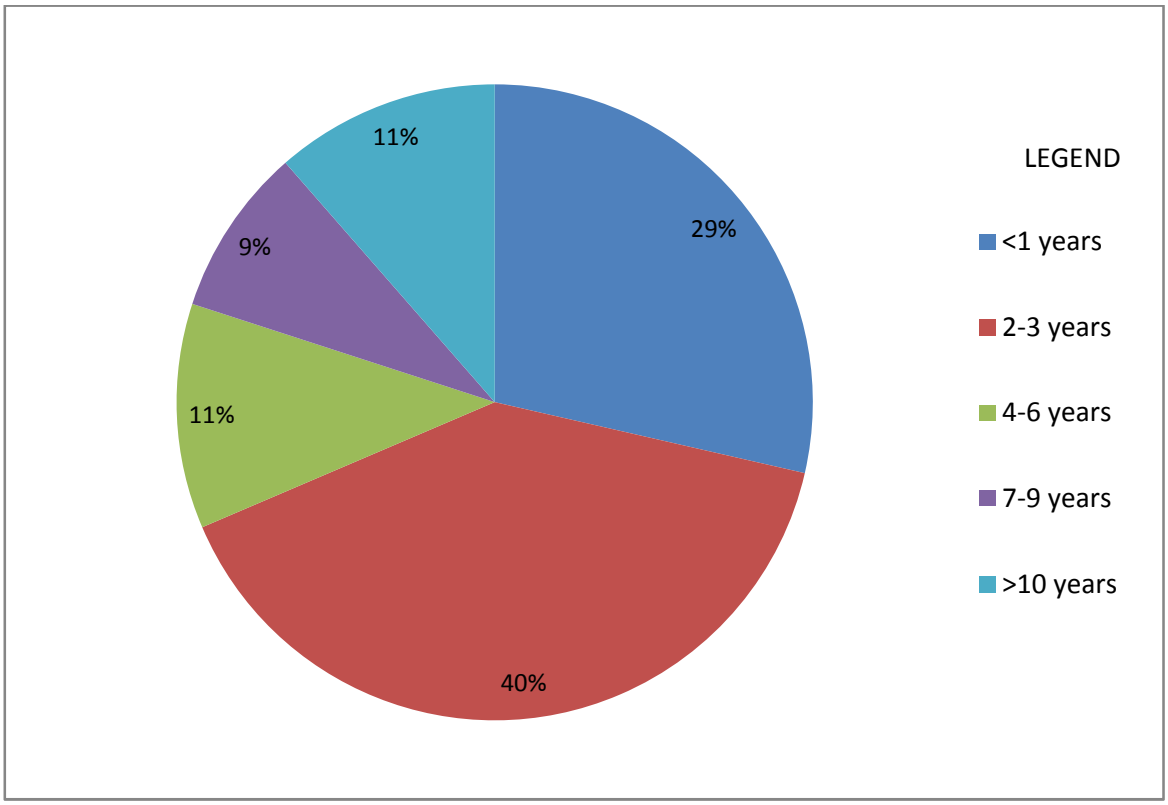

Figure 4.4: Respondents' years of working

4.2.5 Repetitive Movement

For the next questions, it deals with the respondents movement. It shows that 46% from the respondents strongly agree that they are having repetitive movement in their work. Besides that, 26% of the respondents are unsure about their working movement. 20% of them strongly agree that they practice repetitive movement in their working operations. Furthermore, 5% of them disagree that they are having repetitive movement in their working operations while the rest of 3% strongly disagree the fact that they are having repetitive movement in their working conditions. Repetitive movement has been known as the main contributor for the MSD to happen. As the answers from the respondents shows that they are practicing repetitive movement is their work, this means that they are exposed to MSD during working period. Repetitive movement can increase the percentage of having MSD. So, we can infer that a lot of workers are having MSD without they knowing it. Below is the pie chart showing the distributions of answers form the respondents.

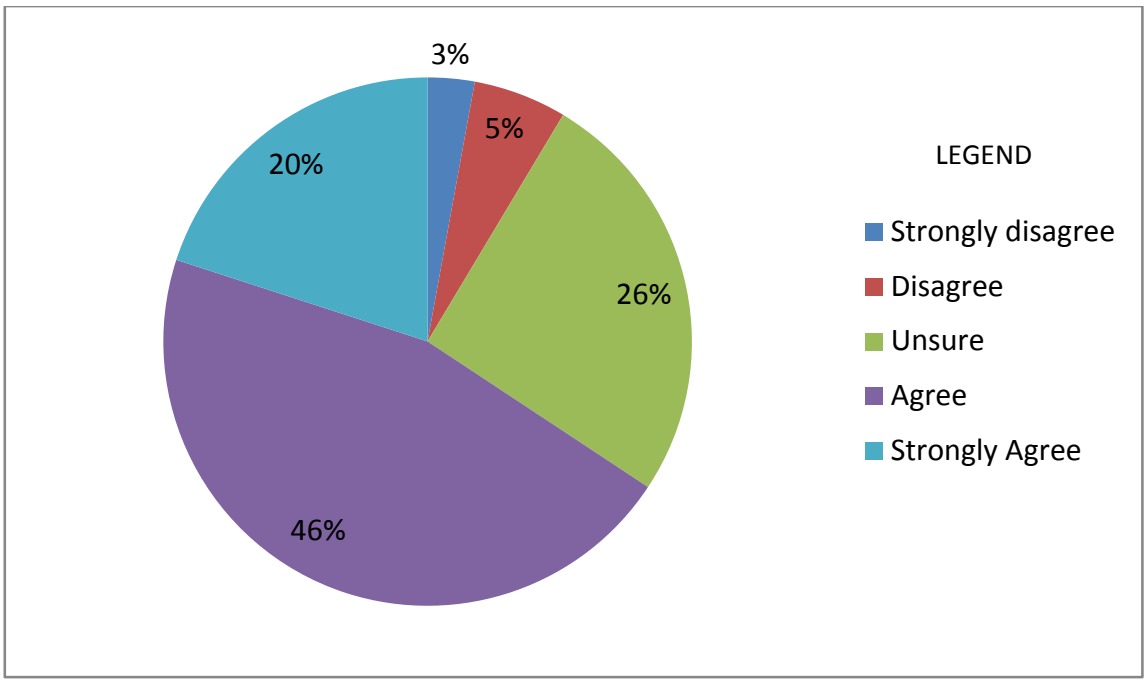

Figure 4.5: Repetitive movement among the respondents

4.2.6 Enough Resting Time

This question is about the resting time for the workers. It shows that 57% form the respondents are agree that they have enough resting time. Meanwhile 19% from the respondents strongly agree that their employer had give them enough resting time during working hours. Besides that, 11% from the respondents are unsure whether they have enough resting time or not. Also showing 11% is the respondents who is disagree that they had been given enough resting time during working period. Last portion of respondents that occupies 3% from the respondents are strongly disagree that they had been given enough resting time during working period. From this question, we know that the workers actually are having enough resting time during working hours. This means that they are not being exposed to MSD at all time of work routine. Below is the pie chart showing the distributions of answers.

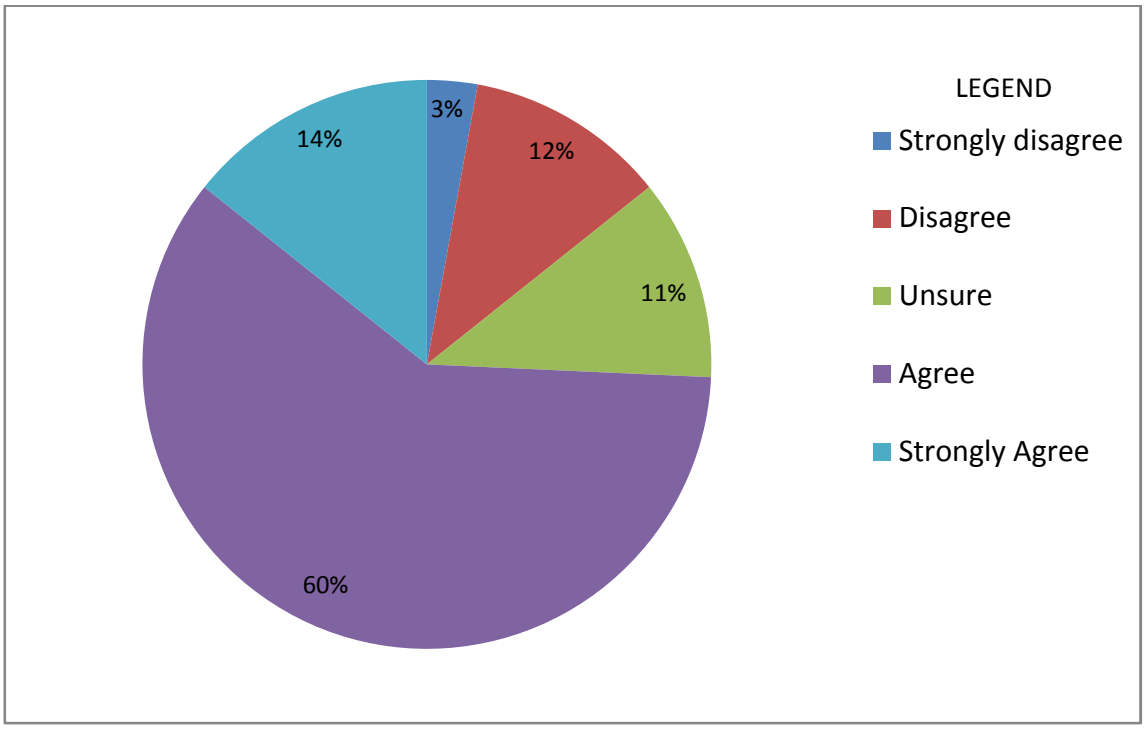

Figure 4.6: Resting time

4.2.7 Sitting For A Long Period

This question will tell about whether the workers have to sit for a long time or being mobile during work. From the question, it shows that 37% from the respondents agree that they have to sit for along period during working. 31% strongly agree for sitting during work. While 17% from the respondents are unsure whether they have to sit or not. This means that they have to be mobile during working. 12% from the respondents disagree with the fact that they have to sit during working and 3% from the respondents are strongly disagree that they have to sit when doing work. This question shows that most workers sit when doing work. So we have to design the pineapple peeler in sitting position and portable. The sitting position is also deals with the spine of the workers. The design should support the spine of the workers when doing work. By this, we can avoid backpain that usually result in MSD. Below is the pie chart showing the distribution of answers from the respondents in percentage.

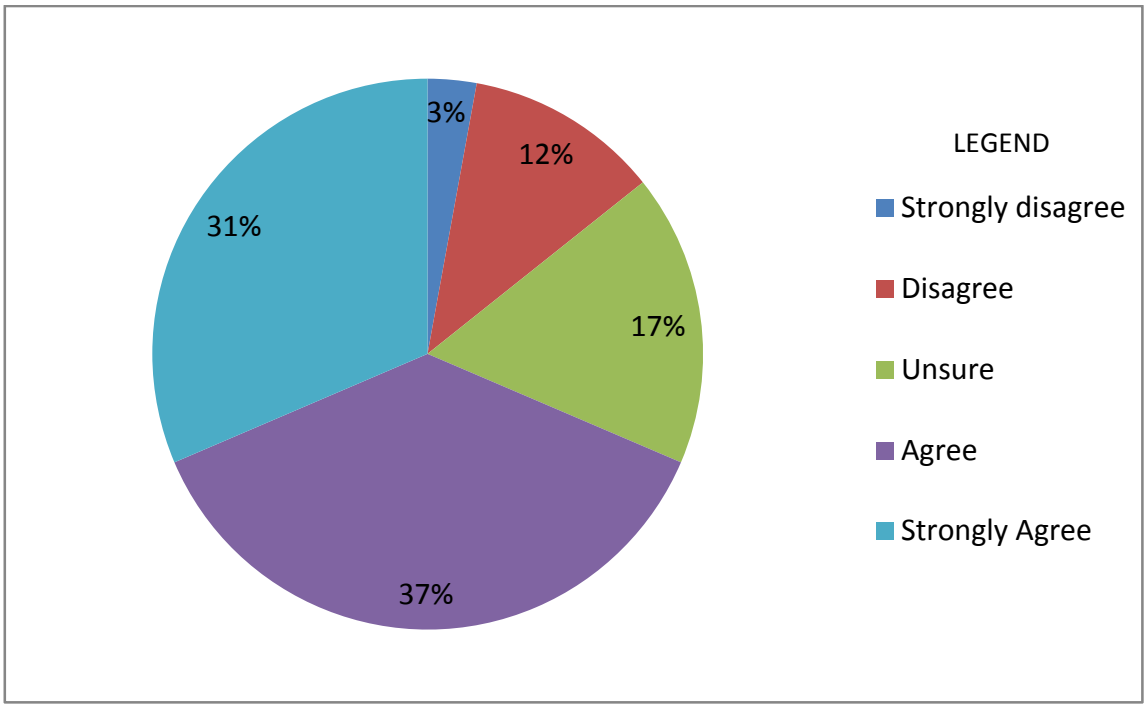

Figure 4.7: Sitting for a long period

4.2.8 Discomfort When Sitting

This question will determine whether sitting position is the desire position for the workers. From the question it shows that 31% form the respondents agree that sitting give them hard time when doing work. Meanwhile 26% form the respondents strongly agree that they had difficult time when doing work while sitting. 17% of respondents disagree that sitting are causing discomfort when doing work. That goes the same for the respondents that is unsure whether sitting gives them discomfort. The last portion of the respondents that occupies 9% from the respondents disagree that sitting gives discomfort to them. From this question, we know that a lot of workers do not like to sit when doing work because it cause discomfort. This means the design have to be adequeate to the standing position. Below is the pie chart showing the distrbutions of anwers from the respondents by percentage.

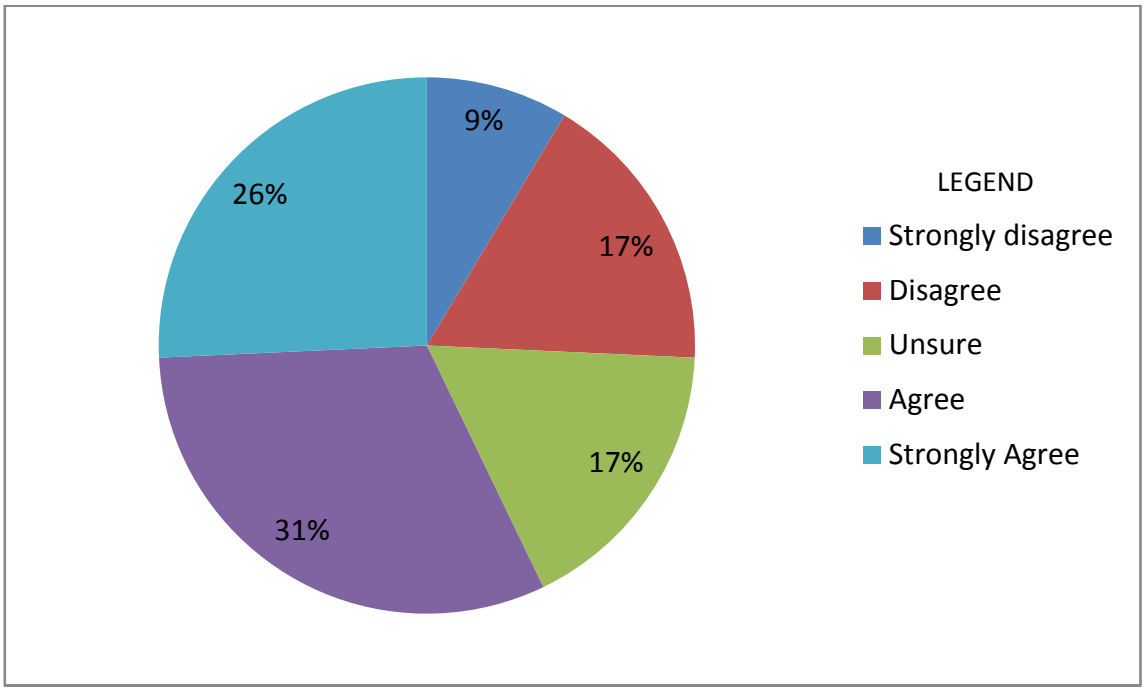

Figure 4.8: Discomfort when sitting

4.2.9 Changing Workpiece Position

The next question is about changing the worpiece position. From the question it shows that 43% of the respondents are strongly agree that they must move the workpiece in order to do their job. Besides that, 31% of the respondents did agree moving the workpiece is a must. Furthermore, 11% of the respondents disagree in moving the workpiece in completing their task. While 9% remain unsure and 6% strongly disagree in moving the workpiece to finish their task. From this question, we know that most of the workers like to move their workpiece in order to complete their task. Thus, the design should be portable so that it can be moved around to compensate the ergonomics usage of the pineapple peeler itself. Below is the pie chart showing the distributions of answers from the respondents in percentage.

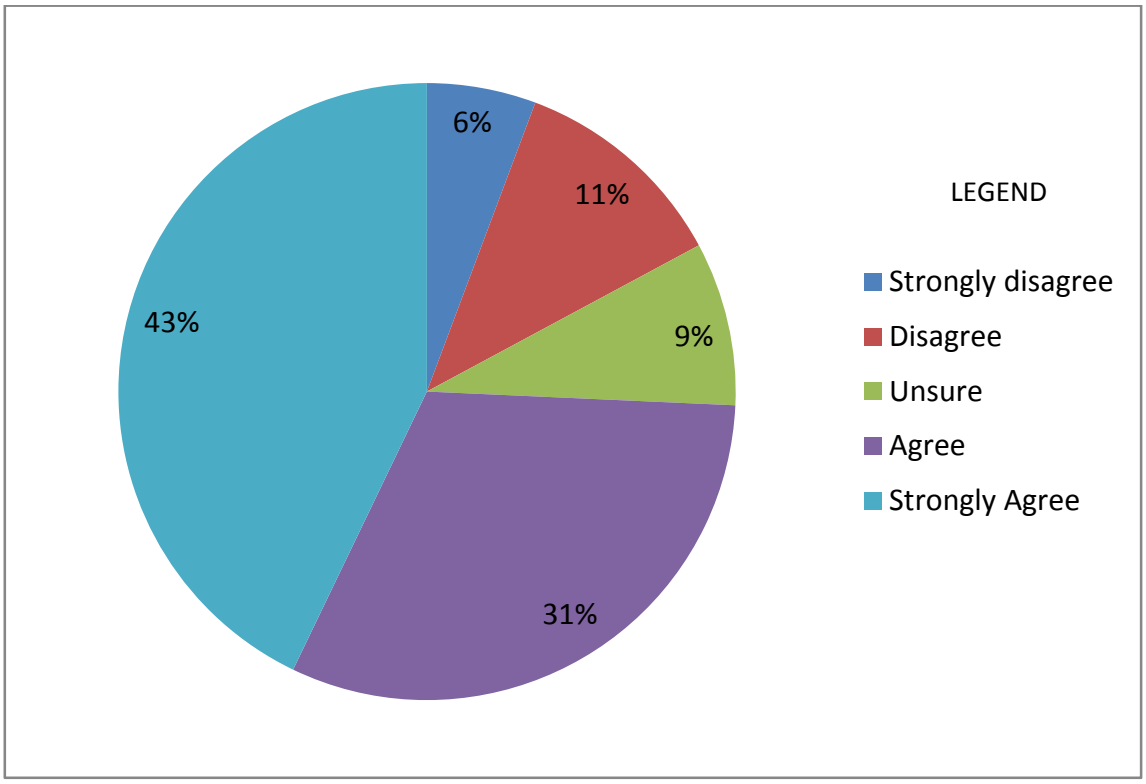

Figure 4.9: Changing workpiece position

4.2.10 Resting of Upper Body After Hours of Working.

The next question is about resting the upper body after hours of working. From the question it shows that 48% of the respondents agree that they need to rest the upper body after working. 40% of the respondents strongly agree about resting the upper body after hours of working. Meanwhile, 6% of the respondents disagree that they must rest up their upper body after working. The last portion of the respondents is 6% in unsure whether they have to rest up their upper body or not after working. From the question we know that most of the respondents agree that resting their upper body after hours of working is a must. This means that the upper body section is highly affected to movement. So, the peeler must be designed to not highly affected the upper body section in order to reduce the risk of injury due to MSD. Below is the pie chart showing the distributions of answers from the respondents.

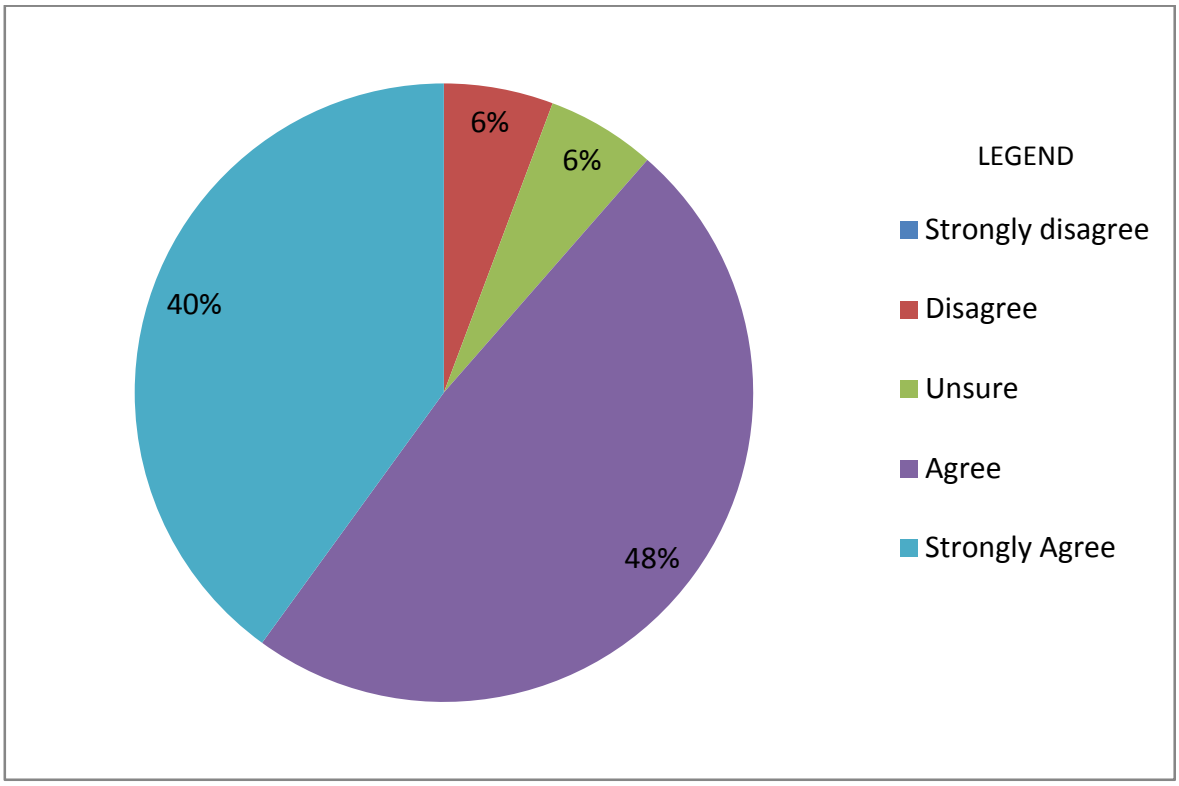

Figure 4.10: Resting of upper body after hours of working

4.2.11 Backpain While Doing Work

This question will discuss about the backpain experienced by the workers while doing work. It shows that 51% of respondents agree that they are having backpain when doing work. Besides that, 37% of respondents strongly agree on the fact that they also having backpain when doing work. But 6% of respondents is unsure whether they are having bakcpain or not while doing work. Apart from that, 3% of respondents disagree that they having backpain while doing work. This goes the same with another 3% of respondents that strongly disagree with the fact that they are having backpain while doing work. From this question, the answers given by the respondents show that most of the workers are experiencing backpain while doing work. This means that they are having MSD. Thus, the design should not cause backpain to the workers in order to minimize or prevent MSD from happening. Below is the pie chart showing the distribution of answers from the respondents in percentage.

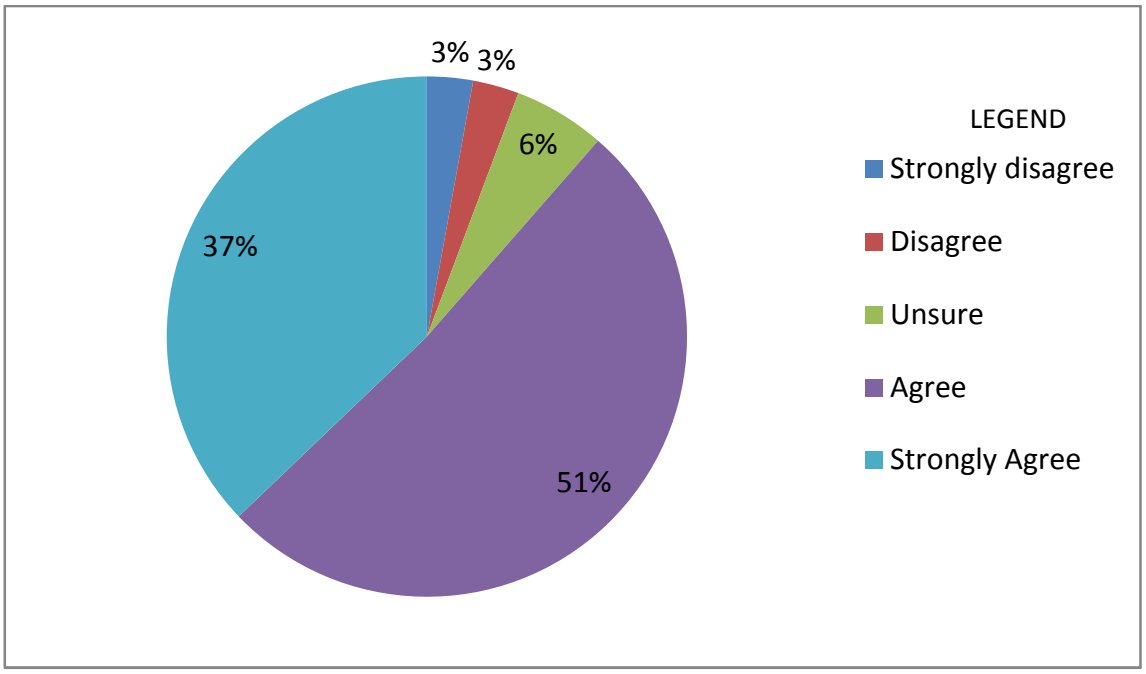

Figure 4.11: Backpain while doing work

4.2.12 Pressure Experienced At The Upper Body

This question deals about the pressure experience at the upper body while doing work. The answers show that 40% of the respondents strongly agree that they experinced pressure to the upper body section while doing work. 31% of respondents agree that they experienced pressure. But 17% of respondents is unsure about whether they experienced pressure or not while doing work. 9% disagree while 3% of respondent strongly disagree that they experienced pressure at the upper body when doing work. From the answers, it shows that most workers experienced pressure at the upper body. So, the design should reduce the pressure experince by the workers. Below is the pie chart showing the distribution of answers by the respondents in percentage.

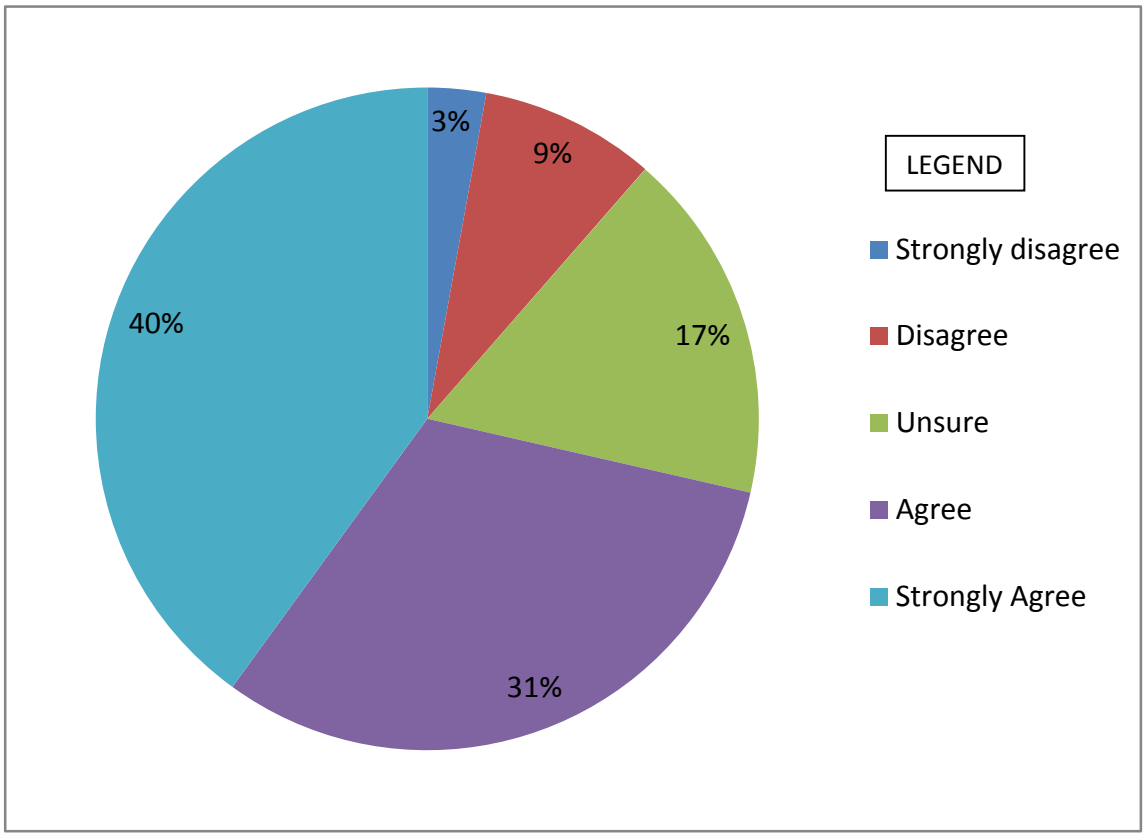

Figure 4.12: Pressure experienced by the upper body

4.2.13 Unchange Position During Working

This question will explain about the workers' position during working. The answers from the question show that 43% of respondents agree that they do not change their position during working time. Meanwhile, 26% of respondents are unsure whether they change or not their position while working. Furthermore, 17% of respondents strongly agree that they do not change their position while working. But, 8% of respondents diagree that their position is the same during working. This goes the same for another 6% of respondents that strongly disagree that they change their position when working. Form this question, we know that a lot of workers do not move around or go mobile during working. Thus, the design should consider the one point center where it can be stationed as well as can be moved around. Below is the pie chart showing the distributions of answers in percentage.

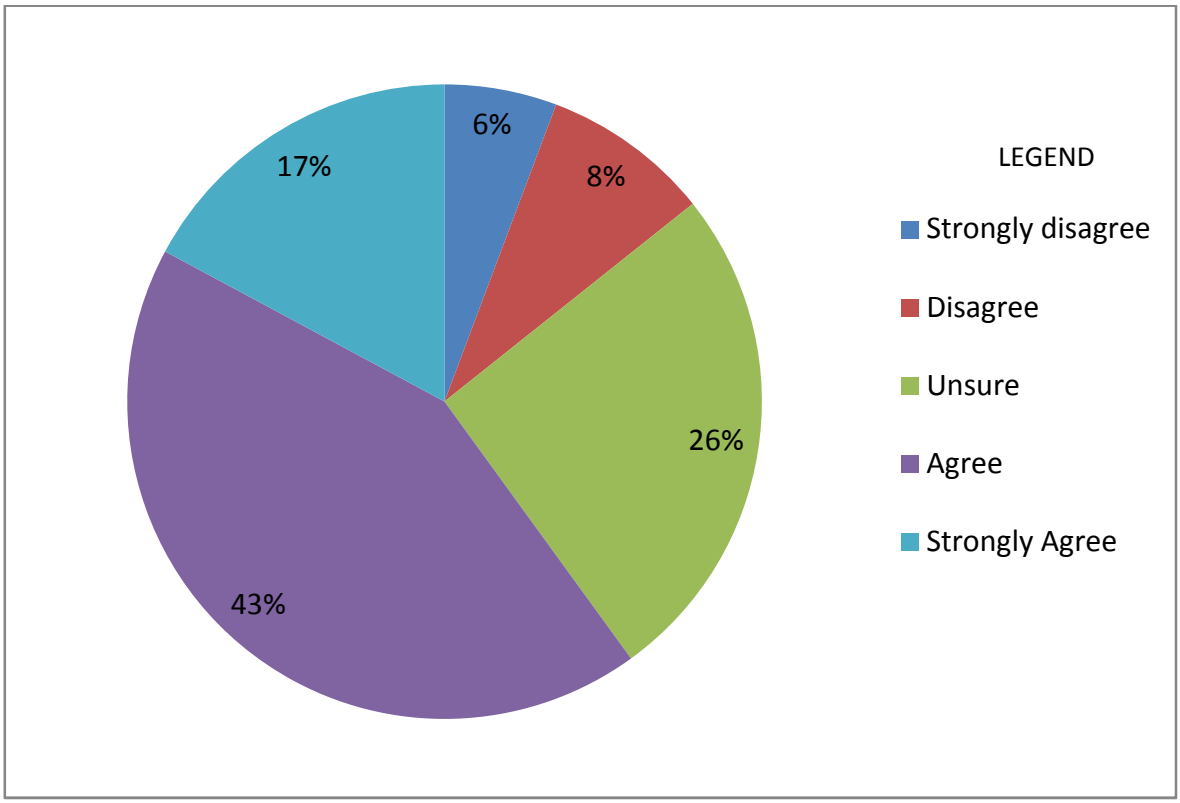

Figure 4.13: Unchange position during working

4.2.14 Feels Comfort When Sitting

This question is about whether sitting position makes the workers feel comfortable or not. The answers show that 51% of respondents agree that sitting gives them comfort when working. Besides that, 29% of respondents is unsure about sitting gives them comfort. 11% of respondents disagree about the fact on sitting gives comfortable. Meanwhile 6% of respondents strongly agree that sitting gives them comfort while working. But 3% from the respondents strongly disagree about sitting position. This question shows that most workers prefer the sitting position rather than standing. This means that the design should support the spine in order to reduce the changes of getting MSD. Below is the pie chart showing the distributions of answers in percentage.

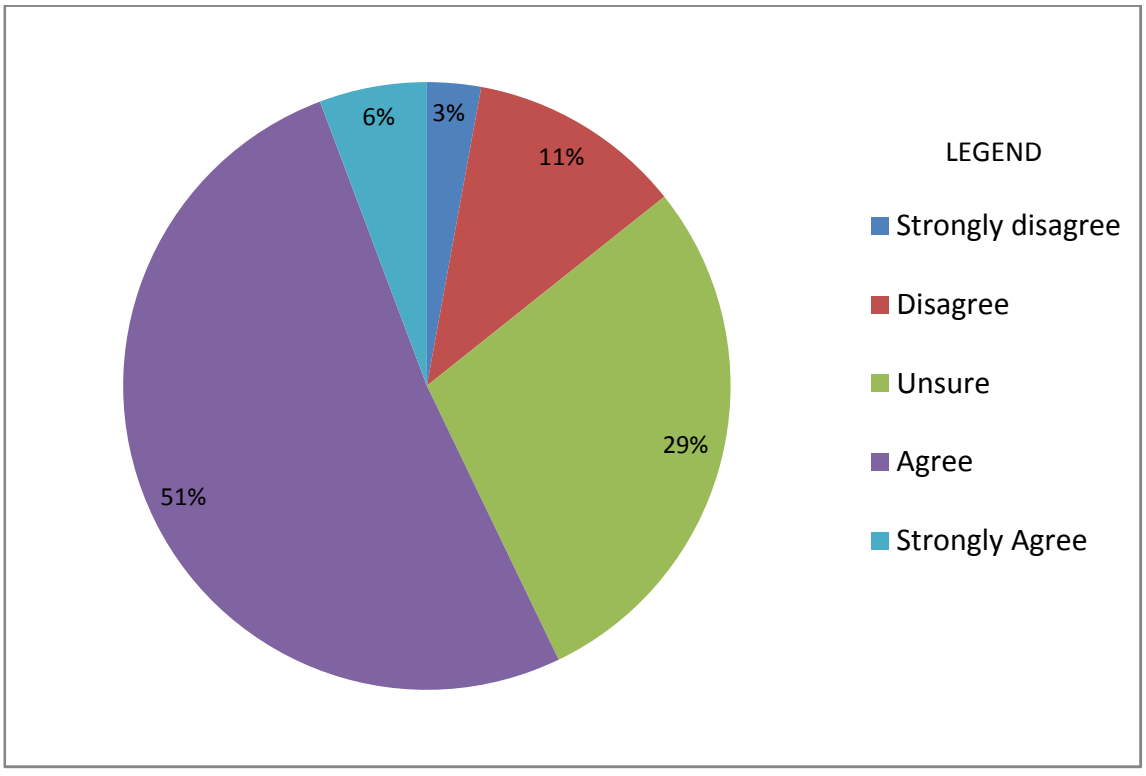

Figure 4.14: Feels comfort when sitting

4.2.15 Bending The Hand While Doing Work

This question discusses about whether the respondents bend their hand during working. The questions shows that 40% of respondents agree that they bend their hands when doing work. But 26% of the respondents does not agree that they bend their hands when doing work. Another 26% of respondents is unsure whether they bends their hands or not during working while 8% of respondents strongly agree that they bend their hands during working. This means, the pineapple peeler should be designed in a way that the hand can be stretched once in a while. This is because when hand is been bent, the tissues in the bones and joints tends to loosen up. This will cause irritations to the workers. Below is the pie chart showing the distributions of answers in percentage.

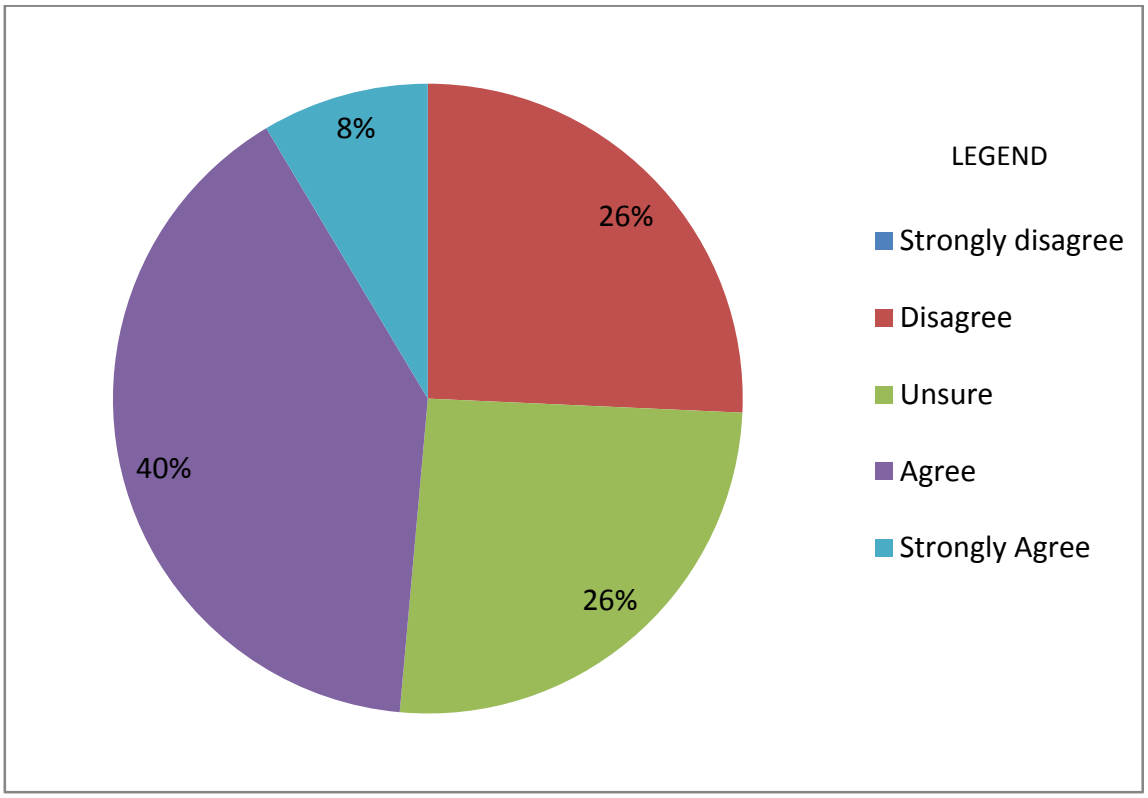

Figure 4.15: Bending the hand while working

4.2.16 All Forces Are Directed To The Hand While Working

The next question is about the forces that are being used by the workers in order to do work. The answers show that 51% of respondents agree that all forces and pressure have been focused and directed to the hand when doing work. While 20% of respondents are unsure whether they directed their pressure to the hand or not. But 14% of respondents disagree that they focus and directed all their forces to their hand. Meanwhile, 9% or respondents strongly agree that they put all their forces to the hand when doing work. The last portion of respondents that contains 6% form the percentage strongly disagree that they put all their forces to the hand. From this question, it shows that most workers put all their forces to their hands when doing work. Thus, the design should also accommodate comfortness among the user. Below is the pie chart showing the answers form the respondents in percentage.

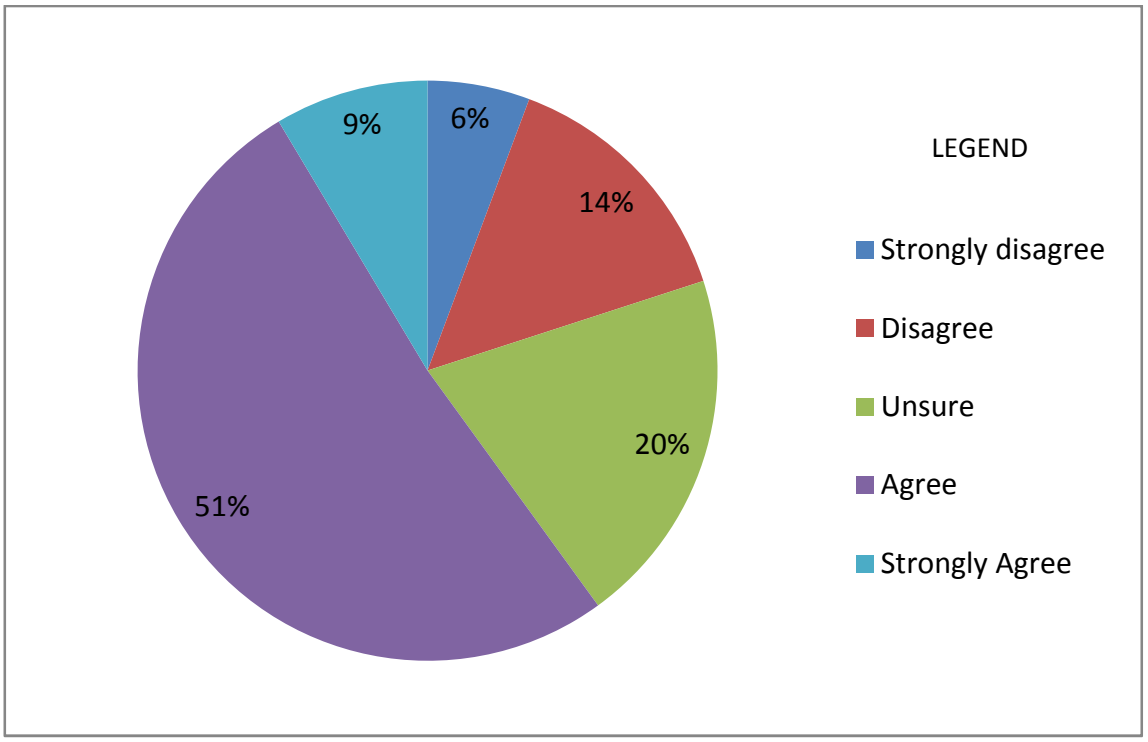

Figure 4.16: Force directed to hand when working

4.2.17 Both Hands Were Not Stretch Out While Doing Work

This question will discuss about whether the hands of the workers while working. The answers show that 46% of respondents disagree that they kept their hand inside instead strech them out. Meanwhile, 23% of respondents are unsure whether they keep their hand inside or stretch it out while working. But, 17% of respondents agree that they keep their hand inside while working. This goes the same for 11% of respondents that strongly agree that they heep their hand inside while working. 3% of respondents strongly disagree that they keep their hand inside. This means that they have stretched them out when doing work. Below it the pie chart showing the distribution of answers from the respondents in percentage.

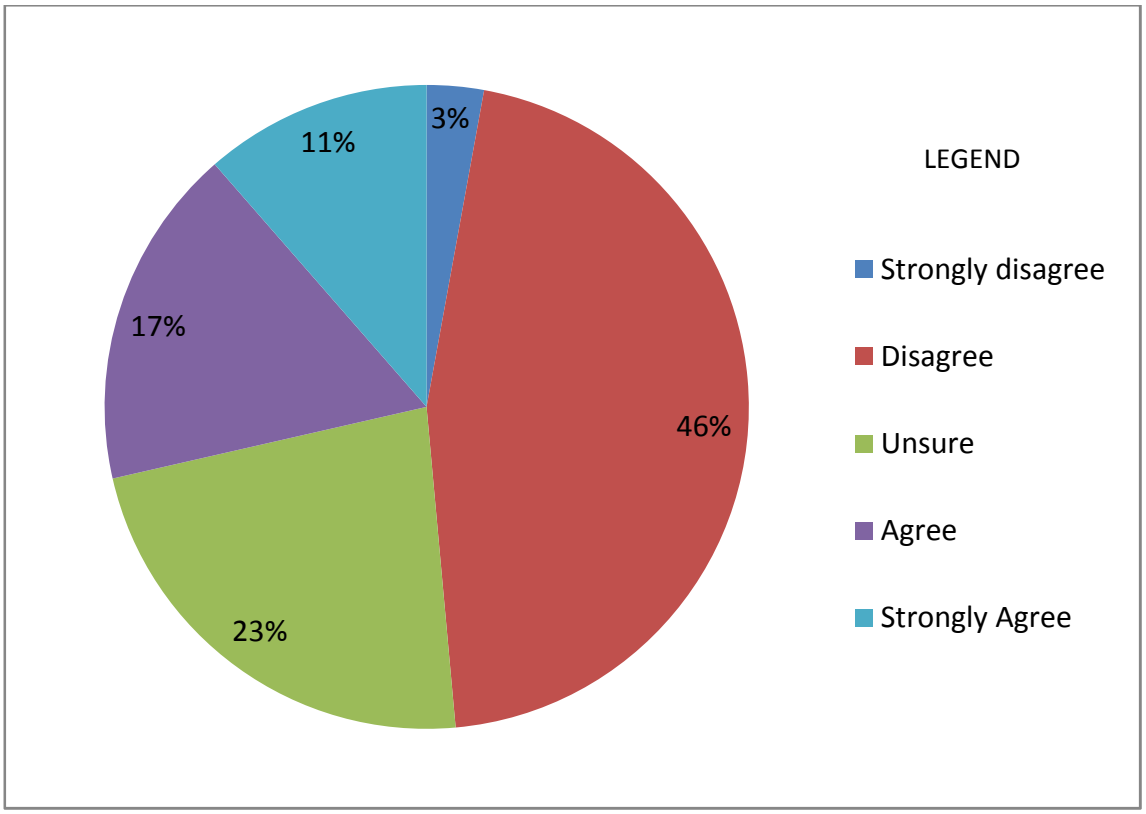

Figure 4.17: Both hand were not stretch out while working

4.2.18 Hands Movement While Doing Work

Next question is about whether the hands of the workers is moving up and down while doing work. The answers shows that 43% of respondents disagree that their hands move up and down when doing work. Meanwhile, 23% of respondents agree that their hands moves up and down when doing work.. But, 20% of respondents are unsure whether their hands move up and downs. This means their hand is static when doing work. This goes the same for 8% of respondents that strongly disagree that their hand moves up aand down during work. So, their hand is fixed at one position during work. 6% of respondents strongly agree that their hands move up and down during work. This means their hand position is not fixed. Below it the pie chart showing the distribution of answers from the respondents in percentage.

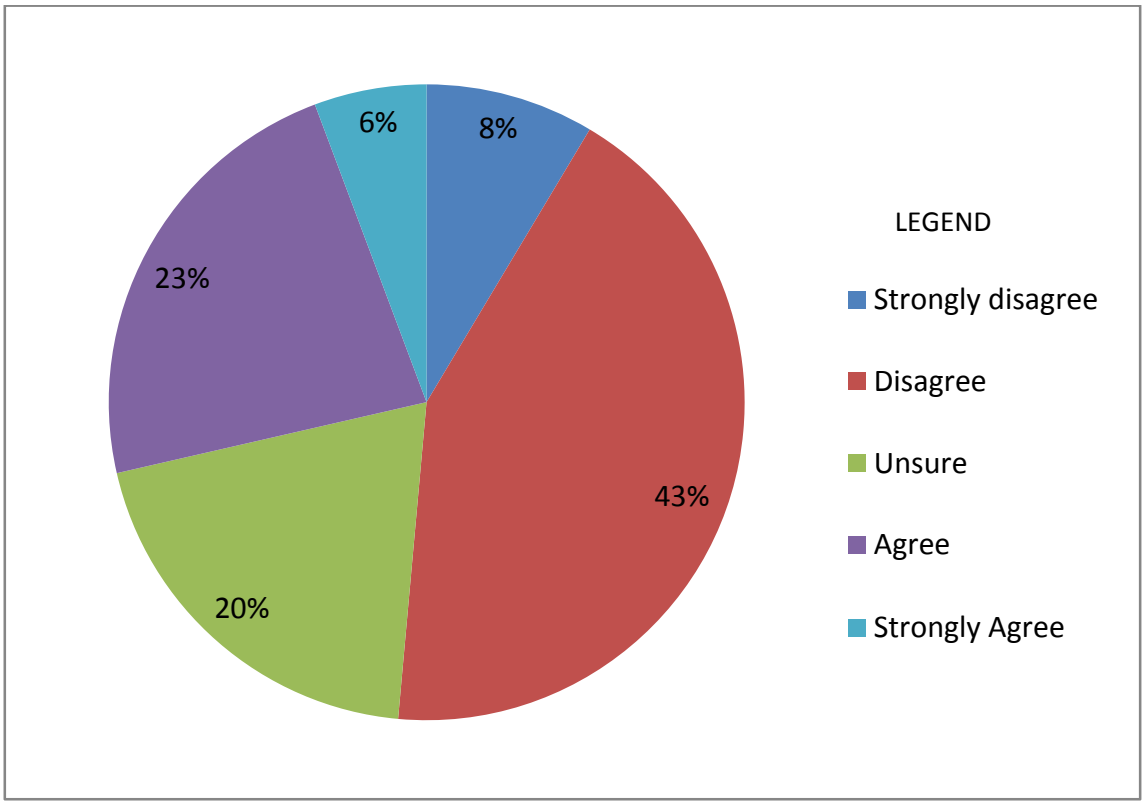

Figure 4.18: Hand movement while doing work

4.2.19 Adjusting the Working Tools to Be Fitted to The Hand

This question will explain about the working tools that need to be adjusted to the worker's hand in order for them to do the job. 51% of respondents agree that the working tools need to be adjusted to their hand in order for them to finish their job. Furthermore, 26% of respondents strongly agree about the matter. On the other hand, 11% of respondents strongly disagree that they need to adjust their working tools to their hand. This followed by another 3% of respondents who strongly agree about adjusting their tools to the hand. Last but not least, 9% of respondents is unsure whether they need to adjust their working tools to their hand or not. From this question we know that the current working tools are not designed to be fitted to the workers. Adjusting the tools during required time and this is not good if it takes too much time but results in poor work quality. Thus, the pineapple peeler should be designed in a way that it does not have to be adjusted to the hand in order to save time. Below is the pie chart showing the distribution of answers from the respondents in percentage.

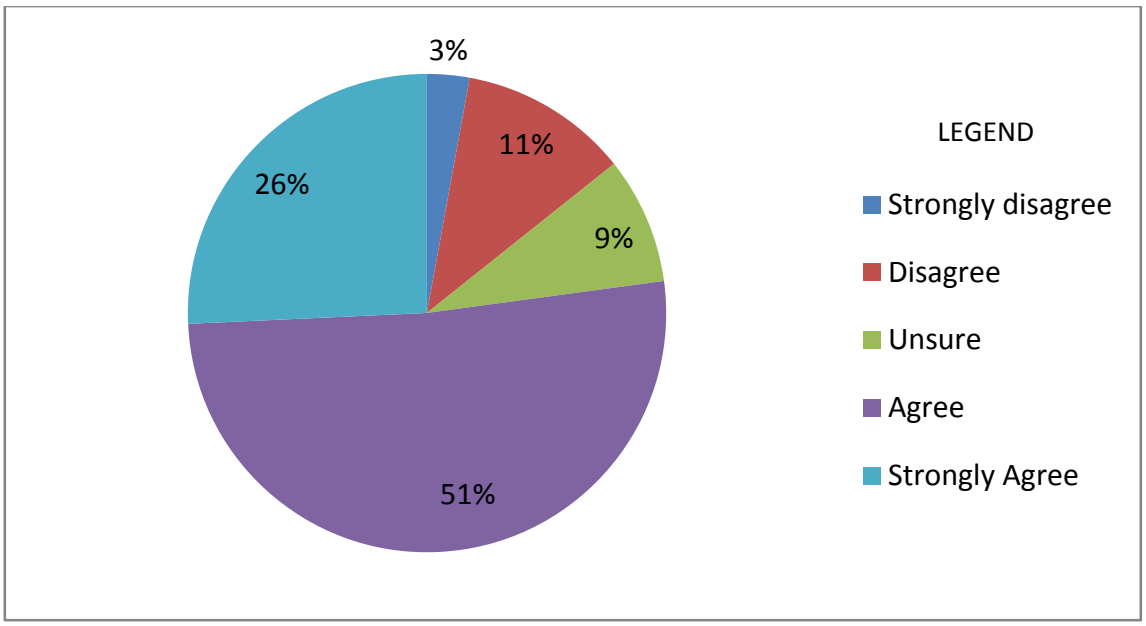

Figure 4.19: Adjusting the working tool to be fitted to the hand

4.2.20 Tools Handle Is Not Big Enough To Be Hold

This question explains about the tools handle size whether it is big enough or not for the workers to hold or grip it. The answers show that 29% of respondents agree that the tools handle is not big enough for them to hold. This means that they are having trouble while doing work because small handle will tend to be loosen from the hand. Furthermore 23% of respondents agree that the tools' handle is big enough for them to hold. 28% of respondents are unsure whether the handle tools is big enough or not. But 14% of respondents disagree that the tools' handle is not big enough for them to hold. This goes the same 6% of respondents who strongly disagree that they tools' handle is not big enough. From the answers, it shows that the workers are currently unhappy with their current working tools. This means the working tools are causing problems to the workers while doing work. As for the design, the peeler's handle need to be designed big enough to be hold. Below is the pie chart showing the distribution of answers from the respondents in percentage.

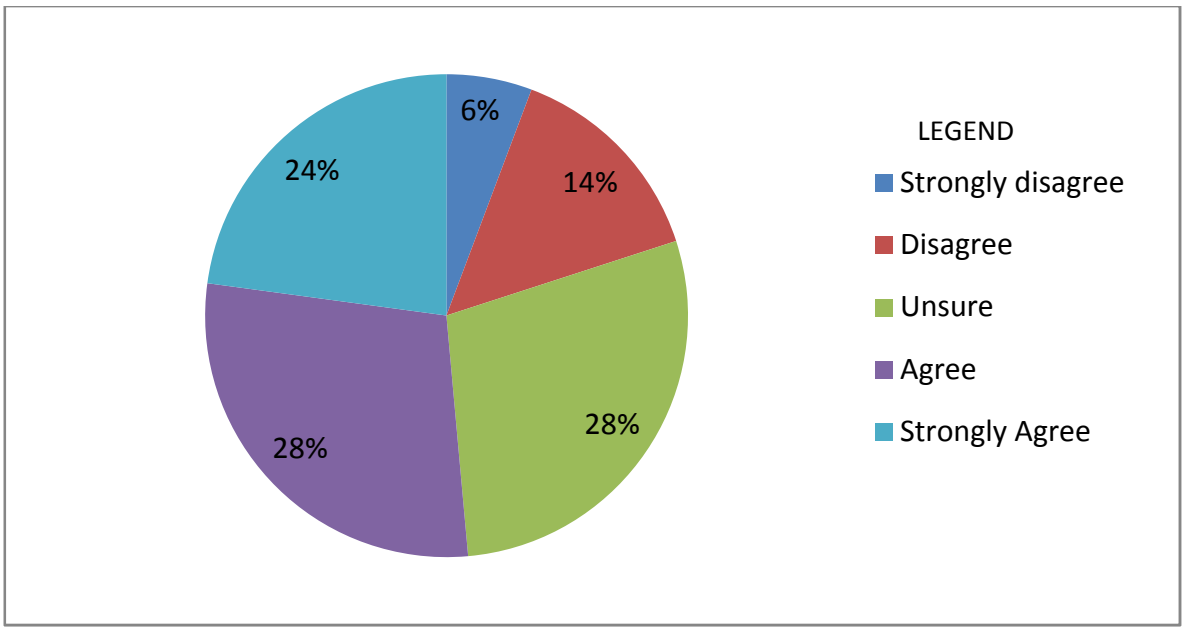

Figure 4.20: Tool's handle is big enough to be hold

4.2.21 Tools' Handle Need To Be Wrap To Comfort The Workers' Palm

Question number 21 is about the tool's handle that needs to wrap in order to give comfort to the workers palm while doing work. The answers shows that 52% of respondents agree that their tool's handle needs to be wrapped. This statement also been supports by another 20% of respondents that strongly agree about wrapping the tool's handle. 14% of the respondents is pretty unsure whether their tool's handle need to be wrap or not. But, 11% of the respondents disagree that they need to wrap their tool's handle to comfort their palm. This goes the same for another 3% of respondents that strongly disagree that they need to wrap their tool's handle to comfort their palm. From the answers given by the respondents, we can determine the pineapple peeler's handle design. Since we know that the previous design gives discomfort to the workers, a type of comforter must be designed to be fitted to comfort the worker's hand while doing work. Below is the pie chart showing the respondents' answers in percentage.

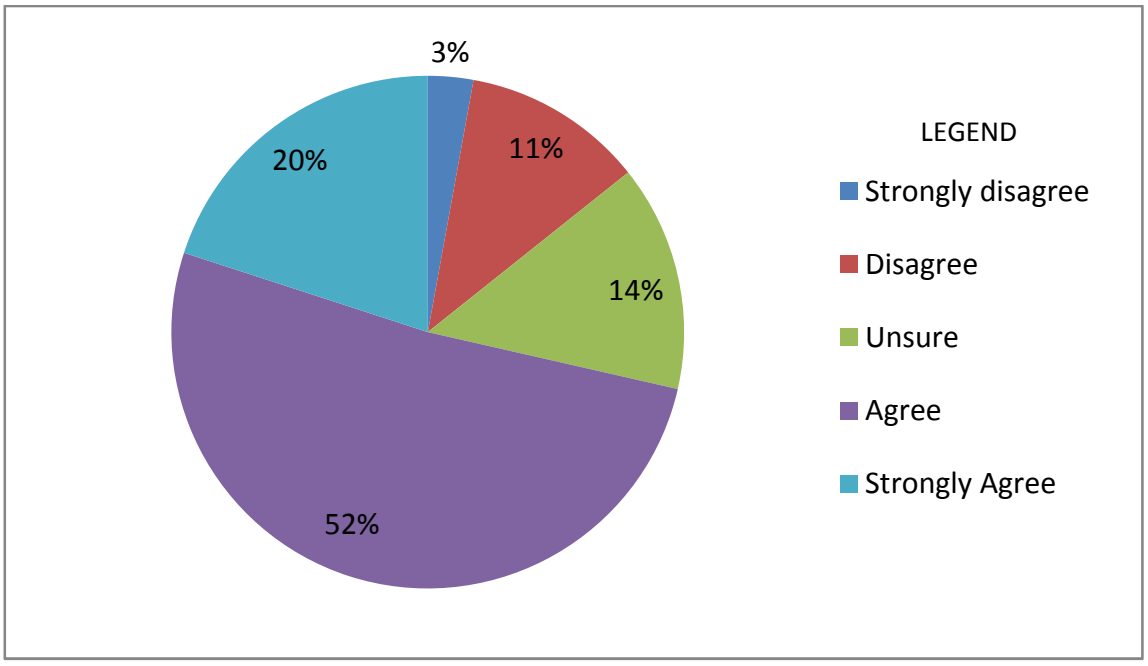

Figure 4.21: Comforting the palm

4.2.22 Forces Use To Move The Work Piece

This question discusses the force usage in moving the workpiece. The answers show that 43% of respondents agree that they need a lot of forces to move the workpiece in order to finish their work. Besides that 20% of the respondents strongly agree that they use a lot of forces to move the workpiece. Another 20% of respondents are unsure whether they use a lot of forces to move their workpiece around. Apart from that, 11% of respondents disagree that they need a lot of forces to move the workpiece around. This goes the same for another portion of 6% of strongly disagreed respondents about the statement of using a lot of force to move the workpiece around. From the answers, we know that the workers usually use a lot of forces to move their workpiece around. Thus, we need to design the workpiece to be light and this will make it much easier to be moved. Below is the pie chart showing the distributions of answers from the respondents in percentage.

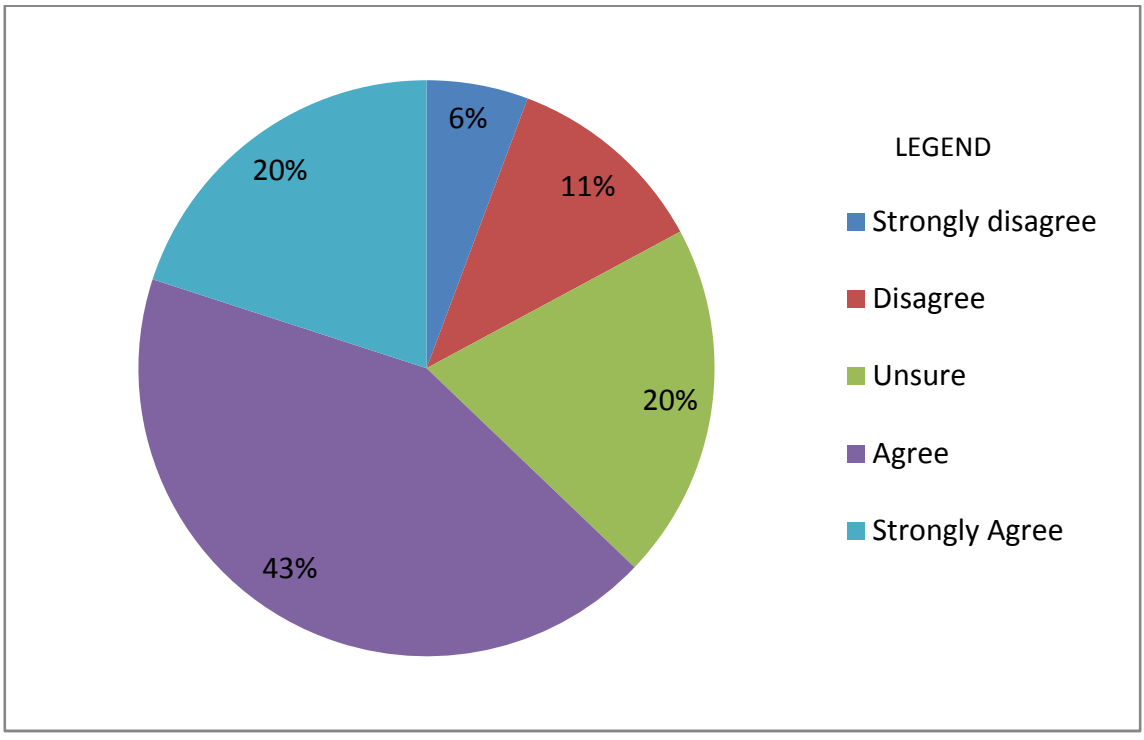

Figure 4.22: Force use to move the workpiece

4.2.23 Current Working Tools Causing Pain To The Body

Working tools that been used by the workers are causing pain among the workers while working will be discussed in this question. The answers show that 37% of the respondents agree that the working tools that they currently use are causing pain to their body. This goes the same for another portion of 20% respondents that are strongly agree that the working tools are causing pain to their body. Besides that, 20% of respondents are unsure whether the working tools are causing pain or not. But 20% from the respondents disagree that the working tools are causing pain to their body. This is also supported by another 3% of respondents that are strongly disagree that their working tools are causing pain to their body. Thus, we must design the pineapple peeler to follow the ergonomics approach and concept to minimize or avoid pain that might occur to the workers' body. Below is the pie chart showing the distributions of answers in percentage.

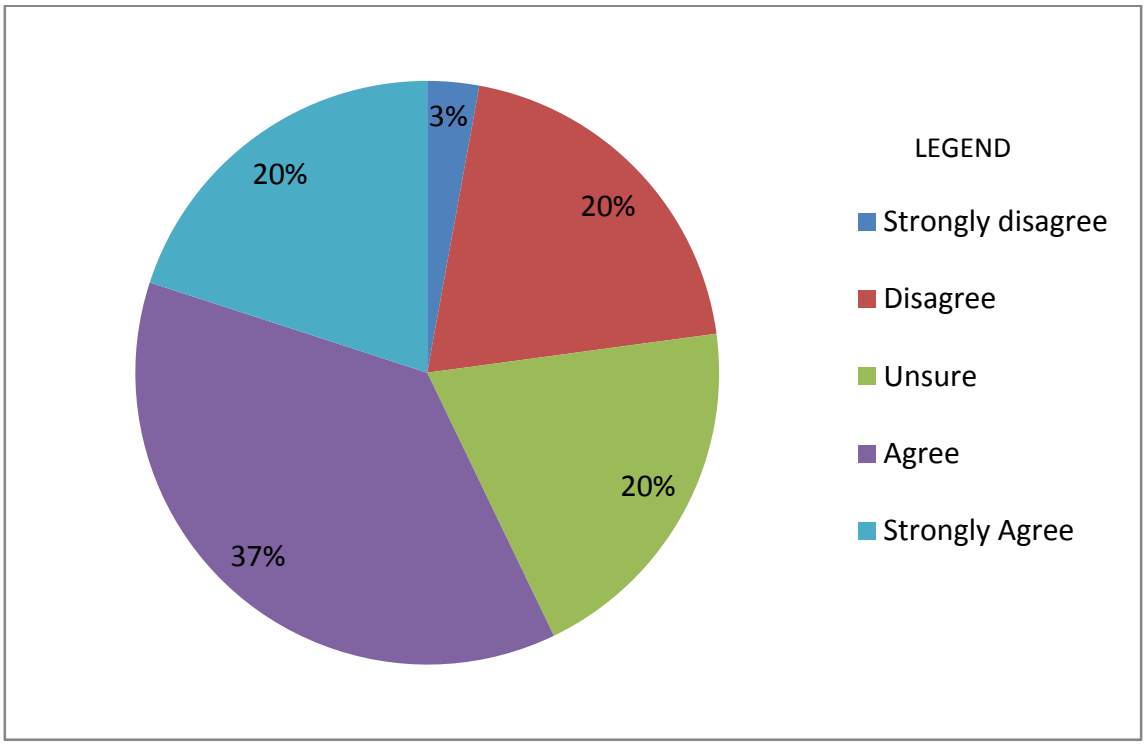

Figure 4.23: Current working tools causing pain to the body

4.2.24 Current Working Tools Causing Discomfort To Body

The answers about the curernt working tools that now being used by the workers are causing discomfort to their body will be discussed thoroughly in this part. The anwers show that 37% of respondents agree that the working tools that they are using are causing discomfort to their body. This also has been supported by another 23% of respondents that strongly disagree that their working tools are the cause of discomfort to their body. Meanwhile, 23% of respondents are unsure whether their working tools is causing discomfort or not. Besides that, 23% of respondents disagree that their working tools cause discomfort pain to their body. From the answers, we know that a lot of working tools that have been used are causing discomfort to the workers' body. Thus, the pineapple peeler needs to be designed to not causing discomfort to the people using it. Below is the pie chart showing the distributions of answers from the respondents in percentage.

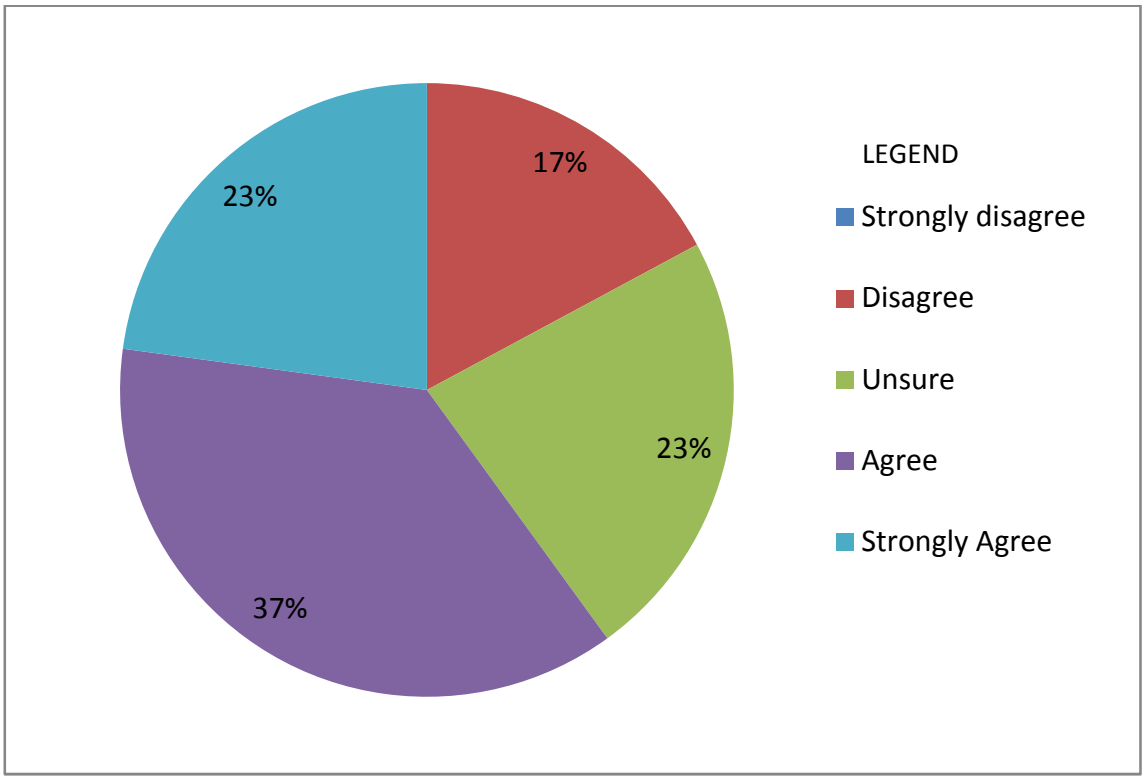

Figure 4.24: Current working tools causing discomfort to the body

4.2.25 Adjusting The Workpiece For Comfort

Question number 25 is about adjusting the workpiece in order for the workers to work with comfort. The answers show that 43% of respondents strongly agree that they need to adjust the position of the working to help them work with comfort. This also has been supported by another 40% of respondents that agree about adjusting the workpiece position. Besides that, 14% of respondents are unsure whether their workpiece need to be adjusted or not. But, 3% of respondents disagree that they need to adjust their workpiece to work with comfort. From this question, we know that a lot of workers need to adjust or move their workpiece before and while doing work. This means we have to design the pineapple peeler to be easy to be lifted and be carried around. Below is the pie chart showing the distributions of answers in percentage.

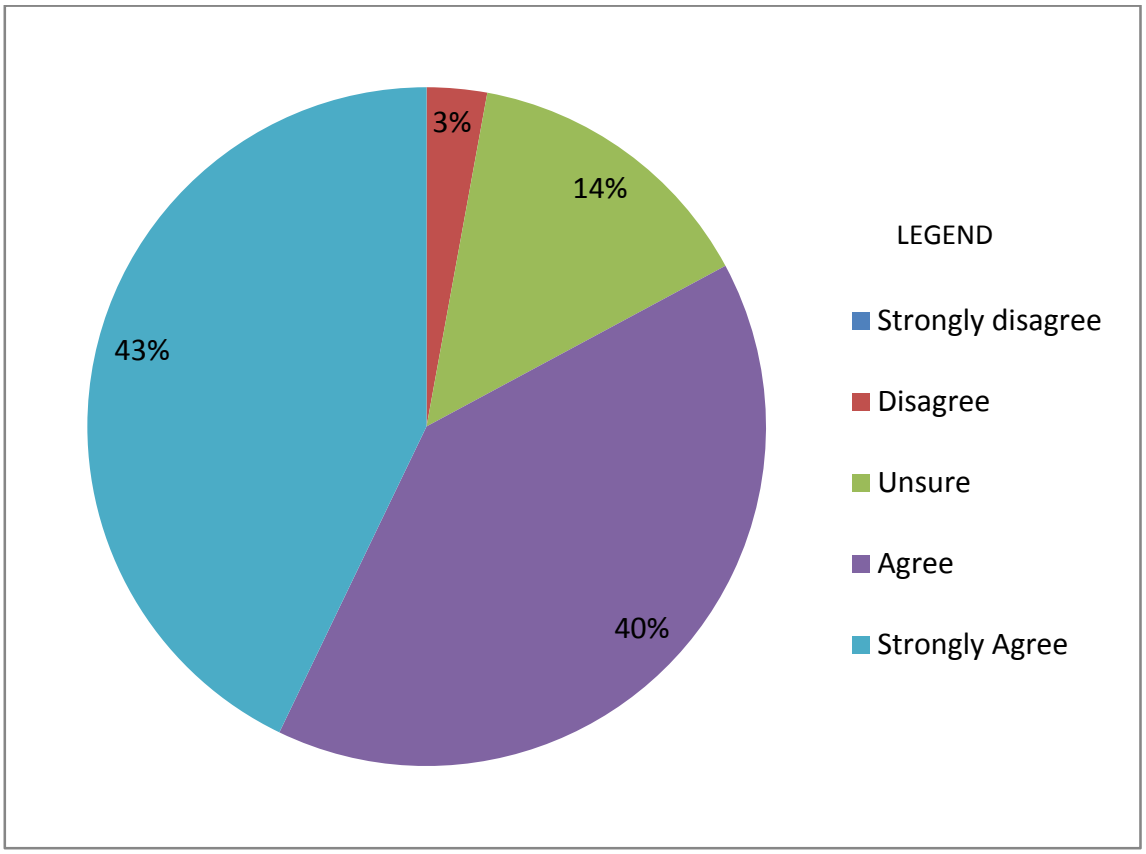

Figure 4.25: Adjusting the workpiece for comfort

4.2.26 Task Perform Produced Vibration

Question 26 is about the task that is performed by the workers is producing vibration or not. 34% from the respondents are unsure whether their task is producing vibration or not. Besides that, 26% of respondents agree that the task that they perform are producing vibration. This is supported by another 23% of respondents that are strongly agree on the question statement. But, 11% of respondents disagree that their task is producing vibration. This goes the same for another 6% of respondents that are strongly agree that their task perform is causing vibration. From the results, we know that not many task perform by the workers is causing vibration. Since the percentage of task perform causing vibration is much higher than not causing vibration, the design should reduce the vibration experience by the workers. This is because vibration can cause MSD since the joint and the hand are used in conducting the job. Below is the pie chart showing the distribution of answers from the respondents is percentage.

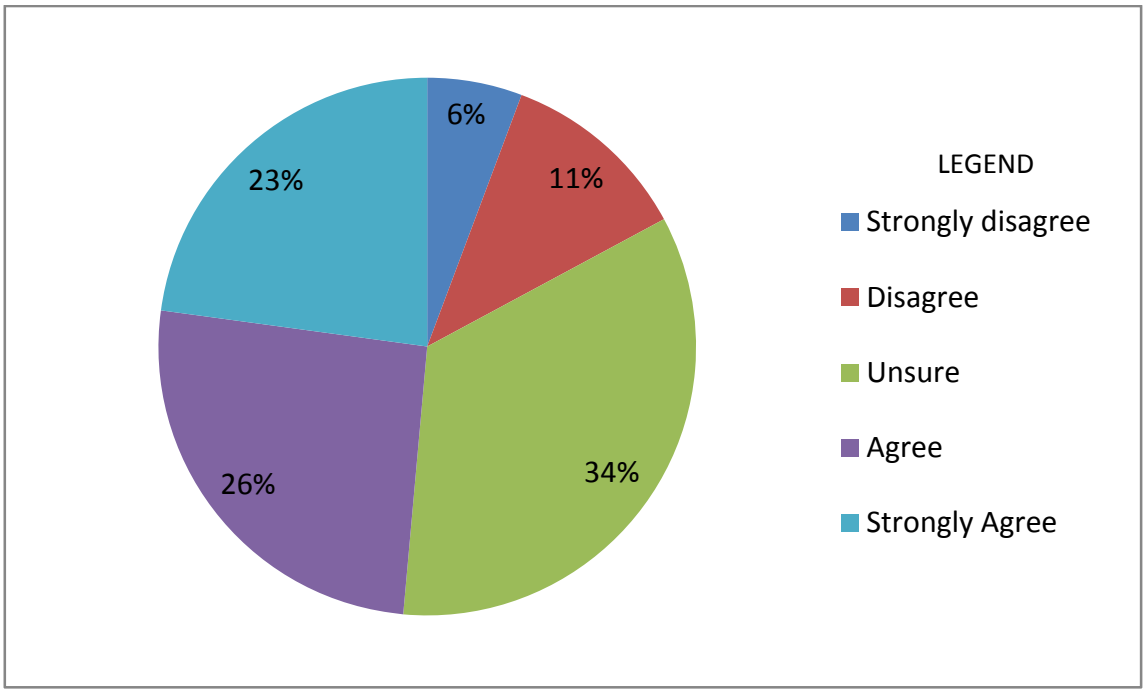

Figure 4.26: Task perform produced vibration

4.2.27 Safisfaction Against Current Working Tools

Question number 27 discussed whether the workers are satisfied with the current working tools that they are using. 37% of respondents agree that they are satisfied with the current working tools. Meanwhile, 8% of respondents strongly agree that they are satisfied with their current working tools. Apart form that, 29% of respondents are unsure whether they are satisfied with the current working tools. But, 23% of respondents disagree that they are satisfied with the current working tools. Furthermore, 3% of respondents strongly disagree that they are satisfied with the current working tools. Although a lot of respondents are satisfied with their current working tools, there are still plenty of room for improvement. This can improve the working tools performance and the workers as well. Below is the pie chart showing the distributions of answers in percentage.

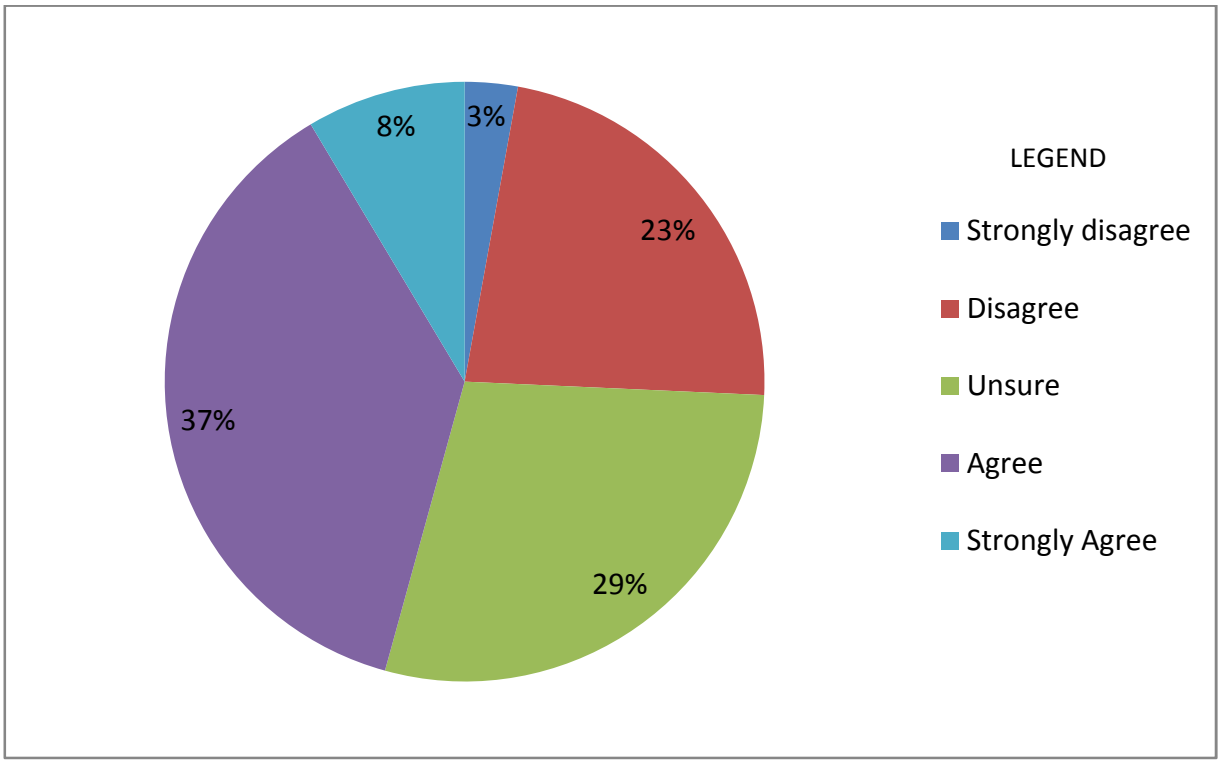

Figure 4.27: Satisfaction against the current working tools

4.3 New Design

The new design of the pineapple peeler will take the consideration of the questionnaire's answers. Figure below shows the new design of the pineapple peeler.

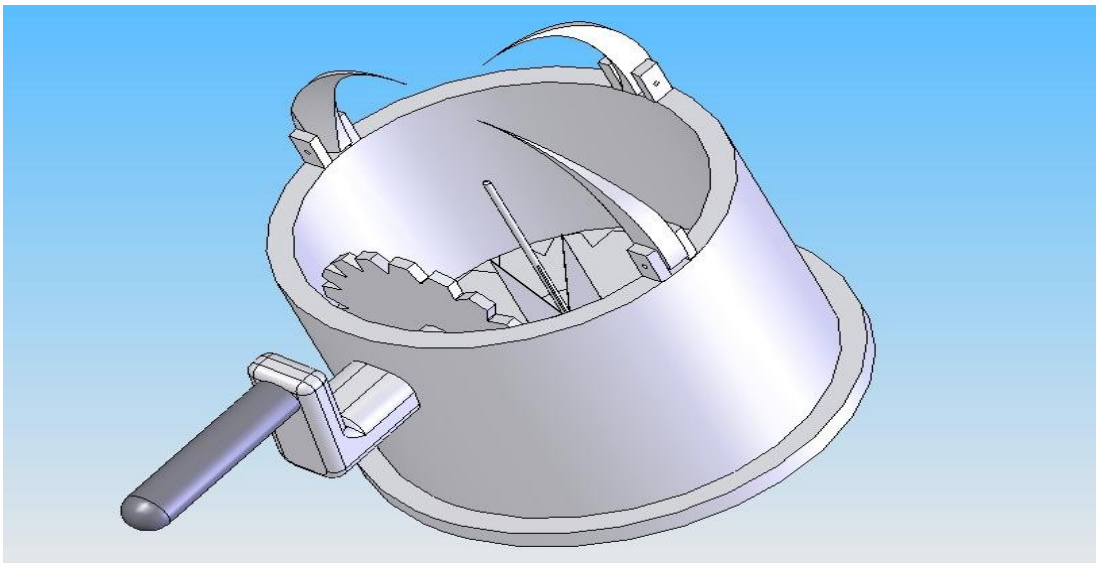

Figure 4.28: Isometric view

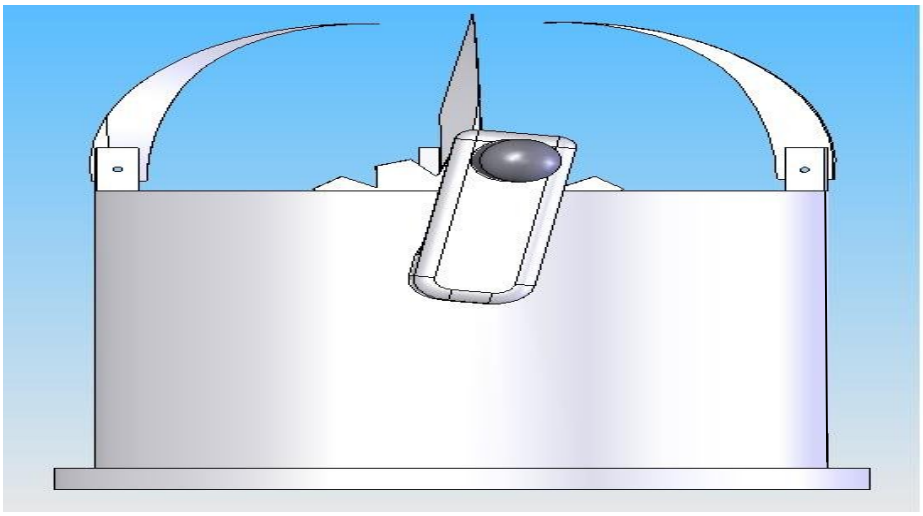

Figure 4.29: Front view

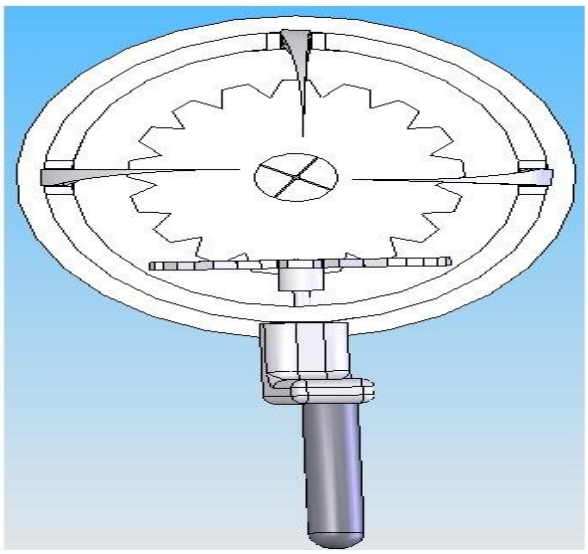

Figure 4.30: Top view

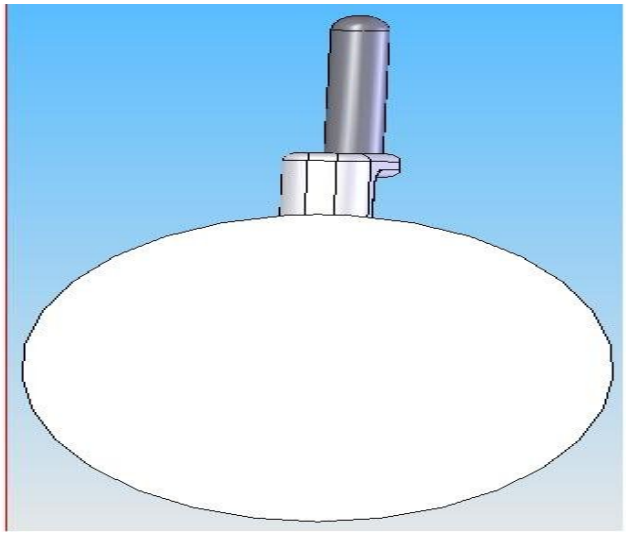

Figure 4.31: Bottom view

4.4 Design comparison

The new design is the improved design based on the preliminary design. Some feature have been updated and improved according to the respondents' expectations. Below is the table of comparison between pre design and the new design.

Table 4.1: Comparison of design

Feature	Pre design	New design	Justifications
Cutting blade	2	3	Increase the cutting area, saves cutting time
Crank handle diameter	50mm	55mm	Improve gripping
Crank handle length	100mm	110mm	More surface coveres on the palm's length
Comforter	Not equipped	Equipped	Comfort the palm while working
Bowl's height	60mm	70mm	More support on the pineapple so that work can be done smoothly

4.5 Analysis of design in Algor

The design has been completed based on the questionnaire that has been distributed. After that, to analyse the design performance based on ergonomics aspects , we use the Algor sofware to subject the design that forces are allowed. The type of analysis is static stress with linear model. The element type has been defined as brick while the material as Aluminium 6061-0. The force has been distributed in Von Misses stress distribution.

For repetitive operations that require finger pinches, keep the forces below 10 newtons (2.2lbf). For gripping actions, keep the required forces to 21 newtons (4.81lbf). These represent 20 percent of the isometric strength of the woman (Chengular et al., 2003).

Since the previous studies indicated that the forces allowed is between 10 to 21 Newton, thus the testing in Algor will be conducted with the value of 10N, 15N, 20N, and 30N. Since we cannot ensure that the user will follow the instructions, so additional force of 40N will also be tested to analyze the effect of the force on the design.

4.5.1 Result for 10N

The result shows that the stress distribution on the handle bar is in the range of 3.4e-10 until 0.776N/mm². This means that when the handle bar is subjected with 10 Newton of force, the effect on the handle bar is small. This goes the same with the hand that is been subjected with the force. MSD occurs when the force is subjected to the palm of the workers during repetitive working is beyond 21 Newton (Chengular et al., 2003). Thus, if the design is experiencing force not more than 21 Newton, we can say that the design satisfies the ergonomics approach in reducing and avoiding MSD to happen. Table 4.1 summarizes all the results and displacements for 10 Newton of force. Figure 4.27 shows the trimetric view of the design after the simulation of the subjected force.

Table 4.2: Von Misses stress for 10N

Load	Type	Min Value	Max Value
10N	Von Misses stress	3.47626e-10N/mm²	2.58814N/mm²

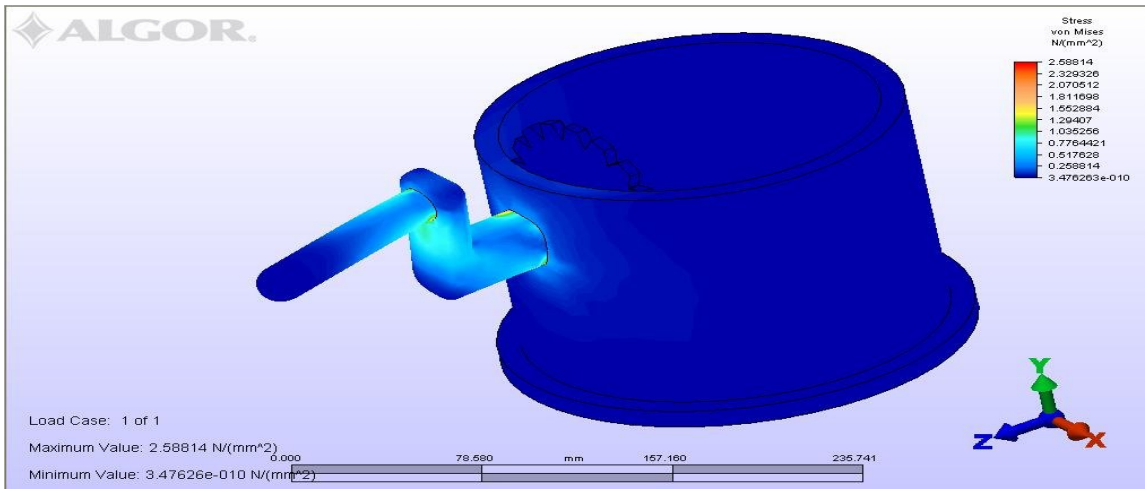

Figure 4.32: Von Misses stress for 10N

4.5.2 Result For 15N

Testing the design for 15 Newton of force had shown that the maximum value of the force distribution on the handle bar is 2.58814N/mm². The minimum force is 5.21426e-10N/mm². This means that when 15N of force is subjected to the handle bar, the force experience by the palm is 3.88221N/mm² for the maximum value. This results prove that the design has produced such small force to the hand. Thus avoiding the chances of developing MSD to the workers. Such large force acting on a human body can cause discomfort or irritations. This phenomenon will lead to MSD in the first place (Lehto, and Buck, 2008). Table 4.2 summarizes all the results while figure 4.28 shows the handle bar after being subjected with 15N of force.

Table 4.3: Von Misses stress for 15N

Load	Type	Min Value	Max Value
10N	Von Misses stress	5.21426e-10N/mm²	3.88221N/mm²

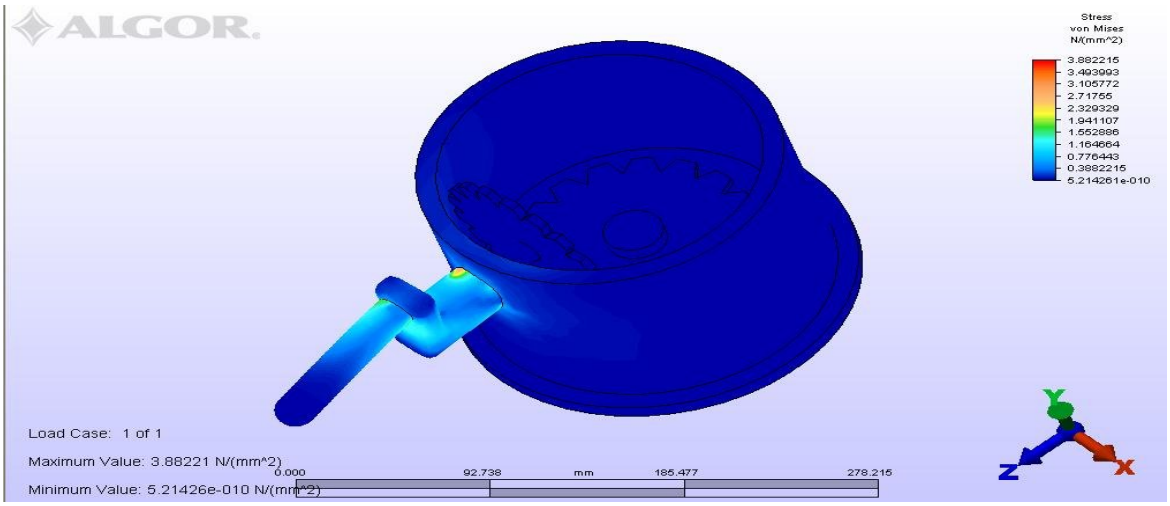

Figure 4.33: Von Misses stress for 15N

4.5.3 Results for 20N

20N of force shows that the maximum force on the handle bar still acceptable according to the ergonomics principle. This is because force exceeding 21N will cause damage to the body of a person if the force is subjected (Chengular et al., 2004). The maximum force at the handle bar for the 21N of force is 7.48817N/mm² while the minimum force is 3.3899e-10N/mm². The force experienced by the palm of the workers eventually will not creating any chances of getting themselves MSD effect. Thus, the design helps the workers to avoid MSD from happening to the workers. Table 4.3 summarizes all the result's data while figure 4.29 shows the visual distributions of force at the handle bar when force is subjected to the design.

Table 4.4: Von Misses stress for 20N

Load	Type	Min Value	Max Value
10N	Von Misses stress	3.3899e-10N/mm²	7.48817N/mm²

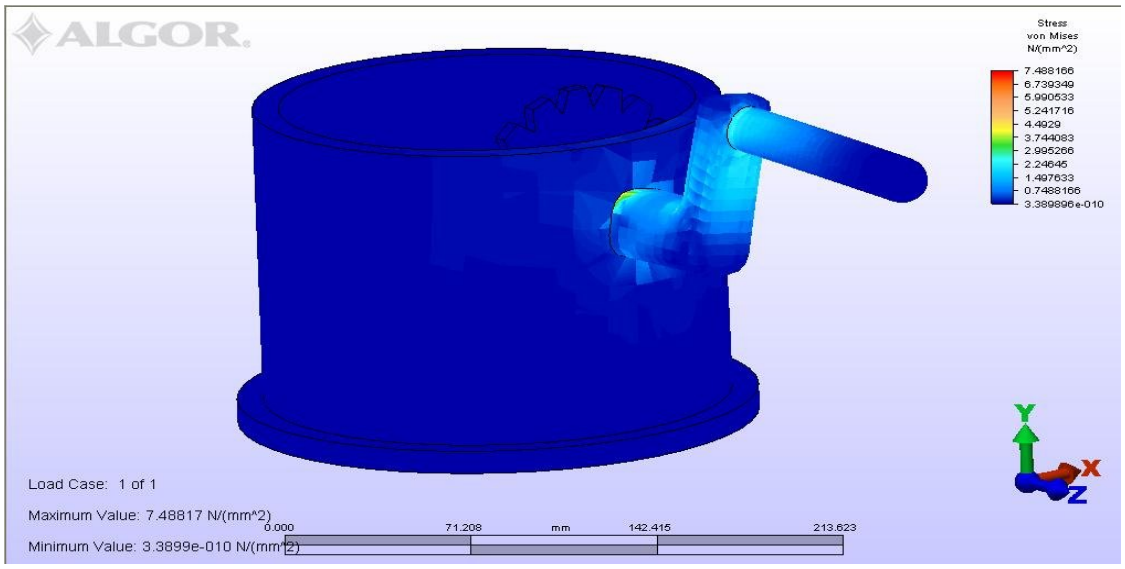

Figure 4.34: Von Misses stress for 20N

4.5.4 Result for 30N

The result for 30N shows that the maximum value for the stress distribution is 7.76443N/mm² while the minimum value for the force is 1.04286e-9N/mm². Although there is an increase in the force subjected to the handle bar, the force still did not exceed the allowed value of force. This shows that the design does avoid MSD from developing when the user use the pineapple peeler. Thus we can conclude that the design does promote safe working style so that MSD can be avoid and the chances of developing MSD in the future can be decreased since the design will be used everyday by the workers. Table 4.4 summarizes all the results for the chosen force while figure 4.30 shows the visual distribution of force at the handle bar.

Table 4.5: Von Misses stress for 30N

Load	Type	Min Value	Max Value
10N	Von Misses stress	1.04286e-9N/mm²	7.76443N/mm²

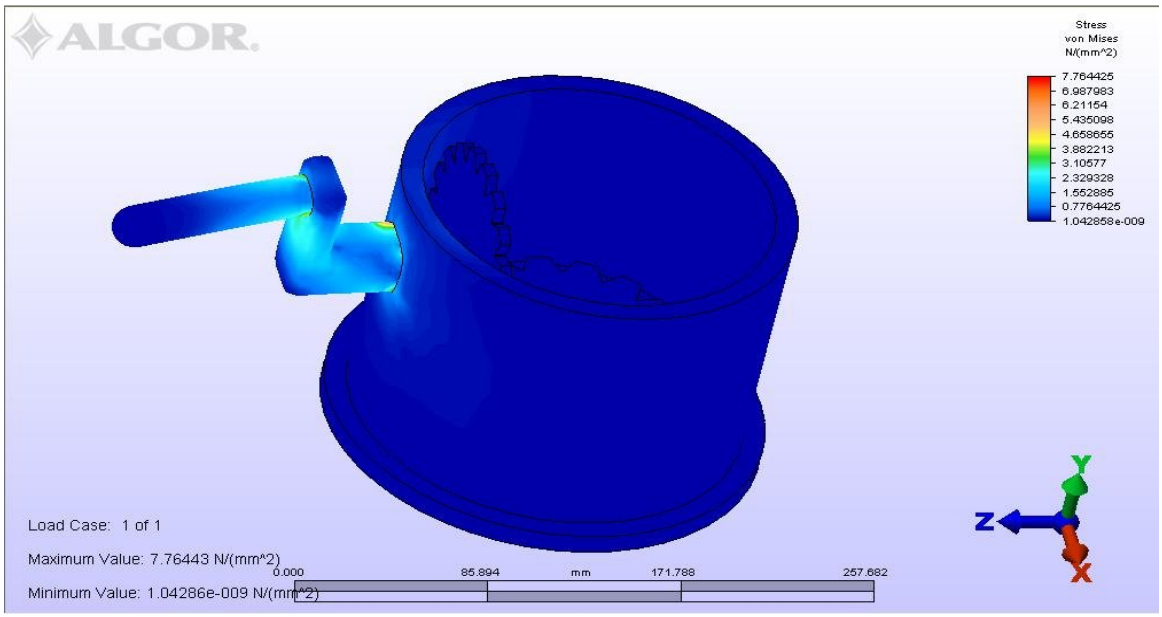

Figure 4.35: Von Misses stress for 30N

4.5.4 Results for 40N

The last force selected to be tested is 40N. This value of force is been selected because the recommended force for repetitive cyclic force to be not more than 30N. The maximum force at the handle bar for this force is 10.3526N/mm² and the minimum value would be 1.3904-9N/mm². This result once again shows that the maximum value of 30N has not been exceeded. Thus showing that MSD can be avoided if the design is been used under the recommended force of usage. Since the design develop stress under the MSD developed force. We can say that the design is safe to be used for everyday use both for domestic and commercial use.

Table 4.6: Von Misses stress for 40N

Load	Type	Min Value	Max Value
10N	Von Misses stress	1.3904-9N/mm²	10.3526N/mm²

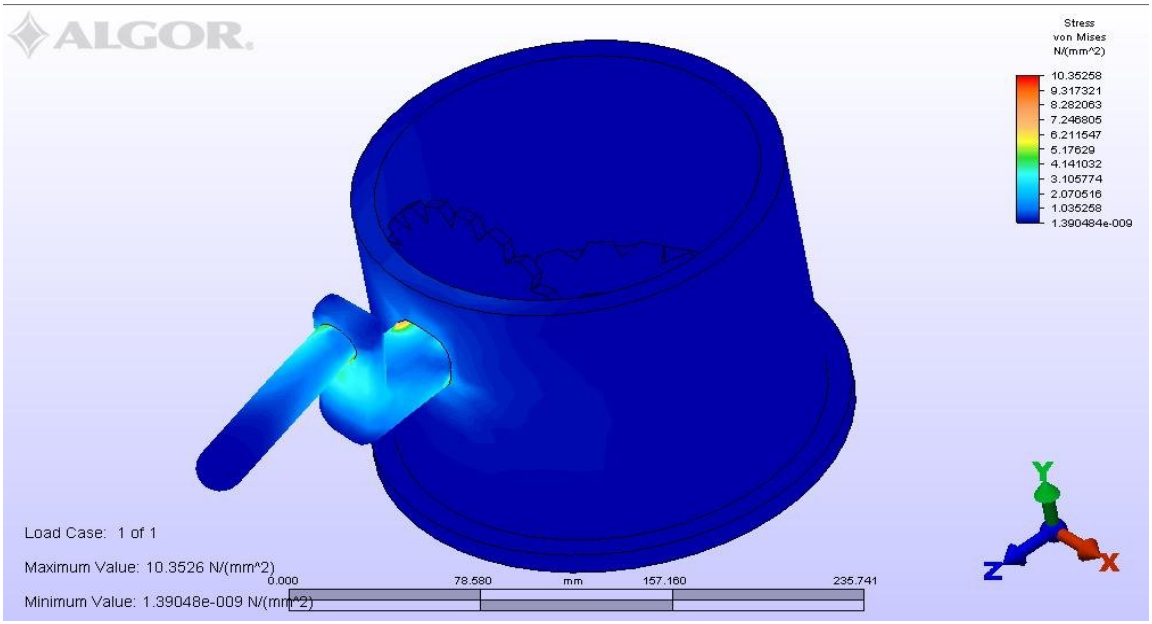

Figure 4.36: Von Misses stress for 40N

4.6 RESULTS AND DISCUSSIONS' CONCLUSION

For the conclusion, the new design seems can withstand to the extended allowed number of force. The maximum number achieved also shows that the design is ergonomics to be used and can control the development of MSD.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

In this chapter, research will be concluded based on the findings and the results that we have done throughout the research. Besides that, the objectives and the purposes of the research will also be evaluated whether they have been achieved or not. This is important so that this research can be improved in the future for the benefits of mankind. Apart from that, the research contribution in terms of theoretical and practical will be concluded since the purpose of this study is also to improve human's health. Recommendations on to improve the research for future study will also be discussed further.

5.2 OBJECTIVES ACHIEVED

The first objective that has been pointed in this research is to design portable pineapple peeler with ergonomics approachs using Solidworks. This objective has been achieved since the preliminary design has been designed and redesigned into a few shape before the final design has been chose based on the ergonomics view. The second objective is to simulate the design in Algor. This is to know how much force the pineapple peeler can withstand. Besides that, we also know that through the simulation, the pineapple peeler does working according to the ergonomics principle. This is because the results that we get from the testing of several forces show the force on the human palm does not exceed the

allowed force by the ergonomics principle. Thus it proves that the design can control MSD among workers.

5.3 CONTRIBUTION OF THE STUDY

The are many contributions of the study. The first one is the usage of the questionaire in asking the public opinion on how a design should be. This is important so that we know what the public wants before the design or the fabrication take place. Besides that, the answers provided can be the guidelines in designing a product so that it satisfies the customer or workers' needs.

The second contributions of the study is in using the ergonomics approach in designing a product or working tools so that we can avoid or reduce the possibility of MSD infection among workers nowadays. The results in chapter four clearly shows that the design of the pineapple peeler exceeded the predecessor in peeling industry that actually causing MSD to the workers. The design produced in this research can control MSD to the user or workers. Thus, using ergonomics designing does benefits mankind in terms of long term health.

The third contribution of the study is the usage of the softwares that helps in doing designing and analysis. The softwares used in this research are Solidworks and Algor had help much during the research. The design can be properly modified according to the workers' needs. The Algor had helped in analyzing the force that the design can withstand without exceeding the force allowed by the ergonomics principle. Both of the software use to help the research to be run smoothly.

In the end, we cannot ignore the human needs in further improving the design. This is because we human always try to satisfies our desire and it is always changing. Research like this must be continuously be done so that more life can be safe and help to improve our quality of working and living.

5.4 LIMITATIONS

There are several limitations that occur during the research. The first one is the lack of ergonomics software. The ergonomics sofware can determine the availability of the product in terms of ergonomics. This is important during preliminary stage that will determine the further development of the product.

Other than that, the fabrication of the product itself was impossible due to the lack of equipment and and facility. Fabrication of a product is essential in determining the fuctionality and performance of the product in real case situation.

Another limitations that happen during the research was getting validation from ergonomics expert. Validation can prove whether the research is on the right track or not. Time constrained and management problem results in unrelevant decision making had cost a lot of time wastes. Due to that, the research is having some problems and the relevancy is only form theoretical view.

5.5 RECOMMENDATIONS

For improvements, an ergonomics software can be used to analyze the design rather than using the Algor software. This is because the ergonomics software is much more accurate and contain relevant data according to the ergonomics principle whereas the Algor only specified on the analyzing the force rather than the ergonomics aspects.

Besides that, fabrication is essential in determining the results of the design. This is because actual movement based on the actual human body can provide sufficient data in improving the design. Data from the questionaire and simulation sometimes can be different in actual situation. Thus, fabrication can improve the research by providing the actual product to be tested.

Furthermore, validation from ergonomics expert can be vital in the research. This is because every work needs to be verified so that we know that the research is on the right track and doing the right thing. Besides that, having validated by the expert will show us what is the problem in the research.

5.6 CONCLUSION

This research has achieved it's objectives in designing a pineapple peeler from ergonomics perspective. The 35 respondents that had given their coorperation are mostly the one who involve in the peeling industry and we can say their answers for the questionnaire is accurate. Futhermore, the research has come up with a design that helps to reduce and avoid MSD among the workers.

The human needs for comfort and satisfaction has change from time to time. It is hard to obtain such exact data on a matter due to the different perspective on how people think of a thing. The research has shown that the current working tools is not safe and it must be improved to save life. Thus, using ergonomics principle and with the helps of todays' leading edge technological software, we can achieve world without fear when working.

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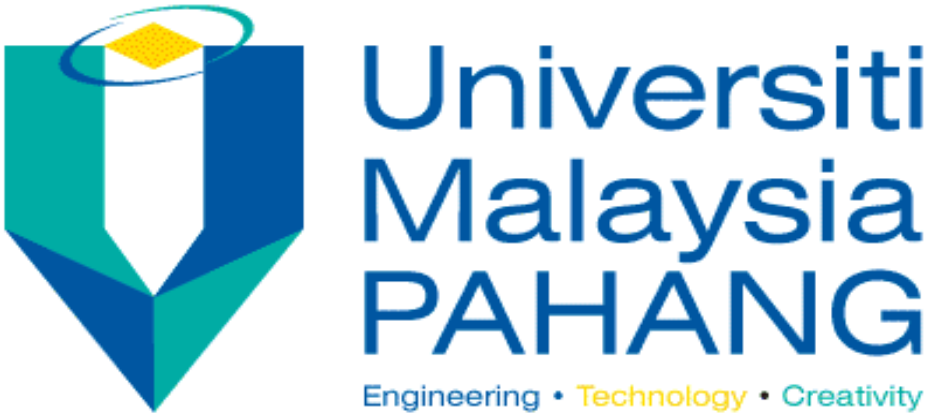


QUESTIONNAIRE ON WORKING ENVIRONMENT AND WORKING ELEMENT FOR DESIGN AND DEVELOPMENT OF PORTABLE PINEAPPLE PEELER: AND ERGONOMICS APPROACH

-This questionnaire will be based on four section. All section is essential in obtaining data for the project. We recommend you to read carefully before answering any question regarding to this project.

Instructions

-Please answer by circling the correct answer. The answer will be based on likert scale. All the meaning for the scale is provided in the questionnaire. Please answer this question base on your true opinion and work routine. We guarantee all your answer will be kept close.

APPENDIX A

ERGONOMICS QUESTIONNAIRE

A. CORRESPONDENT DETAILS

In this part we want to know general information about you. Please sincerely tick to the column below.

1. Age
   <20 __
   21-29 __
   30-39 __
   40-49 __
   50> __

2. Gender
   Male __
   Female __

3. Hours worked per day
   <3 __

4-6 __

7-9 __

>9 __

4. Years in current position

<1 __

2-4 __

4-6 __

7-9 __

>10 __

B. Working style

This section will provide us about your working style. Please answer it sincerely and circle your answers according to the scale below.

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

5.	Your work required repetitive movement	1	2	3	4	5
6.	Break time given is enough for you	1	2	3	4	5
7.	Your jobs requires you to sit for a long time	1	2	3	4	5
8.	Sitting makes you feels uncomfortable	1	2	3	4	5
9.	Moving the workpiece in a certain position is Is required when working	1	2	3	4	5
10.	The upper body needs to be stretch after a period Of time	1	2	3	4	5

C. Body posture

In this section we want to know about your body posture while working that is your body movement. Please circle your answers according to the scale below.

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

11. Your spine is feeling pain due to the work	1	2	3	4	5
12. The upper body is feeling stress due to the work	1	2	3	4	5
13. Your working position is the same throughout the working period.	1	2	3	4	5
14. Sitting position is the best position when doing work	1	2	3	4	5
15. The body needs to be bend when doing work.	1	2	3	4	5
16. All the force are being concentrated to the hand When doing work.	1	2	3	4	5
17. The upper arms need to be close to the body and Not extended outward.	1	2	3	4	5
18. Your hand is move up and down when doing work	1	2	3	4	5

D. Working accessories

In this section we want to know about the tools that you use during working. Please circle the answer that you feel suitable by circleling your answers according to the scale below.

1	2	3	4	5
Strongly disagree	Disagree	Unsure	Agree	Strongly agree

19. The tools need to be adjusted to your hand.	1	2	3	4	5
20. The tools handle/spindle is not large enough for	1	2	3	4	5

You to hold.					
21. The handle/ spindle needs to be wrap with soft material for gripping comfort	1	2	3	4	5
22. A lot of force needed to move the tools	1	2	3	4	5
23. The working tools is causing pain to your body parts	1	2	3	4	5
24. The tools is causing discomfort to your body part	1	2	3	4	5
25. The tools and material position needs to adjusted to fits your height.	1	2	3	4	5
26. Task perform produce vibrations	1	2	3	4	5
27. Current working tools satisfies you	1	2	3	4	5

We sincerely appreciate your time and cooperation. Please check to make sure that you have not skipped any questions. Thanks you.

APPENDIX B

Descriptive answers for questionnaire section A

Demographic	Category	Frequency	Percentage
Age	<20	5	15
	21-29	24	70
	30-39	5	15
	40-49	0	0
	50>	0	0
Gender	Male	24	69
	Female	11	31
Hours work per day	<3	7	18
	4-6	8	20
	7-9	24	62
	>10	0	0

Years of working	<1	10	29
	2-3	14	40
	4-6	4	11
	7-9	1	9
	>10	10	11

Descriptive answers for questionnaire section B

No of question	Strongly disagree		Disagree		Unsure		Agree		Strongly Agree	
	N	%	N	%	N	%	N	%	N	%
5	1	3	2	5	9	26	16	46	7	20
6	1	2	4	11	4	11	21	57	5	19
7	1	3	4	12	6	17	13	37	11	31
8	3	9	6	17	6	17	11	31	9	26
9	2	6	4	11	3	9	11	31	15	43
10	0	0	2	6	2	6	17	48	14	40

Descriptive answers for section C

No of question	Strongly disagree	Disagree	Unsure	Agree	Strongly Agree

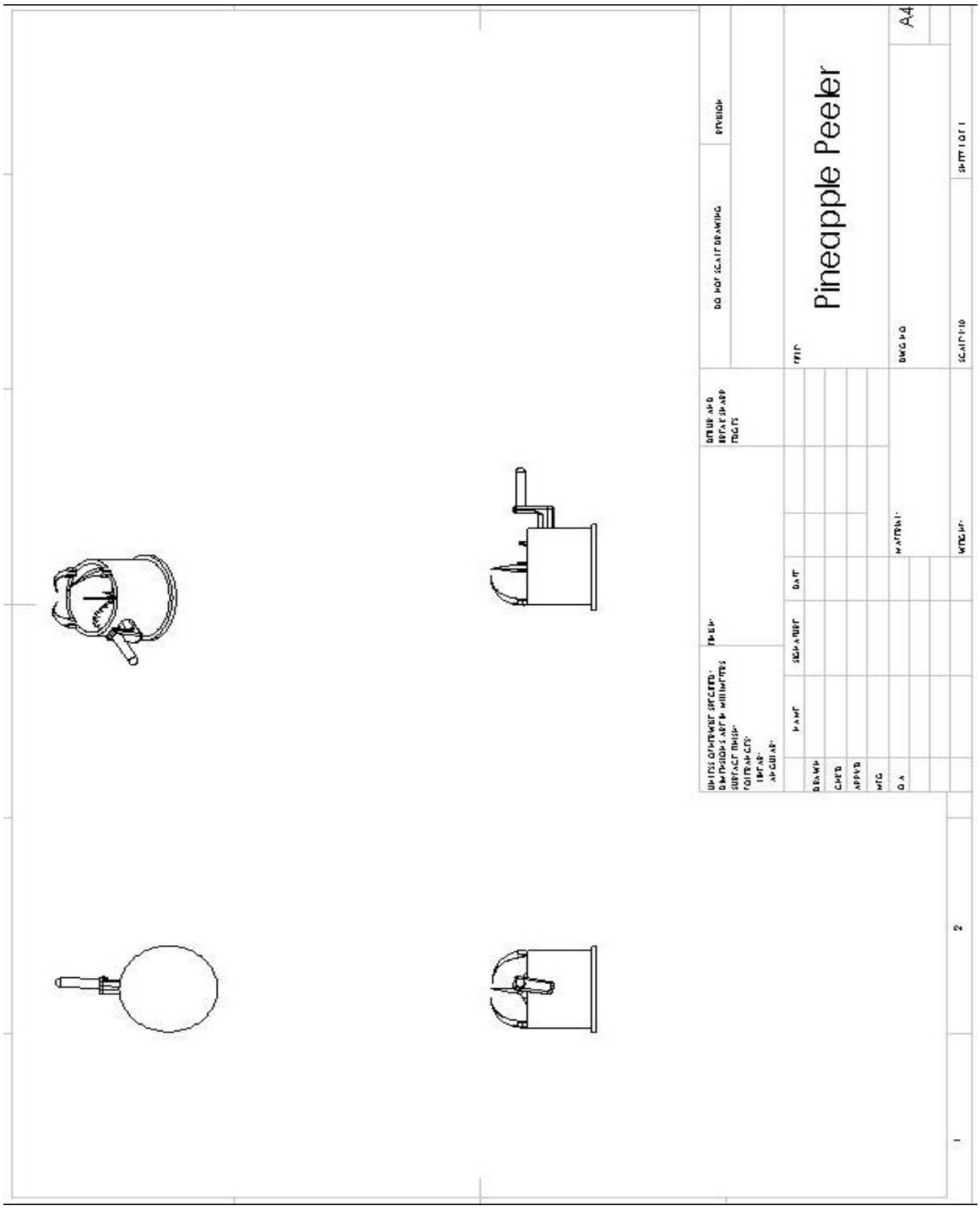
	N	%	N	%	N	%	N	%	N	%
11	1	3	1	3	2	6	18	51	13	37
12	1	3	3	9	6	17	11	31	14	40
13	2	6	3	8	9	26	15	43	6	17
14	1	3	4	11	10	29	18	51	2	6
15	0	0	9	26	9	26	14	40	3	8
16	2	6	5	14	7	20	18	51	3	9
17	1	3	16	46	8	23	6	17	4	11
18	3	8	15	43	7	20	8	23	2	6

Descriptive answers for section D

No of question	Strongly disagree		Disagree		Unsure		Agree		Strongly Agree	
	N	%	N	%	N	%	N	%	N	%
19	1	3	4	11	3	9	18	51	9	26
20	2	6	5	14	10	28	10	29	8	23
21	1	3	4	11	5	14	18	52	7	20
22	2	6	4	11	7	20	15	43	7	20
23	1	3	7	20	7	20	13	37	7	20
24	0	0	6	17	8	23	13	37	8	23
25	0	0	1	3	5	14	14	40	15	43
26	2	6	4	11	12	34	9	26	8	23
27	1	3	8	23	10	29	13	37	3	8

APPENDIX C

Technical Drawing


Pineapple Peeler
A4