DESIGN AND DEVELOPMENT OF DURIAN PEELER: AN ERGONOMICS APPROACH

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DESIGN AND DEVELOPMENT OF A DURIAN PEELER: AN ERGONOMICS APPROACH

SITI NORAZILA BINTI ZAHARI

Thesis submitted in fulfillment of the requirements
for the award of the degree of
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FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled *"Design and development of durian peeler: an ergonomics approach"* is written by *Siti Norazila binti Zahari*. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering

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SUPERVISOR'S DECLARATION

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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 to design a durian peeler machine that followed the ergonomic criteria.The problem statement for this study is workers who manually peeling durian can lead to MSD problem. Regarding the problem statement, the objective of this study is to design a durian peeler with an ergonomics approach using Solidworks software, develop a prototype of durian peeler machine and perfomed a simulation of the prototype. For the methodology, the design will be based on are data gathered from the literature review. The design based on the principles of ergonomics. The prototype of durian peeler develops using rapid prototyping process and simulates the prototype using ALGOR. For the result, a prototype is developed and simulation for the critical part of durian peeler. From the prototype of durian peeler, it showed some problem because of the process rapid prototyping that produce a solid design of prototype. For the validation of durian peeler, it involved working table and supporting bar. For the working table, the analysis of strength of material used in for the construction. Two different materials which are stainless steel AISI 304L AND steel ASTM A36. The stainless steel AISI 304L with higher shear modulus of elasticity is more suitable for the construction of durian peeler. For the supporting bar, the analysis of different forces had been applied. The forces that being applied shown that the ability of the working table to support the force. For the conclusion, the design of prototype of durian peeler using Solidwork had achieved. The prototype of durian peeler and simulation of durian peeler also been done.

ABSTRAK

Kajian in adalah mengenai mereka bentuk sebuah mesin pengopek durian yang memenuhi ciri-ciri ergonomik. Permasalahan yang timbul untuk kajian ini adalah,pekerja yang meggunakan kaedah mengopek durian secara manual meningkatkan potensi "MSD". Berdasarkan daripada permasalahan yang dibangkitkan, objektif kajian ini telah ditetapkan iaitu mereka bentuk sebuah mesin pengopek durian yang menenuhi ciri-ciri ergonomic, membuat prototaip pengopek durian dan membuat simulasi prototaip pengopek durian. Kaedah yang digunakan dalam kajian ini, reka bentuk pengopek durian adalah berdasarkan hasil pembacaan.mengenai prinsip-prinsip ergonomik Prototaip pengopek durian dibuat melalui proses *Prototaip pantas* dan simulasi menggunakan *ALGOR*. Hasil daripada kajian, proses *Prototaip pantas* dan simulasi untuk bahagian penting pengopek durian dapat dibuat. Melihat daripada prototaip pengopek durian, ia menunjukkan sedikit masalah kerana proses prototaip pantas yang menghasilkan pengopek durian yang dibina daripada bahan yang padat. Untuk validasi pengopek durian, ia melibatkan bar meja kerja dan bar penyokong. Untuk meja kerja , analisis kekuatan material yang digunakan untuk pembinaan. Dua bahan yang berbeza iaitu besi tahan karat AISI 304L AND besi ASTM A36. Besi tahan karat AISI 304L yang mempunyai modulus ricih bagi keanjalan bahan yang tinggi lebih sesuai untuk pembinaan pengopek durian. Bagi bar penyokong pula, daya yang berbeza dikenakan. Daya yang dikenakan untuk menguji keupayaan bar penyokong untuk menampung daya. Untuk kesimpulan, rekabentuk pengopek durian menggunakan perisian ALGOR dapat dicapai. Prototaip pengopek durian dan simulasi juga telah dilaksanakan.

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E	Modulus of elasticity
σ	Stress
$\in$	Strain

LIST OF ABBREVIATIONS

MSD	Musculoskeletal disorders
SME	Small and medium enterprise
MARDI	Malaysian Agricultural Research and Development Institute
IEA	International Engineering Association
EPA	European Productivity Agency

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The durian fruit (*Durio Zibethenus Murr*) is one of the most famous seasonal fruit in tropical Asia. It is a climacteric fruit (Tongdee et al. 1990 and Booncherm and Siripanich, 1991) belonging to the family Bombacaceae. In the family of durio, it consists of 27 species in which six produced edible fruit. Nicknamed 'King of Fruits'; durian is highly valued in Southeast Asian countries. Durian has a very distinguished smell and its skin is thorny and hard. The dimension of a durian fruit is about fifteen to thirty centimeters and its weight is about three kilograms. Durian flowers bloom in a cluster and there are about three to thirty identical clusters borne on its trunk and large branches. Every flower has petals and about five to six petals. Durian is round although the oblong shape is not irregular. The shells are green or brown while its flesh is luminous yellowish or reddish color.

In ASEAN countries, the durian fruit that originating in Malay Peninsula grown commercially. In Southeast Asia, particularly Malaysia, Indonesia, Thailand and Philippines, durian grows in warm, wet conditions of the equatorial tropics and cultivated. Although there are more than 100 durian clones registered by the Malaysian Agriculture Department, it is only about 80% of the total area is planted with clones (Voon et al., 2007).

Durian is rich in sugar. It is also rich of vitamin C, tryptophan, potassium, carbohydrates, fats as well as proteins. Health professionals frequently recommend it as an effective source for taking in raw fats. However, some point out that as the durian contains a high amount of fatty acids it is advised to limit its consumption. Malaysian uses its leaves as well as roots to produce a decoction for fever. A research from University of Tsukuba reveals that durian fruit has significant power to detoxify the body.

Durian's skin is very thorny and hard and usually we were having a problem to peel a durian's shell. Traditionally, we were using a sharp knife or cleaver to penetrate through the durian shells compartment and peel the shell out. Another problem is the parabolic shape of durian that makes it difficult to hold when we want to peels the shells out. We also need to apply high force to peel durian's shell put. The risk of injury during peel operation is high that caused by the sharp knife used and our hands and can be injured by the thorn skins of durian itself.

Due to these problems, the durian peeler was designed and developed from time to time. One of them is the students from Pusat Latihan Teknologi (ADTEC) in Johor designed a durian peeler based on method and mechanism that is suit to anybody that cannot peel the durian peeler manually using sharp knife. This durian peeler can minimize the hand injury due to the minimum usage of physical energy. Their design and fabrication of durian peeler using the component that can be assemble or disassemble and easily transported to any places.

Even though durian peeler machine had been developed, the current durian peeler machine still not follows the ergonomics approach of their design. The current durian peeler machine only considered about the safety during peeling session and minimized the energy used in order to save time and budget for the company production.

In this study, ergonomics design being considered with regard to productivity, health and safety as well as injury prevention such as musculoskeletal problem. A musculoskeletal disorder (MSD) is an injury that developed in the soft tissue structures of the body due to repeated or prolonged ergonomics exposures. In this study, ergonomics design being considered with regard to productivity, health and safety as well as injury prevention such as musculoskeletal problem. A musculoskeletal disorder

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1.2 PROJECT OBJECTIVES

There are several objectives that have to be achieved from this project:

(i) To design a durian peeler with ergonomics approach using Solidwork

(ii) To make a prototype of durian peeler machine using Rapid Prototyping machine (3D Printer)

(iii) To validate the durian peeler machine using simulation.

1.3 PROJECT SCOPES

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

(i) The developed durian peeler is only prototype and is not readily functional as a commercial product.

(ii) The validation of the durian peeler is considered precise.

1.4 PROJECT ASSUMPTIONS

This thesis based on certain assumption

(i) All anthropometry data are taken from Thailand anthropometry (Juruwan Klamklayaet al, 2006)

(ii) Dimension for typical durian size is 30 centimeters in length and 15 centimeters in diameters based on Malaysian Agricultural Research and Development Institute (MARDI).

(iii) Average durian weight is 1 to 3 kg (MARDI).

(iv) Machine is only for Small and Medium Enterprise (SME).

(v) This machine is only used by the operator aged 18-25. This is due to the anthropometry data that are used for this study is only vary between aged 18-25.

1.5 PROJECT BACKGROUND

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

1.6 THESIS ORGANIZATION

This thesis will be divided into five chapters. On the first chapter, it discuss about introduction and general information of the thesis, briefing about the project's idea and some acknowledgement about the durian peeler. There will also include the problem statement, scopes of the project and objectives included.

In the second chapter is the literature review. This chapter will discuss generally about the durian peeler and previous study about the ergonomics. In addition, this chapter contains the main idea of the fabrication process and the material selection that will be used in the development of the product. Some common information about the validation is also stated.

For the third chapter is the methodology. This chapter will discuss about the method we used and the progress of the project. This project used Solidwork in the designing process and Rapid Prototype machine in the making of the prototype.

Then, the fourth chapter is all about the analysis of the processes, results and discussion. For this the chapter, the results will be shown.

Finally, the last chapter is for the conclusion. The problems arise and the recommendations are also stated in this chapter where it is useful and important for further study of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to collect the information from the journal, book and article that are related to ergonomics study and manufacturing process that involved in this project. Basically, this chapter has been divided into several sections. For the first section of this literature review, it will cover all about ergonomics including background history, definition and development of product based on ergonomics approach. Second section will review about the process and machine involved for making the prototype of the machine. The third section will be discussed briefly about the system that being applied for blade mechanism in the durian peeler machine. The last section is about the validation of the durian peeler via simulation. All the sources for this chapter are from the journal of Science Direct and Scopus, books, article and newspaper.

2.2 ERGONOMICS

This section will discuss about ergonomics including the background history of ergonomics and definition of development of product based on ergonomics approach that basically having the basic principles.

2.2.1 Ergonomics: History

Contemporary ergonomics disciple introduced independently by Murell in 1949 was viewed at that time as an applied science, a technology and sometimes both. British scientist founded the Ergonomics Research Society in 1949. The development of ergonomics internationally can be linked to a project initiated by the European Productivity Agency (EPA), a branch of the organization for European Economic Cooperation, which established a human factor Section in 1955 (Salvendy, 2006).

Under EPA project in 1956, specialist from European countries visited United States of America to observe human factors research. A steering committee being formed consisting of work scientist that were charged with developing specific proposal for an association. The committee decided to adopt the name International Ergonomics Association. The steering committee designated itself the Committee for International Association of Ergonomics scientist and G.C. E Burger elected as its first president, K. U. Smith as a treasurer and E. Grandjean as secretary. On 6th April 1959 at a meeting in Oxford, England, Grandjean declare the foundry of the International Engineering Association (IEA).

2.2.2 Ergonomics: Definition

Ergonomics is the study of work was originally defined and proposed by Polish Scientist B. W Jastizabowski as a scientific discipline with a very broad scope and wide range of interest and application, encompassing all aspects of human activities including labor, entertainment, reasoning and dedication. Ergonomics is a physical aspect of work meanwhile human factor is a perception and cognition.

From the definition of International Ergonomics Association defines ergonomics (human factor) as the scientific discipline concerned with the understanding of the interactions among human 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. Ergonomics disciplines promotes a holistic, human centered approach to work systems design that consider physical, cognitive, social, organizational, environmental and other relevant factors.

There are three types of ergonomics which are physical, cognitive and organizational. Physical ergonomics is concerned primarily with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity (Karwowski, 2006). Physical ergonomics usually best used to describe the physical injuries resulting from over use of certain muscles, joints, and tendons, as well as strain to the eye in the workplace. Most common example of physical ergonomics is repetitive strain injuries when using computer because of the physical strain of keyboarding, mousing, and viewing the computer screen.

Cognitive ergonomics focused on mental processes such as perception, memory and information processing, reasoning and motor response as they affect interactions among humans and other element of system (IEA, 2000) Example of cognitive ergonomics applications include designing a software interface to be "easy to use," designing a sign so that the majority of people will understand and act in the intended manner, designing an airplane cockpit or nuclear power plant control system so that the operators will not make catastrophic errors. Cognitive ergonomics also played a vital part in the design of complex, high technology or automated systems.

Organizational ergonomics also known as macro ergonomics is concerned with the optimization of socio-technical system including their organizational standard, policies and processes. Usually this types of ergonomics deals with the woks environment such as shift work, scheduling, job satisfaction, motivation, supervision, teamwork, telecommuting, and ethics.

2.2.3 Ergonomics: Development of product based on ergonomics approach

This section will discuss briefly about the ergonomics principle that being considered for the new design of durian peeler. There are six principles that being discussed for the consideration before making a new design of durian peeler (MacLeod, 2006).

Table 2.1: Ergonomics Principles and Description

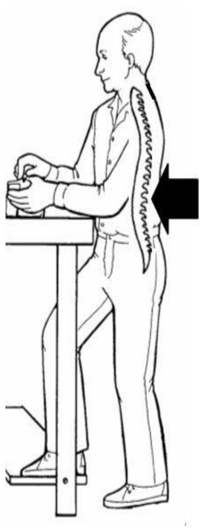
Ergonomics principles	Description	Product Development
Work in neutral posture 	• working in awkward position increases fatigue and physically stress in the body • reduces strength and dexterity, thereby making task became more difficult to complete • It is important to maintain the natural S-curve of the back whether sitting or standing. The most important part of this “S” is in the lower back which means it is good to keep a slight “sway back	• Adjustable workplace is needed as people vary in size and strength based on Kodak Ergonomics Design for People at Work, 2004 • Height of the working surface should maintain a definite relationship with the operator elbow height, depending on the type of work based Ergonomics in Manufacturing, 1998 • Elbow height 105.19 cm(female) and 119.54 cm (male) based on the anthropometry data of the southern Thai population

Table 2.1: Continued

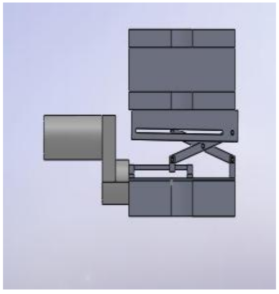
Ergonomics principles	Description	Product Development
Reduce excessive force	• Excessive force on your joints can create a potential for fatigue and injury. In practical terms, the action item is for you to identify specific instances of excessive force and think of ways to make improvements	• The usage of pneumatics system to control the movement of peeler blade so we will not use more force to peel the durian shell.
Reduce excessive motion	• The number of motions you make throughout a day, whether with your fingers, your wrists, your arms, or your back.	• The usage of the pneumatic system to control the movement of peeler blade. This will reduce the chances of doing of repetitive work
Work at proper high	• Working at the right height is also a way to make things easier. • A good rule of thumb is that most work should be done at about elbow height, whether sitting or standing. • Sometimes you can adjust heights by extending the legs to a work tables or cutting them down. Or you can either put a work platform on top of the table (to raise the work up) or stand on a platform.	• Specific mechanism is introduced where users only need to rotate the crank for adjusting the working table height. 

Table 2.1: Continued

Ergonomics principles	Description	Product Development
Minimize fatigue and static load	• Holding the same position for a period of time is known as static load. It creates fatigue and discomfort and can interfere with work.	• The usage of wrapper on the crank to increase the comfort and also to adjust the diameter of crank • For grip shape, grip shape should maximize the area contact between the palm and the grip to provide better pressure distribution and reduce change of forming pressure ridges or pressure concentration point. Handle diameter should be 41 to 86 mm for power grip. Grip length should be at least 102 mm. Based on Ergonomics in Manufacturing, 2004
Provide clearance	• Work areas need to be set up so that you have sufficient room for your head, your knees, and your feet. You obviously don't want to have to bump into things all the time, or have to work in contorted postures, or reach because there is no space for your knees or feet	• The minimum lateral clearance at waist level are determined by adding 5 cm on both side or 10 cm to hip breadth(standing position) based on Ergonomics in Manufacturing, 1998 • Hip breadth = 32.91 cm (female) based on the anthropometry data of the southern Thai population

There are some modifications done at an old designed machine to make sure the machine fulfill ergonomics criteria without sacrificing user's comfort. The below design is the new design of durian peeler machine based on ergonomics approach.

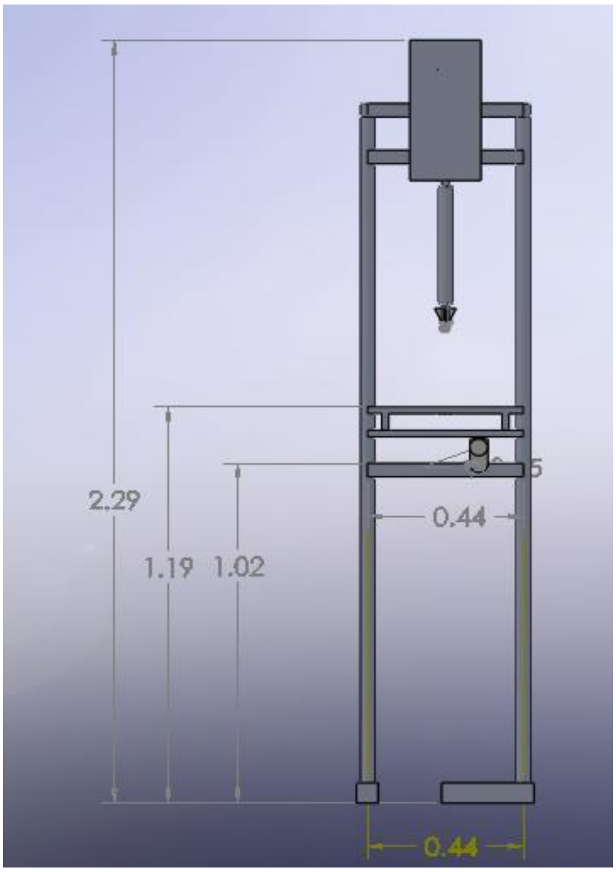


Figure 2.1: New design of durian peeler machine using Solidwork

TABLE 2.2: Machine parameters and dimension

Parameters	Dimension (m)
Total Height	2.29
Width	0.48
Working table height	1.19-1.29
Grip diameter	0.05
Grip length	0.11

2.3 PROCESS AND MACHINE INVOLVED IN MAKING PROTOTYPE

In the development of a new product, there is invariably a need to produce a single example or prototype of a designed part or system before allocation of large amounts of capital to new production facilities or assembly lines. Prototype is specially built product that is same in design, function and appearance but not in production method. For this project the prototype of durian peeler being produced by one of the rapid prototyping machine (Spectrum Z510® DESIGNmate™ Cx3D Printer).

This machine creating a 3D prototype model from 3D or other digital data can take days, if not weeks depending on the type of rapid prototyping machine used.The software first converts a three-dimensional design built using 3D CAD into cross sections or slices that are between 0.0035" - 0.004" (0.0875 - 0.1 mm) thick. The printer then prints these cross-sections one after another from the bottom of the part to the top. Inside the printer there are two pistons. On the printer, the roller and the print assembly are mounted together on the gantry which moves horizontally across the build area.

To begin the 3D printing process, the printer first spreads a layer of powder in the same thickness as the cross-section to be printed. The print heads then apply a binder solution to the powder causing the powder particles to bind to one another and to the printed cross-section one level below. The feed piston comes up one layer and the build piston drops one layer. The printer then spreads a new layer of powder and repeats the process, and in a short time the entire part is printed. The printer employs several techniques to quickly build parts.

First, binder solution is applied in a higher concentration around the edges of the part, creating a strong "shell" around the exterior of the part. Within parts, the printer builds an infrastructure by printing strong scaffolding within part walls with a higher concentration of binder solution. The remaining interior areas are printed with a lower saturation, which gives them stability, but prevents over-saturation, which can lead to distortion of the part. After printing, the part is removed from the powder bed, depowdered and dried. The part can then be infiltrated with wax, epoxy, or other materials to increase strength and durability.

2.4 SYSTEM THAT BEING APPLIED FOR BLADE MECHANISM

Hydraulics is a branch of science that deals with the study and use of liquids as related to the mechanical aspects of physics while pneumatics is a branch of science that deals with the study and use of air and other gases as related to the mechanical aspects of physics. Most fluid power circuit used compressed air or hydraulics fluid as their operating media. The pneumatics and hydraulics system have their different characteristics in certain ways.

2.4.1 Hydraulics System

Hydraulics is very different from pneumatics because it is used in controlling, transmitting and harnessing power using pressurized fluid. Hydraulics is frequently used in the concepts of dams, rivers, turbines and even erosion In hydraulics, the substances used is a compressible fluid medium wherein the most common example is oil. Hydraulics system use a greater amount of pressure compared to pneumatics applications. Hydraulics based application frequently use pressures that range from 1000-5000 pound per square inch.

2.4.2 Pneumatics System

Pneumatics is dealing more on studying the impact of pressurized gases and how it influences mechanical movement. Pneumatics is applied in various field of dentistry, mining, and general construction among others. The material or substance used for pneumatics is a compressible gas like air itself or an appropriate pure gas. In pneumatics, only 80-100 psi of pressure is used for its industrial applications. There are different kinds of pneumatics actuators that transform the potential and kinetic energy of the stream of compressed gas in mechanical energy. Air or pneumatics power cylinders are devices that convert power of compressed air into mechanical energy. This mechanical energy produces linear or rotary motion. Device with forward cylinder are divided into single acting and double acting pneumocylinders with or without rod. The air cylinder consists of steel or stainless steel piston, piston rod, cylinder barrel and end covers. In piston pneumatics cylinders, the potential energy of the compressed gas is used, but presence of the piston with mobile condensation allows reaching big moving of the output link. As compressed air moves into the cylinder, it pushes the piston along the length of the cylinder. Compressed air or the spring located at the end of the cylinder pushes the piston back. The two types of standard air cylinder based on their performance are single acting and double acting cylinders. A double acting cylinder has two directed powered motion in with pressure on both sides. When a cylinders is pushed out in one direction, compressed air moves it back in the opposite direction. Air lines running into both ends of the cylinder supply the compressed air. A single acting cylinder which is a spring return air cylinder has air pressure on one side of the piston flange, supplying the return force after the pressure release. Single acting cylinders require approximately a half of amount of the air used by double acting cylinder for a single operating cycle.

2.4.3 Selection of Fluid Power Circuits

From the above explanation about hydraulics and pneumatics system, the selection of fluid power circuit had been made. For this new design of durian peeler, pneumatics system is more suitable than hydraulics. There are many reasons why the pneumatics system had been chosen. The first reason, the pneumatics runs at low power usually around two to 3 horsepower and it means the pneumatics systems require only a smaller component. The components can be made of relatively inexpensive material often by mass production processes such as plastic injection molding, or zinc or aluminum die-casting. With regard to the control of application, pneumatics system is deemed to be simpler and easier to handle than hydraulics systems. Using pneumatics is just like the light switch that made to choose between two simple choices of ‘on’ or ‘off’ because most pneumatics designed with simple cylinders and standard components only.

2.5 SOFTWARE FOR SIMULATION

Ergonomics simulation is when human and his or her activity is virtually analyzed and simulated. Visualization, analysis and animation are the most common form of ergonomics simulation. There is plenty of software available at the market. Each of that software has its own advantages and disadvantages. For this section, there are two software that will be discussed and compare. Air-operated systems are always cleaner than hydraulic systems because atmospheric air is the force transmitter. The other reason is air-driven machines are usually quieter than their hydraulic counterparts. This is mainly because the power source (the air compressor) is installed remotely from the machine in an enclosure that helps contain its noise. Hydraulic systems are usually more complex and require maintenance personnel with higher skills. Therefore, pneumatics system is the suitable choice for the mechanism of blade.

2.5.1 ALGOR

ALGOR is used as the pre-processing, processing and post-processing software. First, it prepares the model for the analysis. After having specified the nature of the analysis as either steady-state or transient, ALGOR enables one to build the geometry, define the physical properties, and specify the boundary condition such as a fixed temperature, or a surface with radiation, convection or insulation. The definition of the different material properties is made by possible by assigning a different color to each different type of material. The heat flux boundary condition is applied manually (node by node) during the pre-processing stage. ALGOR also provide s the mesh of the model by meshing the different regions into finite numbers of nodal elements. Two dimensional thermal elements are 3- or 4-node formulated in the Y-Z plane. Meshes can be uniform across the model or concentrated around critical regions. ALGOR also displays verifies all data prior to executing the analysis.

2.5.2 PATRAN

PATRAN is a pre and post processing package for the finite element program ABAQUS. In addition it has the capability of the capability of finite element analysis. This software's advanced modeling and surfacing tools to create a finite element model from scratch. PATRAN imports model geometry without modification .PATRAN offers complete integration with MSC Software analysis solvers. As a post processor, PATRAN quickly and clearly display analysis results in structural, thermal, fatigue, fluid, magnetic term, or in relation to any other application where the resulting values are associated with their respective finite elements or nodes. PATRAN is the de-facto standard for linking design, analysis and results evaluation in a single, seamless environment.

2.5.3 Selection of software

For the simulation of durian peeler, ALGOR is more suitable compare to PATRAN. ALGOR allowed the development of a well-defined finite element mesh in the model and it can be adapted and compatible with Solidwork software. So it is much easier to do the simulation because all the new design of durian peeler being developed using Solidwork software.

2.6 CONCLUSION

Ergonomics design is related to the principle of ergonomics. To design an ergonomics tools, principle of ergonomics need to be followed. Before making the model of machine, we do the prototype of the machine to check whether the current design is better than previous design. For the simulation for durian peeler model, we use ALGOR instead of PATRAN.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In general, this chapter is about process used in order to produce a prototype for the durian peeler machine study. Explanations for this chapter will be based on several elements that contains in flow chart of the study.

3.2 FLOW CHART OF THE STUDY

Figure 3.1 shows overall flow chart of the study.

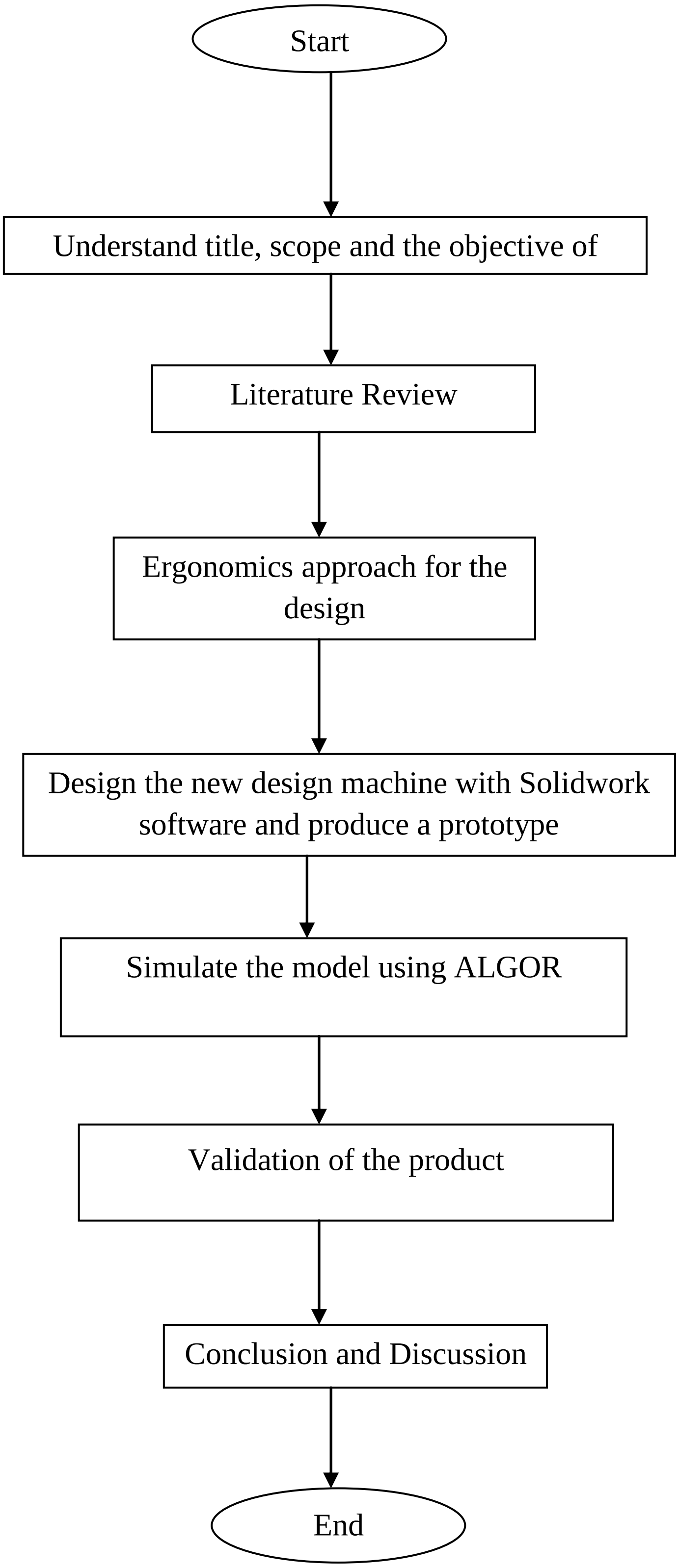


Figure 3.1: Flow Chart

3.3 LITERATURE REVIEW

For this study, the data and information gather from the reliable sources such as journal from established databases such as Science Direct and Scopus, book from library, conference proceedings, newspaper, internet (electronic journal), CD-ROM and also articles. A literature review is a method to collect the data and information. There a several steps in doing literature review. First step, know the purpose of the work.

3.4 ERGONOMICS APPROACH FOR DURIAN PEELER

For the design of the durian peeler machine, 10 principles of ergonomics approach being considered which are (Karwowski, 2006)

(i) Work in neutral posture
(ii) Reduce excessive force
(iii) Keep everything in easy reach
(iv) Work at proper high
(v) Reduce excessive motion
(vi) Minimize fatigue and static load
(vii) Minimize pressure point
(viii) Provide clearance
(ix) Move, exercise, and stretch
(x) Maintain a comfortable environment

The design and dimension of the machine is followed the ergonomics approach in order to satisfy the customer's need and to prevent the musculoskeletal problem among workers who manually peel the durian.

3.5 DESIGN USING SOLIDWORK AND MAKING A PROTOTYPE

After considering the ergonomics principles for the design, the next process are design the machine using Solidwork and making a prototype.

3.5.1. DESIGN USING SOLIDWORK

Durian peeler machine being designed using Solidwork. The figure below had shown the overview of the machine with its dimension.

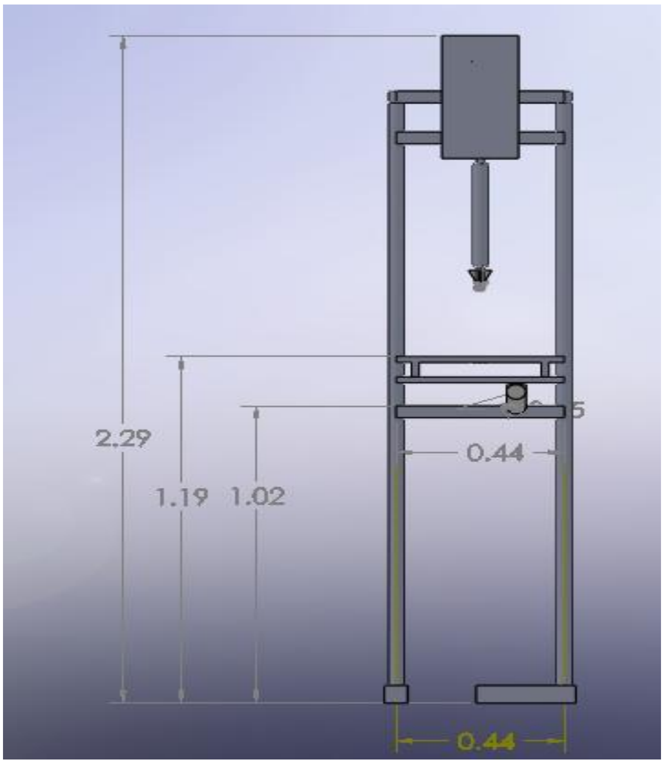


Figure 3.2: New design of durian peeler

Generally, a machine can be divided into three main sections which are peeler, working table and controller. Figure below show the three main sections for the machine. To use the machine, the operator needs to place a durian in upside position on the working table. The height for working table can be adjusted by rotating crank place at the controller section based on operator demand. After that, press the start button placed on the controller section to lowering the peeler. The peeler will move lower and higher automatically. Manually remove the opened durian from the table and repeat the step for other durian.

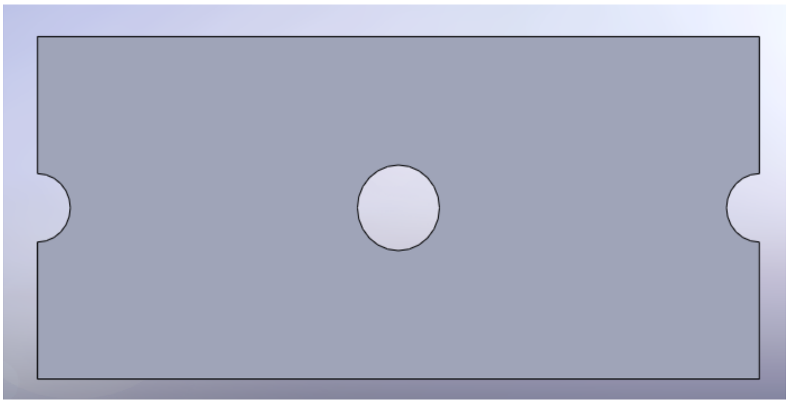


Figure 3.3: Peeler table

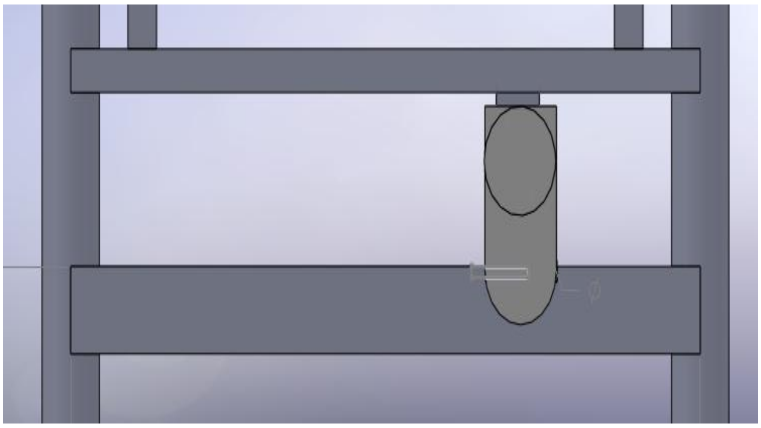


Figure 3.4: Front view of working table

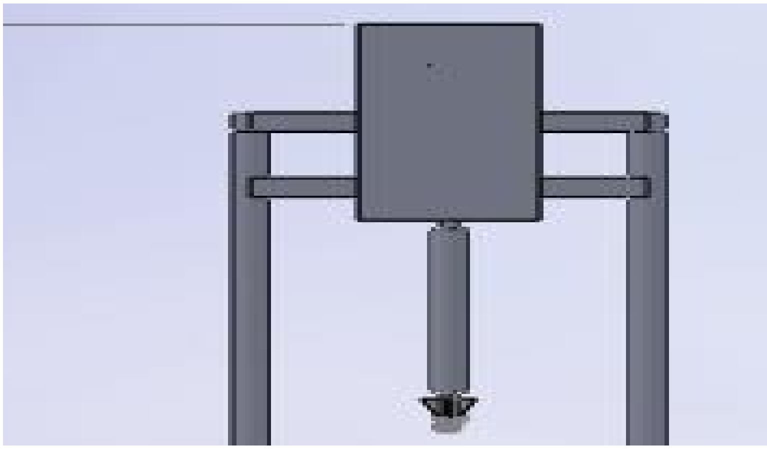


Figure 3.5: The controller

3.5.2 Making a Prototype

After making a design in Solidwork, the next procedure is making the prototype using rapid prototyping machine which is Spectrum Z510/Cx 3D Printer. This machine is to be used by design engineers and other professionals in the production of early-stage 3D appearance models and prototype. The 3D Printer System is based on the Massachusetts Institute of Technology's patented 3DP™ (3D Printing) technology.

Figure 3.6: 3D Printer

Procedure to make a prototype using 3D Printer:

(i) Preparing 3D Printer

- Fill the feed box with powder.
- With the printer offline, spread powder over build area by pressing the Spread button on the control panel for four spreads. The printer will automatically spread powder over the build area.
- Clean the service station by rinsing and wiping the parking caps and rubber wiper.

- Check the binder bottles.
- Check the wash fluid and the waste fluid. Fill the wash fluid and dispose of the waste fluid.
- Put printer online by pressing the Online button on the control panel.

Figure 3.7: Spreading the powder over the build area

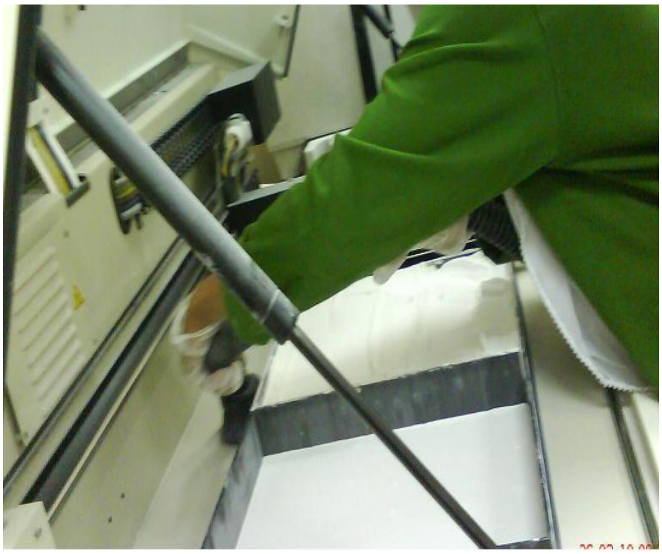


Figure 3.8: Clean the service station

(ii) Preparing the build in the ZPrint Software

- Launch ZPrint and open or import your file(s).
- Orient and scale the file, if needed.
- Open the File menu and select 3D Print Setup. In the 3D Print Setup dialog, select your Printer,Powder Type, and Layer Thickness options.
- Select 3D Print on the File Menu or click the 3D icon on the Toolbar. Choose your settings in the Printing Options dialog and click OK. Proceed through the series of preparation dialogs that appear before the build starts.

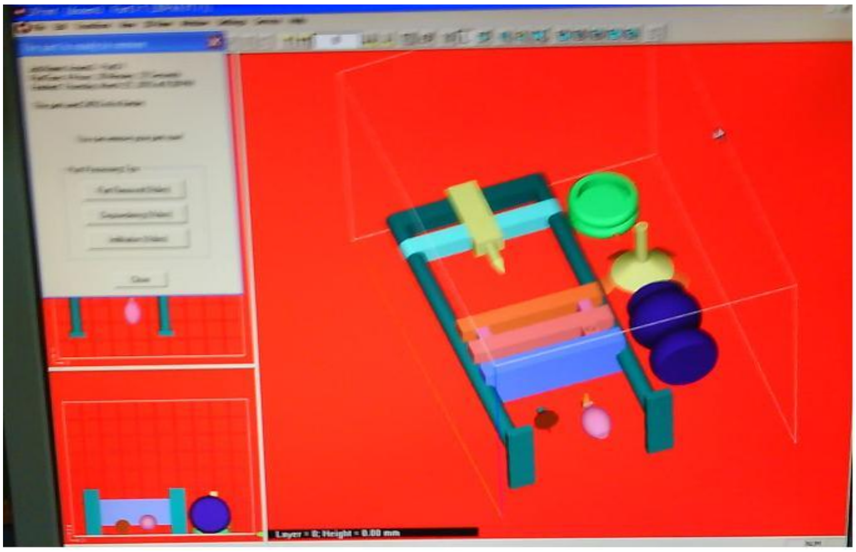


Figure 3.9: Preparing for the build in ZPrint Software

(iii)Removing the part

- Wait for part to complete printing. Check the software for part orientation
- Gross depowder the part and remove from build area.
- Fine depowder part and post-process as needed

Figure 3.10: Transfer the prototype from the build area

(iv)Depowdering the part

- Place parts inside the depowdering station.
- Turn on the vacuum cleaner.
- Turn on the air compressor.
- Change the air pressure as needed and check the pressure with your hand before applying air on the part.
- Then, the prototype already finished and ready to be displayed

Figure 3.11: Applying air on the part

3.6 SIMULATION OF DURIAN PEELER MACHINE

The simulation software that will be used in this thesis is ALGOR. By using ALGOR, we can do analysis and simulation whether this new design of durian peeler can be validated or not. This simulation only applied for certain part of the durian peeler that being considered as critical part.

3.7 CONCLUSION

This chapter is the description of the methodology that has been used in order to design and make the prototype of the project. This section also included the process to simulate that machine.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will be focused on the result for the rapid prototyping and simulation for the durian peeler machine. The results that obtained from the simulation can be used to do some modification and recommendation for the better durian peeler machine.

4.2 RAPID PROTOTYPING

The prototype of durian peeler had produced using rapid prototyping method. The durian peeler prototype is different from the original model due to some limitation. Even though it different compare to model, prototype is often used as part of the product design process to allow engineers and designers the ability to explore design alternatives, test theories and confirm performance prior to starting production of a new product. Figure below shown the prototype that being produced using Spectrum Z510/Cx 3D Printer.

Figure 4.1: Prototype of durian peeler

From the result of prototype above, it appears that the prototype is so ductile and the supporting bar cannot support the whole body of prototype. The solid body of working table contributes to greater weight of the prototype consequently made whole body of machine fail. The design of durian peeler machine is still not suitable and still need some modification. The prototype is not tough enough and had low strength to support the machine body. However, this prototype is not using a same material as model and the size had been reduced from the original size in order to compatible with the rapid prototyping machine. This result can be tolerate because it is very common for the result of prototype due to limitation in material, size and processes that involved. This prototype also contribute to the testing the part of the design that most likely to have a problem and solve the problem before make a full design and model.

4.3 SIMULATION OF DURIAN PEELER MACHINE

The simulation of durian peeler based on the analysis of Finite Element Analysis (ALGOR). This analysis divided by two main part of the durian peeler which are working table and the supporting bar. The analysis had been doing for this part because these are the critical part that determine whether the design of machine suitable enough or need some modification. The figure below showed the design of durian peeler machine using Solidwork.

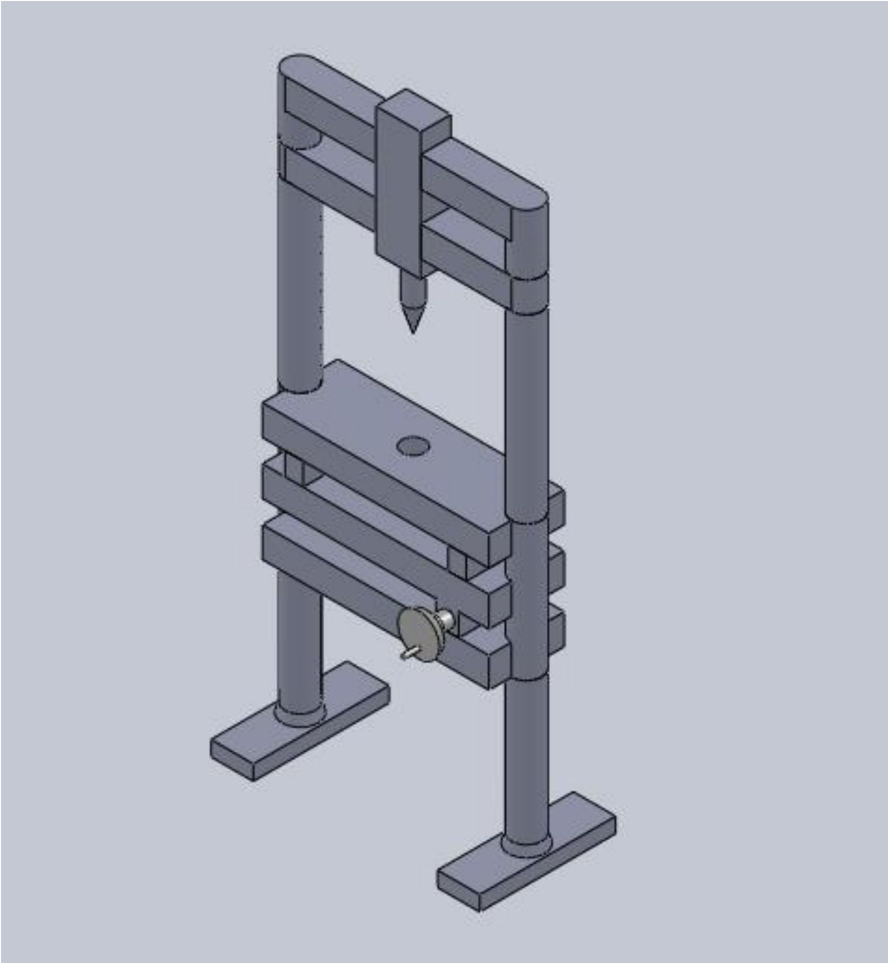


Figure 4.2: Design of Durian Peeler Using Solidwork

4.3.1 Finite Element Analysis using ALGOR for Working Table

The design of durian peeler machine had been developed take a consideration of ergonomics criteria for users. The analysis for working table considered for two different materials which are steel ASTM A36 and stainless steel AISI Type 304.The analysis of Von de Mises stress had been taken for this project in order to measure the strength of the part of model. The figure below showed the analysis of durian peeler for different two materials:

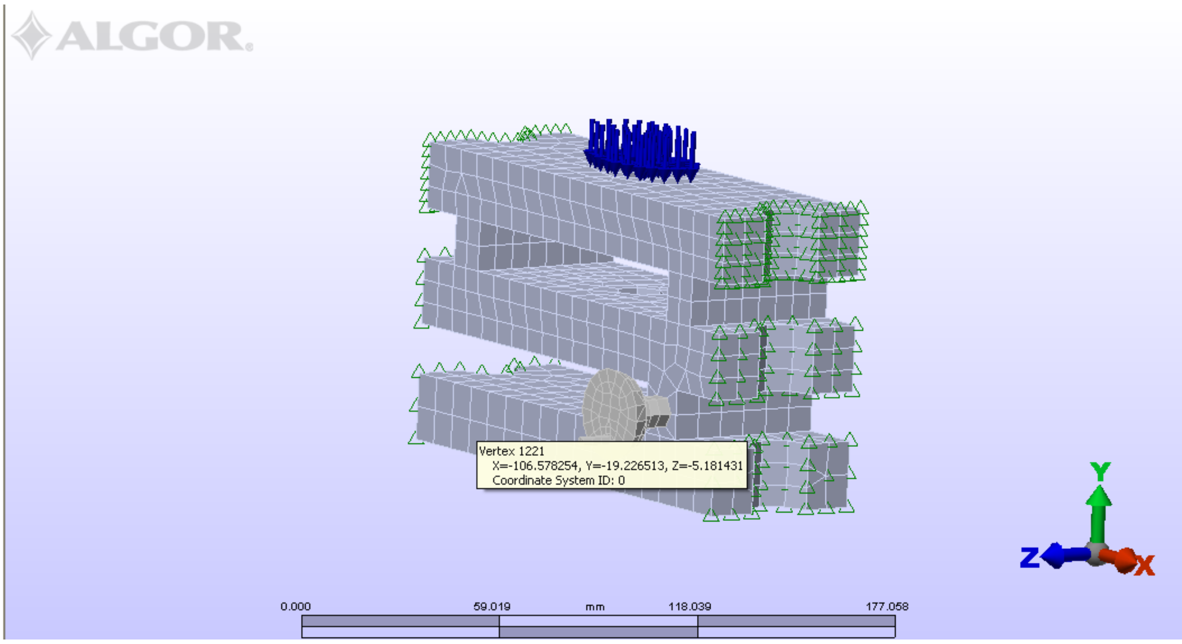


Figure 4.3: The forces applied on the working table for steel ASTM A36

The forces that applied on the working table are the weight of durian and the blade that being applied towards it.

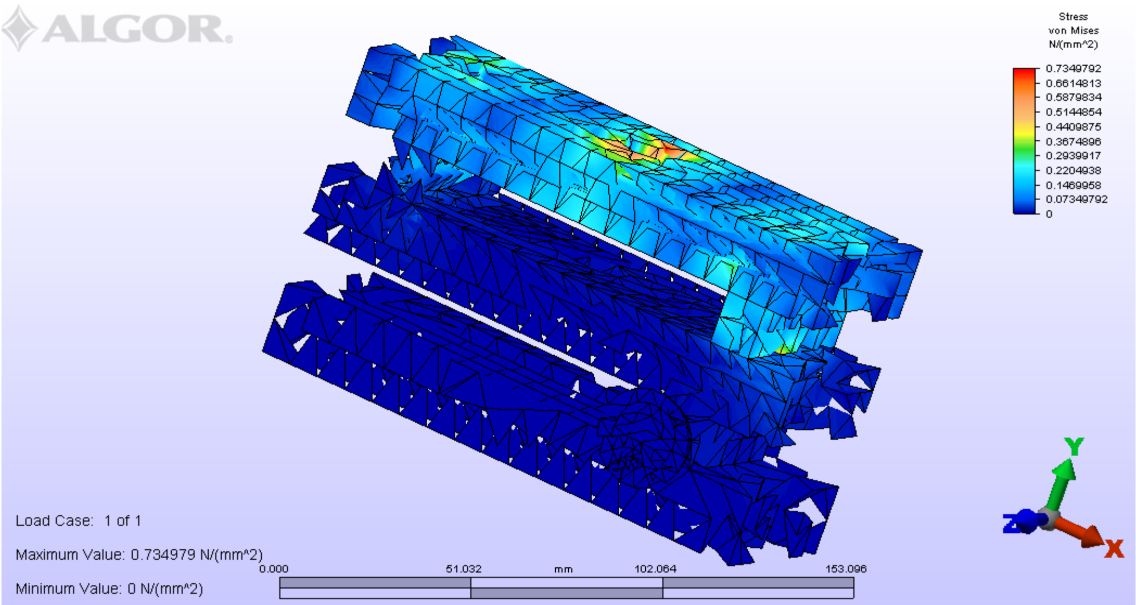


Figure 4.4: Stress von Mises analysis for Steel ASTM A36

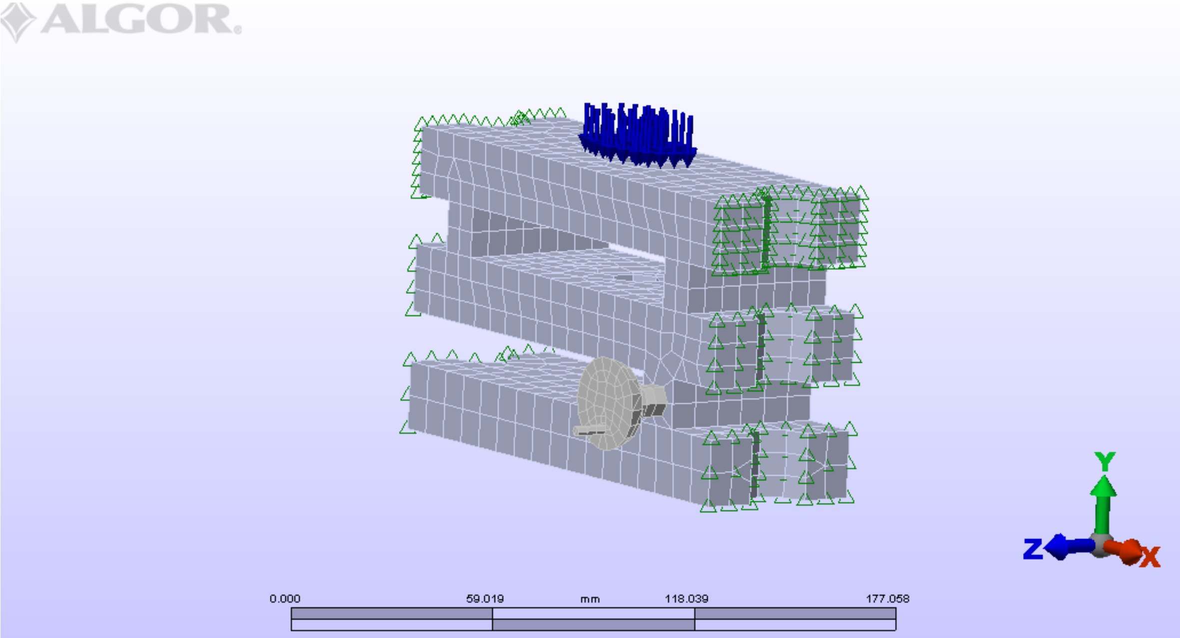


Figure 4.5: The force applied to the working table

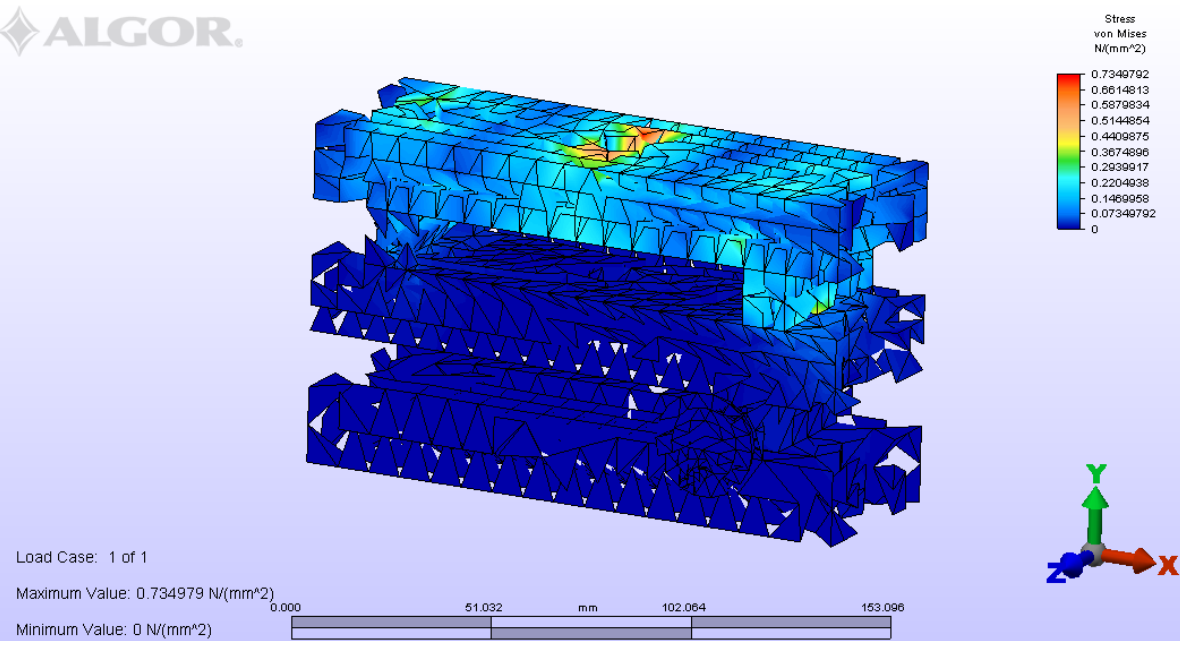


Figure 4.6: Stress von mises analysis of stainless steel AISI 304L

4.3.2 Finite Element Analysis using ALGOR for Supporting Bar

The supporting plays a vital role in the construction of durian peeler machine. It should have great amount of strength in order to support the other part of durian peeler. For this supporting bar, it also been analyzed for the Von de Mises stress analysis. Figures below show the different forces that being analyzed for supporting bar part:

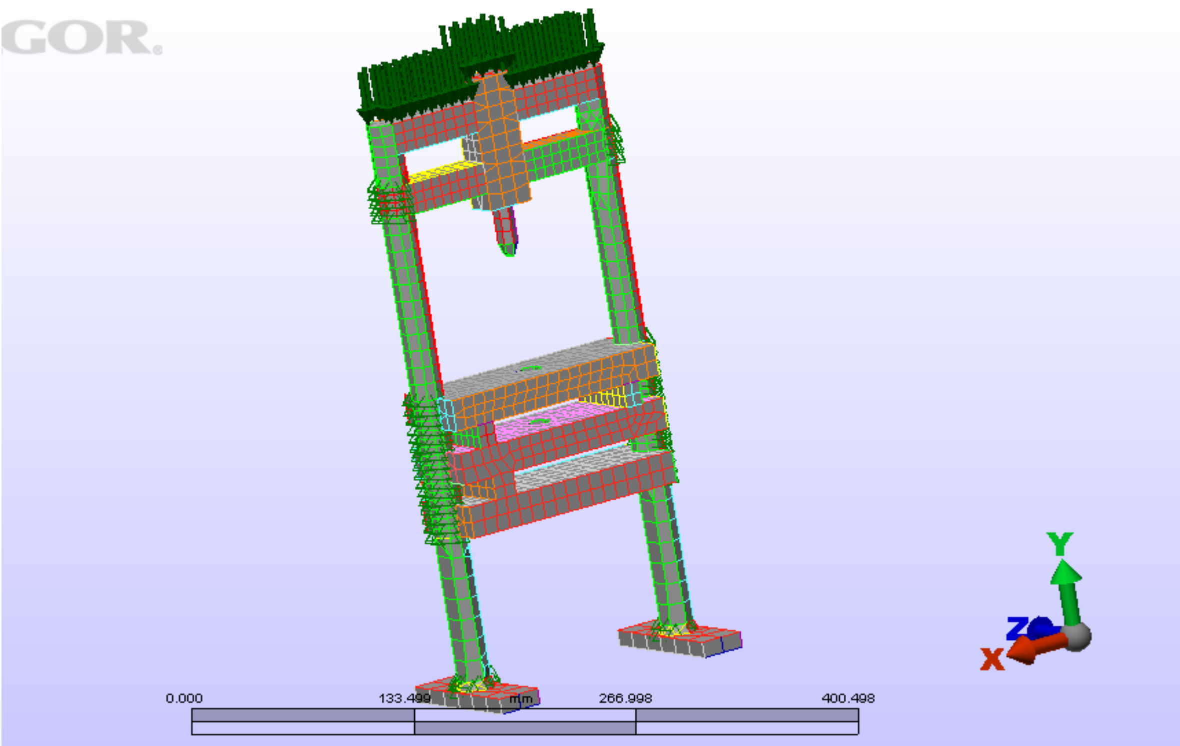


Figure 4.7: Forces that applied at the top of durian peeler body

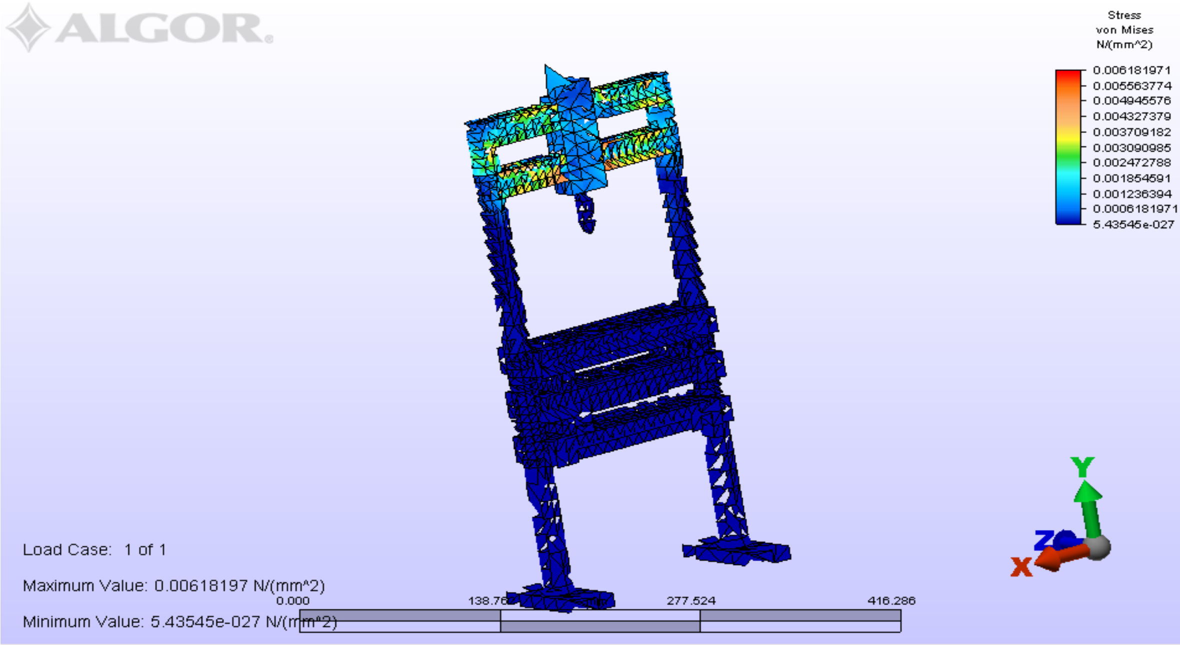


Figure 4.8: Forces of 0.147 N

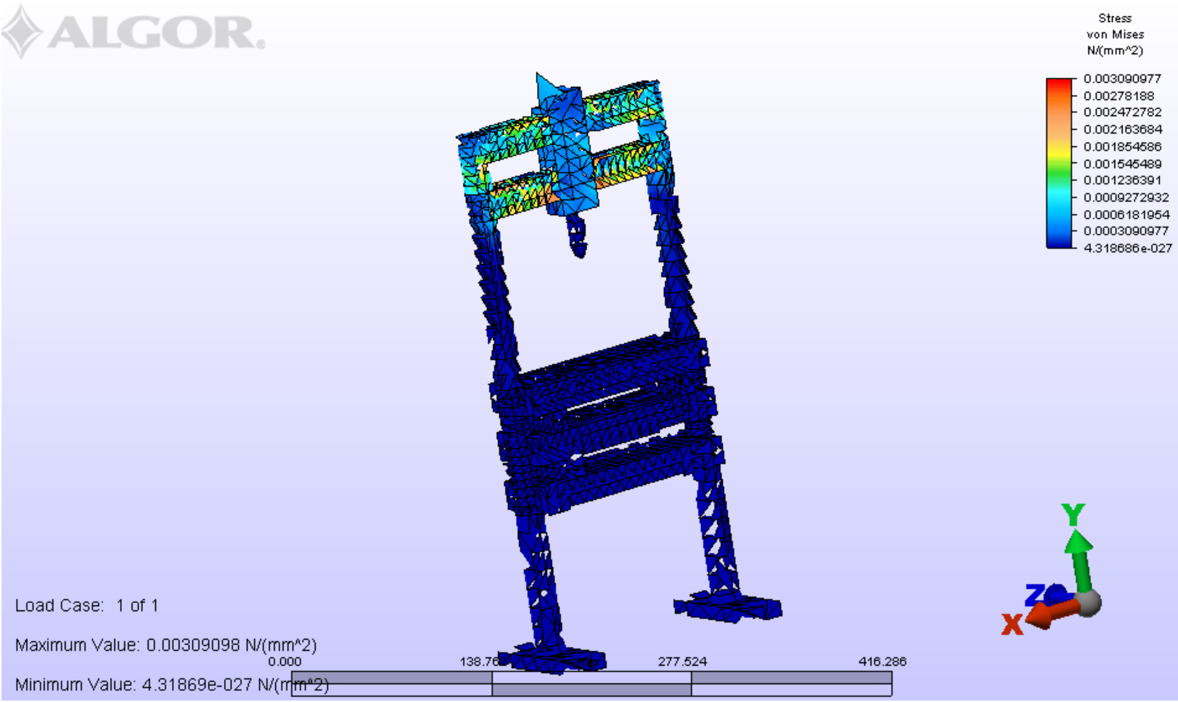


Figure 4.9: Forces of 0.0735 N

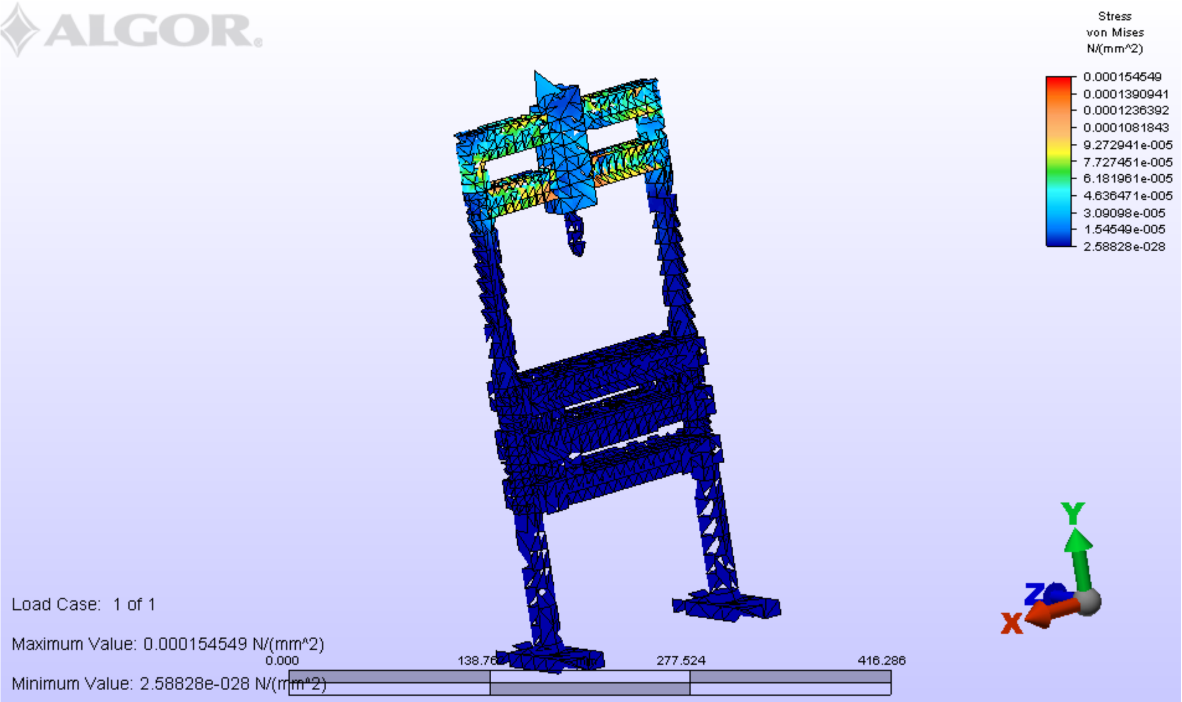


Figure 4.10: Forces of 0.03675 N

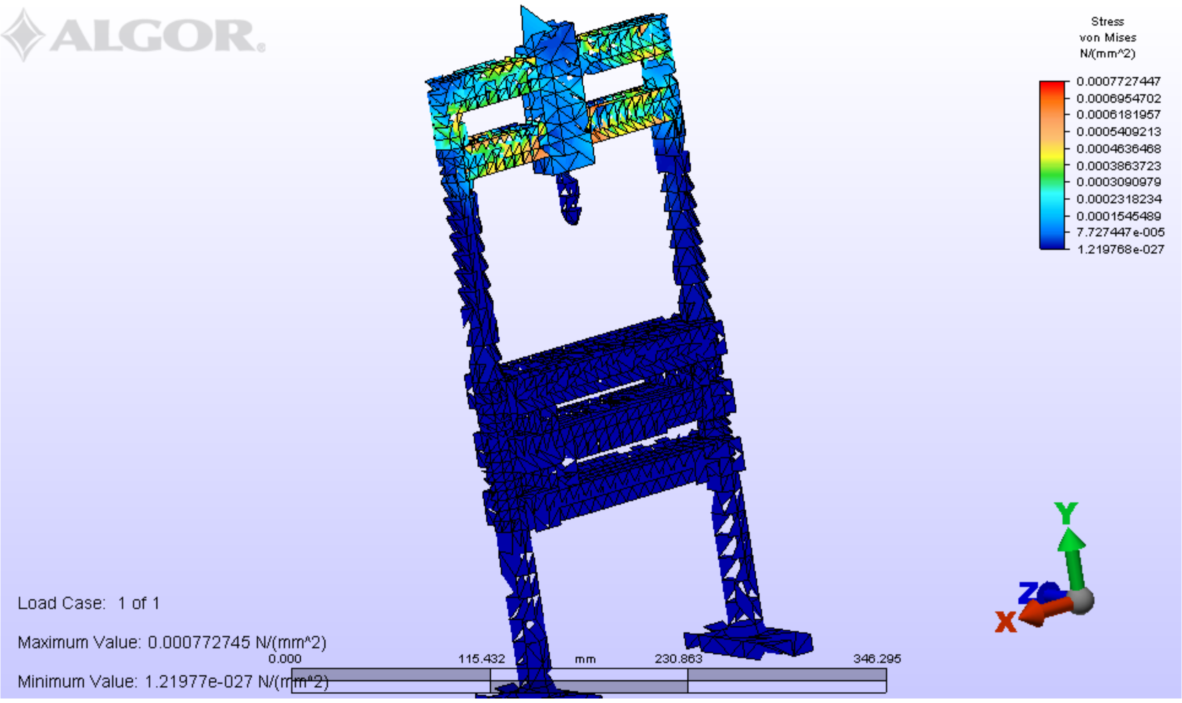


Figure 4.11 Forces of 0.01837 N

For the result, it can be simplify into a table to get more understanding about the analysis of Von de Mises.stress Table below will show that the properties of material for steel ASTM A36 and stainless steel AISI 304L. Each material had different properties and its properties also contribute to the result for the Von de Mises stress.

Material Information

Steel (ASTM - A36) -Tetrahedral

Material Model	Standard
Material Source	ALGOR Material Library
Material Source File	D:\Algor\22.00\matlibs\algormat.mlb
Date Last Updated	2004/09/30-16:00:00
Material Description	Structural Steel
Mass Density	0.0000000078548 N·s²/mm/mm³
Modulus of Elasticity	199950 N/mm²
Poisson's Ratio	0.29
Thermal Coefficient of Expansion	0.0000117 1/°C
Shear Modulus of Elasticity	77221 N/mm²

Figure 4.12: Properties of Steel ASTM A36

Material Information

AISI Type 304 Stainless Steel -Tetrahedral

Material Model	Standard
Material Source	ALGOR Material Library
Material Source File	D:\Algor\22.00\matlibs\algormat.mlb
Date Last Updated	2004/10/28-16:02:00
Material Description	None
Mass Density	0.000000008 N·s²/mm/mm³
Modulus of Elasticity	193000 N/mm²
Poisson's Ratio	0.29
Thermal Coefficient of Expansion	1.730000E-005 1/°C
Shear Modulus of Elasticity	86000 N/mm²

Figure 4.13: Properties of Stainless steel AISI 304L

Source: ALGOR FEMPRO Software

The maximum value of von mises stress of each material obtained form analysis of ALGOR. Therefore to get fully understanding, the result transferred into a table below with a different material.

Table 4.1: Maximum and minimum value of Von de Mises stress

MATERIAL	MAXIMUM VALUE	MINIMUM VALUE
Steel ASTM A36	0.7349792	0.073497920
Stainless steel AISI 304L	0.8621776	0.086217760

Based on the table above, Von de Mises stress for steel ASTM A36 had a lower maximum value which is 0.7349792 compare to stainless steel AISI 304L .It means that stainless steel need higher maximum stress in order to ruptures compares to steel ASTM A36. From the properties table, its shown that stainless steel had greater number of shear modulus elasticity compare to steel ASTM A36. Metal deformation is proportional to loads over a range of loads. Since stress is proportional to load and strain is proportional to deformation, this implies that stress is proportional to strain. Hooke's Law (Beer et al. 2006) is the statement of that proportionality,

$$. E = \frac{stress}{strain} = \frac{\sigma}{\in} \qquad \text{(Eq 4.1)}$$

Thus, this implies that material with higher shear modulus of elasticity need a higher stress in order to deform. So material with higher modulus such as stainless steel AISI 304L is more suitable for the construction of working table.

For the second analysis is for supporting bar of durian peeler. For this analysis, different forces applied to the top of the supporting bar. The forces as a substitute for the weight of the whole body of durian peeler.The result of analysis for supporting bar simplified into the table below for more information.

Table 4.2: Maximum of von mises stress for different forces applied

Forces	**Maximum value**
0.01837	0.000772745
0.03675	0.000154549
0.07350	0.00309098
0.14700	0.00618197

From the table above, the higher forces that applied on top of supporting bar required higger maximum value of stress. Based of this statement, the forces applied influenced the amount of maximum value of stress. Decreasing the maximum value of stress can be get if we applied lower forces. The forces that applied is from the weight of working table so its better to decrease the weight of that part.

4.4 SUMMARY

This chapter discussed about the result for the analysis of some main part of durian peeler machine using ALGOR.

The next chapter will discuss about the conclusion and some recommendations for this project. It also discussed about the limitation that been through for complete this project.

CHAPTER 5

CONCLUSSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter will conclude all about the study**.** Besides that the objectives of the study should be reviewed to determine whether it's achieved or not. The contribution and the limitations for this study also been discussed in this chapter.

5.2 CONTRIBUTION OF THIS STUDY

The main contribution for this study is the ergonomics criteria that being considered first before making a new design of durian peeler.

Second contribution from this study is to give information and instruction for other people on how to make a prototype using Rapid Prototyping machine. The steps and instruction for making the prototype were discussed details in this study.

5.3 LIMITATIONS

There are many limitations in order to complete this study. The first limitation is the used of anthropometry data from other country which is Thailand. The data is limited from Malaysia. Since Thailand's citizen is a bit same with Malaysian people, the data from that country been used.

The second limitation is the fabrication of the durian peeler cannot be done because of money and time constraint. It is also due to complex process that should be done to fabricate the durian peeler.

Another limitation is the limited source of previous study of durian peeler. It is because this fruit is only planted in Southeast Asean, the durian peeler machine rarely been developed. Therefore, it is difficult to find the source for the literature review.

The fourth limitation is on the ergonomics software. Since there is no ergonomics software available, the analysis for the product cannot been done.

Last limitation is the simulation from the experts cannot be done due to the cancellation of fabrication of product.

5.4 RECOMMENDATIONS

The new design of durian peeler based on the ergonomics criteria for the better use for the user. From the prototype of durian peeler, it can be concluded that the design of durian peeler using the solid material cannot be applied because it will make the durian peeler fail to function and cannot stand properly. The weight of material for working table and the whole body should be taking more consideration and modification because it affect the functionality of the durian peeler instead taking a consideration of ergonomics criteria. The height of the durian peeler also contributes to the failing of the new design durian peeler. Even though, the height of durian peeler based on the ergonomics criteria for people's height population, at this height machine will not achieve a great stability and it will endangered for the user if it will broken or damage.

There are few recommendations to be made for this study of durian peeler. The first thing is the design of durian peeler. The modification of the durian peeler should be doing for the height of the durian. The height of durian peeler should be suitable with the weight of the whole body. The second modification to be made is the base of supporting bar. It is more safety and stable if the area of the base larger. The larger the area of supporting bar’s base, the lower pressure will be applied from the whole body. Other recommendations are the material for the production of durian peeler machine. The material for the working table and supporting bar should be low density and mass. The hollow rectangular or cylinder bar should be used for the construction of durian peeler because this type of bar had a low density and weight. Furthermore, it also had larger strength to support the whole construction of durian peeler.

5.5 CONCLUSION

The objectives for this study is to design the durian peeler with ergonomics and make a prototype using Rapid Prototyping machine had been achieved The validation of the new designed durian peeler also been achieved.

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APPENDIX A

Anthropometry data of the male southern Thai population, aged 18–25 years (*n*= 100)

	Dimension[a]	Mean	S.D.	1st percentile	5th percentile	50th percentile	95th percentile	99th percentile
1	Weight (kg)	61.85	8.57	46.00	49.95	60.42	75.42	86.06
2	Stature	171.94	5.15	161.99	164.60	170.92	181.25	184.60
3	Eye height	160.21	5.01	151.73	153.60	159.28	169.07	172.35
4	Shoulder height	140.67	11.74	99.14	135.56	141.30	149.44	154.06
5	Elbow height	109.18	8.75	98.83	102.40	107.78	119.54	151.03
6	Hip height	84.96	4.09	76.03	77.88	84.55	91.25	95.61
7	Knuckle height	74.19	10.13	64.79	69.00	73.07	79.23	83.86
8	Fingertip height	63.21	4.87	55.44	59.17	63.18	69.06	71.08
9	Sitting height	90.16	3.41	83.01	85.30	89.95	95.30	100.90
10	Sitting eye height	78.01	3.37	70.69	72.69	78.13	83.04	84.57
11	Sitting shoulder height	60.63	2.68	53.66	56.16	60.82	65.31	66.52
12	Sitting elbow height	25.11	2.58	19.05	21.47	25.05	28.85	30.84
13	Thigh thickness	14.21	1.46	11.10	11.90	14.18	17.10	17.40
14	Buttock–knee length	58.52	2.45	53.43	54.95	58.40	61.91	64.25
15	Buttock–popliteal length	48.23	3.95	43.85	45.02	48.42	51.78	54.02
16	Knee height	52.81	2.29	47.86	48.62	52.85	56.07	59.11
17	Popliteal height	43.04	1.56	39.66	40.64	43.02	45.51	46.18
18	Shoulder breadth (bideltoid)	43.24	2.26	38.10	39.63	43.12	46.94	49.27
19	Shoulder breadth (biacromial)	40.45	1.99	35.96	37.28	40.25	43.85	44.77
20	Hip breadth	34.34	5.48	29.80	30.82	33.77	36.89	39.52
21	Chest (bust) depth	19.85	1.92	14.73	16.68	19.90	22.59	25.63
22	Abdominal depth	20.90	2.43	16.00	17.52	20.98	24.45	26.97
23	Shoulder–elbow length	35.97	1.46	32.70	33.46	35.93	38.21	39.47
24	Elbow–fingertip length	47.12	1.63	44.00	44.70	47.00	50.24	50.64
25	Upper limb length	77.12	4.12	70.16	72.92	77.02	82.57	83.54
26	Shoulder–grip length	66.55	2.73	61.52	62.65	66.47	71.44	72.05
27	Head length	18.99	0.73	17.59	17.93	18.92	20.04	20.70
28	Head breadth	15.78	0.56	14.60	14.86	15.80	16.70	17.03
29	Hand length	19.11	7.16	16.80	17.13	18.40	20.30	21.49
30	Hand breadth	8.22	0.35	7.40	7.66	8.25	8.87	8.90
31	Foot length	25.35	0.99	23.29	23.63	25.42	26.90	27.20
32	Foot breadth	9.80	0.54	8.73	8.97	9.75	10.67	11.07
33	Span	174.28	13.88	107.32	166.35	175.15	187.73	190.85
34	Elbow span	90.07	3.14	84.43	85.72	89.90	95.71	96.51
35	Vertical grip reach (standing)	204.73	12.51	170.51	195.95	204.65	217.17	220.61
36	Vertical grip reach (sitting)	124.78	14.51	115.42	117.63	124.02	132.92	177.06
37	Forward grip reach	73.66	4.70	64.41	68.00	73.78	80.34	81.63

APPENDIX B

Anthropometry data of the female southern Thai population, aged 18–25 years (*n*= 100)

	Dimension[a]	Mean	S.D.	1st percentile	5th percentile	50th percentile	95th percentile	99th percentile
1	Weight (kg)	49.90	7.59	38.00	40.95	48.07	64.22	72.11
2	Stature	157.94	5.32	146.36	149.44	157.98	167.18	169.48
3	Eye height	146.29	5.15	135.73	137.41	146.03	155.09	158.57
4	Shoulder height	129.71	4.94	119.91	122.73	129.43	139.19	142.30
5	Elbow height	99.02	6.15	90.63	92.25	98.65	105.19	117.82
6	Hip height	78.36	4.08	69.76	72.62	77.90	85.67	87.27
7	Knuckle height	68.26	3.03	61.99	63.55	68.40	73.00	74.20
8	Fingertip height	59.08	2.89	51.97	54.56	59.22	63.11	65.38
9	Sitting height	83.70	5.00	77.22	79.39	84.00	88.43	91.01
10	Sitting eye height	72.97	2.93	66.12	68.76	73.27	76.75	80.55
11	Sitting shoulder height	56.50	4.35	47.13	52.33	56.25	61.24	66.83
12	Sitting elbow height	23.12	2.06	18.96	20.02	23.07	26.04	27.21
13	Thigh thickness	12.01	1.03	10.27	10.62	11.87	13.84	14.90
14	Buttock–knee length	54.54	2.51	49.87	50.96	54.30	59.38	60.37
15	Buttock–popliteal length	46.43	2.22	42.73	43.39	46.12	50.69	52.07
16	Knee height	48.13	2.16	43.96	44.70	47.77	51.77	53.74
17	Popliteal height	40.17	1.41	36.66	38.13	40.08	42.90	43.24
18	Shoulder breadth (bideltoid)	38.75	1.96	35.24	35.83	38.57	41.88	44.67
19	Shoulder breadth (biacromial)	35.19	1.59	31.76	32.60	35.22	37.74	38.64
20	Hip breadth	36.15	2.18	32.36	33.18	35.65	39.91	41.15
21	Chest (bust) depth	19.95	1.67	17.52	17.83	19.70	23.35	24.22
22	Abdominal depth	18.45	1.70	15.23	16.20	18.30	21.76	23.34
23	Shoulder–elbow length	33.36	1.64	30.03	30.80	33.17	36.24	37.12
24	Elbow–fingertip length	42.57	3.52	38.93	39.36	41.92	45.77	47.31
25	Upper limb length	69.71	3.18	63.26	64.72	69.30	75.24	76.35
26	Shoulder–grip length	59.56	2.78	53.83	55.53	59.53	64.54	66.57
27	Head length	17.97	0.64	16.57	16.96	17.93	18.97	19.20
28	Head breadth	14.95	0.58	13.70	14.00	14.95	15.87	16.20
29	Hand length	16.61	0.73	15.20	15.46	16.57	17.84	18.10
30	Hand breadth	7.26	0.34	6.50	6.57	7.30	7.77	7.87
31	Foot length	22.68	0.94	20.50	21.05	22.78	24.00	24.57
32	Foot breadth	8.63	0.47	7.46	7.93	8.63	9.47	9.63
33	Span	157.41	6.86	143.96	146.97	155.60	169.46	172.50
34	Elbow span	81.17	3.35	74.97	76.02	80.55	87.31	88.24
35	Vertical grip reach (standing)	187.12	9.56	170.96	176.16	187.53	201.47	208.29
36	Vertical grip reach (sitting)	114.81	10.86	101.75	106.76	113.38	122.63	153.57
37	Forward grip reach	68.45	3.28	62.91	63.60	67.77	74.13	78.37

APPENDIX C

GANTT CHART FOR FINAL YEAR PROJECT 1

PROJECT ACTIVITIES	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**	**W15**
Receive and understand the FYP title															
Brief explanation about the project from supervisor															
Collect the information about the project from book and internet															
Design and making the prototype															
Gathering information and prepare the Chapter 1, Chapter 2, Chapter 3															
Prepare the technical paper and slide presentaation															
Submit the technical report and slide presentation to supervisor															
Preparation for presentation															
FYP 1 presentation															

APPENDIX D

GANTT CHART FOR FINAL YEAR PROJECT 2

PROJECT ACTIVITIES	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**	**W15**
Discuss about the previous presentation	■														
Make some amendment for objective		■	■												
Gather information about software for simulation			■		■										
Make a design for prototype			■	■											
Stimulate the prototype						■	■	■							
Gathering the informations and prepare the thesis							■	■	■	■	■	■	■		
Submit the thesis to supervisor													■		
Preparation for the presentation														■	
FYP 2 presentation															■