UNIVERSITI MALAYSIA PAHANG

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JUDUL: DESIGN AND DEVELOPMENT OF VACUUM FRUIT FRYING MACHINE FOR SMI AND SME APPLICATION

SESI PENGAJIAN: 2009/2010

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DESIGN AND DEVELOPMENT OF VACUUM FRUIT FRYING MACHINE FOR SMI AND SME APPLICATION

AHMAD BAKRI BIN ABDUL AZIZ

BACHELOR OF ENGINEERING

UNIVERSITI MALAYSIA PAHANG

DESIGN AND DEVELOPMENT OF VACUUM FRUIT FRYING MACHINE FOR SMI AND SME APPLICATION

AHMAD BAKRI BIN ABDUL AZIZ

Thesis submitted in fulfillment of the requirements
For the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled "*(Design and development of vacuum fruit frying machine for smi and sme application)"* Is written by (*Ahmad Bakri Bin Abdul Aziz*.) 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 fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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Examiner Signature

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Date:

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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Date:

To my beloved mother and father,

Mrs. Khabsah Binti Deraman
Mr. Abdul Aziz Bin Him

ACKNOWLEDGEMENTS

Praise to Allah S.W.T, the most Merciful and the most Compassionate. Peace upon him Muhammad S.A.W, the messenger of Allah.

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ABSTRACT

Frying in vacuum condition is a new technology that can be used to improve the quality of fried foods such as chips and fruit vacuum frying machines suitable because it is working in low temperatures and use the minimum oxygen content. The most significant difference between frying exposed to atmospheric and vacuum conditions are frying in humidity and sliced fruit color after frying. Shown promise for vacuum frying techniques that can be used to reduce the oil content in fried sliced fruit while maintaining color and taste products. especially. In the vacuum frying process, the process of drying the fruit slices before frying will occur and it will give better results than frying exposed to the atmosphere. For example fried sliced fruit that will be absorbed vacuum drying and this will reduce the moisture in the fruit slices and this will reduce frying time.

ABSTRAK

Menggoreng dalam keadaan vacum adalah sebuah teknologi baru yang boleh digunakan untuk meningkatkan kualiti makanan goreng seperti kerepek buah dan mesin penggoreng vacum amat sesuai kerana ia bekerja dalam suhu rendah dan menngunakan kandungan oksigen yang paling minimum. Perbezaan yang paling ketara diantara penngorengan yang terdedah kepada atmosfera dan pengorengan dalam keadaan vakum adalah kadar kelembapan dan warna hirisan buah setelah digoreng. Penggorengan vakum ditunjukkan untuk menjanjikan teknik yang boleh digunakan untuk mengurangkan kandungan minyak g di dalam hirisan buah sambil mengekalkan warna dan rasa produk. terutamanya.,Di dalam proses penggorengan vacuum ,proses pengeringan ke atas hirisan buah akan berlaku sebelum penggorengan dan ia akan memberikan hasil lebih baik daripada penggorengan yang terdedah kepada atmosfera. Sebagai contoh hirisan buah yang akan digoreng diserap vakum akan mengering dan ini akan mengurangkan kelembapan didalam hirisan buah itu dan ini akan mengurangkan masa penggorengan. .

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LIST OF SYMBOLS

L	length
m	Mass
V	Volume
ρ	Density
e	Efficiency
r	Radius
D	Diameter
E	Modulus of elascity
Cp	Specific heat
A	Area
u	Heat transfer coefficient
Q	Heat transfer
q	Heat flux
T	Temperature
t	Time
V_o	Volume of the sample
S_v	Degree of shrinkage in volume

LIST OF ABBREVIATIONS

AISI	American Iron and Steel Institute
ASTM	American Society for Testing and Materials
CAD	Computer Aided Design
FEA	Finite Element Control

LIST OF APPENDICIES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Frying nowadays has been one of the most important cook methods in the world. By using this method it can transfer heat from the pan to the food being cooked. Today, consumers more interested for a snack food that have a healthy criteria such as lower oil content but still retain the texture and flavors.

Vacuum frying is a method to production of fruit and vegetables snacks with low oil content and the good texture and flavor characteristic. It is defined as a frying process under vacuum pressure. When the pressure lowering, the boiling point of the oil in the food is lowered and the oil temperature also lowered than fraying at atmosphere condition. Vacuum frying have some advantages, first it can reduce oil content in the fried product. Second it can preserve natural color and flavors of the product depend to the low temperature and oxygen content during frying process and third it has less adverse effect on oil quality

1.2 PROBLEM STATEMENTS

In recent years, snack foods industries tends to produce lower oil content that still maintain the desirable texture and flavors. Because of consumers preference for low fat and fat free products is increased. Oil content in the snack is higher when use atmospheric frying. It also tends to be damaged natural color and flavors of the product due to the high temperature and oxygen content during the process

For decades, consumers have desired deep-fat fried products because of their unique flavor–texture combination, ranging from potato chips, French fries, doughnuts, extruded snacks, fish sticks, and the traditional-fried chicken products. In 2000, Americans spent $110 billion on fast foods, with fried foods playing an important role. Americans consume about three hamburgers and four servings of French fries per week. However, the increased awareness of consumers to the relationship between food, nutrition, and health has emphasized the need to limit oil consumption, calories originating from fat, and cholesterol among others.

Today, consumers are more interested in healthy products that taste good. Fried products are produced today using non-hydrogenated oil, and contain no saturated fat and no trans-fats. Some of these products (sweet-potato chips, apple chips, potato chips-blue) are fried under vacuum yielding less oil absorption with higher retention of their natural color and flavors.

Vacuum frying is an efficient method of reducing the oil content in fried snacks, maintaining product nutritional quality, and reducing oil deterioration. It is a technology that can be used to produce fruits and vegetables with the necessary degree of dehydration without excessive darkening or scorching of the product. In vacuum frying operations, food is heated under reduced pressure [<60 Torr ~ 8 kPa] causing a reduction in the boiling points of the oil and the moisture in the food.

1.3 PROJECT OBJECTIVE

There are objectives that should be achieved in the end of the project. The objective of this project is to design and development of a vacuum frying to produce high quality fruit and chips for example potato chips in terms of reduced oil content, good texture, and color.

1.4 SCOPE

There are 3 scope determined to make sure all the objectives can achieved. These scopes are:

1. Literature review of the vacuum frying.
2. Redesign of vacuum frying drawing using CADCAM software with Solidwork 2008.
3. Fabricate the prototype of product

1.5 CONCLUSION

This chapter described about overall introduction of this project. Background of this project will discuss after defining problem statement. Then, scopes and objectives of this project is determined as a guidelines of the project. Structure of thesis described about synopsis of every chapter of this thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 FRYING

Frying is a cooking of food in oil or fat. It is a technique that appeared in ancient. Chemically, oils and fats are the same differing only in melting point. In industry many fats are called oils for example palm oil and coconut oil. Palm oil is a form of edible vegetable oil obtained from the fruit of the oil palm tree. It is the second-most widely produced edible oil, after soybean oil and coconut oil. It also known as coconut butter and is fat consisting of about 90% saturated fat, extracted from coconuts and used in cosmetics as well as baking and cooking which are solid at room temperature.

Fats can reach much higher temperatures than water at normal atmospheric pressure. Through frying, one can sear or even carbonize the surface of foods while sugars. The food is cooked much more quickly and has a characteristic crispness and texture. Depending on the food, the fat will penetrate it to varying degrees, contributing richness, lubricity, and its own flavor.

Frying techniques is varying in the amount of fat required, the cooking time, the type of cooking vessel required, and the manipulation of the food. Stir frying, pan frying, and deep frying are all standard frying techniques.

Stir-frying is involved cooking foods in a thin layer of fat on a hot surface, such as a frying pan, griddle and wok. Stir frying involves frying quickly at very high temperatures, requiring that the food be stirred continuously to prevent it from adhering to the cooking surface and burning.

Shallow frying is a type of pan frying using only enough fat to immerse approximately one-third to one-half of each piece of food. Deep-frying, on the other hand, involves totally immersing the food in hot oil, which is normally topped up and used several times before being disposed. Deep-frying is typically a much more involved process, and may require specialized oils for optimal results.

Deep frying is now the basis of a very large and expanding world-wide industry. Fried products have consumer appeal in all age groups, and the process is quick, can easily be made continuous for mass production, and the food emerges sterile and dry, with a relatively long shelf life. The end products can then be easily packaged for storage and distribution for examples potato chips, french fries, nuts, doughnuts and instant noodles

2.2 VACUUM

A vacuum is a volume of space that means empty of matter, such that its gaseous pressure is much less than atmospheric pressure. The quality of a vacuum refers to how closely it approaches a perfect vacuum. The gas pressure is the primary indicator of quality, and is most commonly measured in units called torr, even in metric contexts. Lower pressures indicate higher quality, although other variables must also be taken into account. Vacuum is useful in a variety of processes and devices. It’s used to protect the filament from chemical reaction. The chemical reaction is not useful for electron beam welding, cold welding, vacuum packing and vacuum frying

2.3 VACUUM FRYING

Vacuum frying is an effective method to production of fruits and vegetables with low oil content and having a texture and flavor characteristics. The consumer today need for low-fat and fat-free products because it will to produce healthy having a lower oil content products but it still retain the desirable texture and flavor. In vacuum frying operations, food is heated under reduced pressure in a closed system that can lower the boiling points of both the frying oil and the moisture in food. Water in the fried food can be rapidly removed when the oil temperature reaches the boiling point of water. Because food is heated at lower temperature and oxygen content during vacuum frying [Garayo and Moreira, 2002], the natural color and flavor can be better preserved than conventional deep fat frying. Vacuum frying is an excellent alternative to conventional frying, since when frying below atmospheric pressure significant advantages such as healthier and high quality products are reached [Garayo and Moreira, 2002].

The frying process can be defined as carried out under well pressures below atmospheric levels. Due the pressure lowering, the boiling points at the oil and the moisture in the foods are lowered. Vacuum frying also is an efficient method of reducing the oil content in fried snacks, maintaining product nutritional quality, and reducing oil. It is a technology that can be used to produce fruits and vegetables with the necessary degree of dehydration without excessive darkening or scorching of the product. In vacuum frying operations, food is heated under reduced pressure and causing a reduction in the boiling points of the oil and the moisture in the foods [Garcia-Viguera and Bridle, 1999]

The advantages of vacuum fraying are first ,it can reduce oil content in the fried product, second ,it can preserve natural color and flavors of the product due to the low temperature and oxygen content during the process, and third has less adverts effects on oil quality .[Granda and Moreira, 2005]

2.3.1 VACUUM FRYING SETUP

In vacuum frying the frying vessel was covered with a stainless steel (type 316L) lid and tightly screwed. The vessel was connected to a vacuum pump which allowed a maximum vacuum level of 5.4 kPa (absolute pressure, at this pressure the boiling point of water is 34 C). The condenser consist of a dry ice trap, was placed between the frying vessel and the vacuum pump. The objective of the condensation system was to prevent the mix of the water vapor coming from the product with the pump's oil, thus avoiding damage to the pump .A dual seal vacuum that can generate a vacuum up to 1.333 kPa is used to provide vacuum to the vessel. Once the oil temperature reached the target value, five or eight blanched pre-dried slices were placed inside the frying basket, covered with a grid, the lid was fastened and the vessel was depressurized. When the pressure in the vessel achieved, the basket was lowered and immersed in the oil for the required period of time. Thereafter the basket was raised, shaken manually and the vessel was pressurized. Samples were then removed from the fryer and hold in a stainless steel grid, as in atmospheric frying. The vacuum frying system is illustrated in figure 1[Granda and Moreira, 2005]

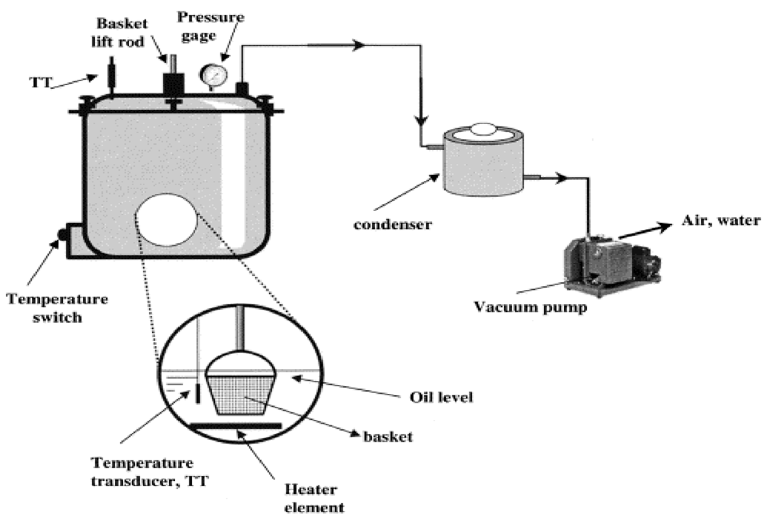

Figure 2.1: Schematic of the vacuum frying system

The fryer's basket rod was making by a motion feed-through-type shaft-seal attached at threaded port . This shaft-seal used to allows rotary motion of the shaft running from the atmosphere side to the vacuum side of the chamber wall. The sealing mechanism consists of two washers, the inner of edges surfaces and at under compression, seal against the shaft outer diameter.[Granda and Moreira, 2005]

Three levels of vacuum pressure (16.661 kPa, 9.888 kPa, and 3.115 kPa) and three levels of oil temperature (118 °C, 132 °C, and 144 °C) was used. The vacuum vessel was set to the target temperature and allowed to run for one hour before frying started. The oil volume in the vessel was 6.5 L. For this oil volume, there was a temperature differential between the bottom layer and the top layer of oil in the vessel of about 3 °C. Fresh soybean oil was used in all experiments. The potato chips were fried until the equilibrium moisture content was reached.

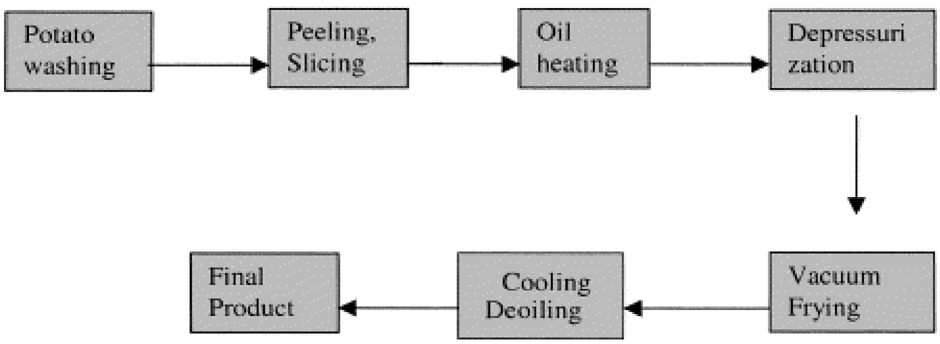

Figure 2.2: Flow diagram of the vacuum frying process

The figure 2.2 presents about a block diagram of the vacuum frying process for producing potato chips. The potatoes were take out from storage at least 12 hours before frying to let it to reach room temperature .Once the potatoes were peeled and sliced, it soaked in water for a few seconds, and then dried in paper towels to frying. About five or six slices of potatoes (20 to 25 g) were fried each time. Once the oil temperature reached the target value, the potatoes placed into the basket, the lid was close, the vessel evacuated. At this moment, the basket was lowered to the oil and frying began for the desired frying time. Once the potato slices were fried, the basket was lifted from the oil and the vessel pressurized. Then, the vessel was opened and the potato chips were removed from the basket. Then the potato chips allowed cooling at room temperature, dried with paper towel, and later stored in polyethylene bags for further analysis. [Granda and Moreira, 2005]

2.4 PRODUCT CHARACTERISTIC IN FRYING

2.4.1 Shrinkage

When frying method is used, a few characteristics will happen. First of that is shrinkage. Degree of shrinkage in volume (S_v) was evaluated by

:

$$S_v = \frac{V_o - V(t)}{V_o} \times 100$$

where V_o is the original volume of the sample (m^3) and V(t) is the volume (m^3) of the sample at time t. The volume of the sample (elliptical shaped) at any given time can be calculated by $V=(\pi Dd/4)L$ where D is the larger diameter of the sample (m) and d is the smaller diameter (m) of sample, and L the samples thickness (m). Ten samples were taken to determine shrinkage for each frying condition at the equilibrium time.

Volume shrinkage during early stages of frying very nearly equals the volume of water loss however, in the final stages of drying the volume shrinkage is smaller .Therefore volume shrinkage depends on water transfer within the product. For the same frying time, higher temperatures result in a higher mass diffusivity, higher water loss, and consequently lower volume shrinkage. The final shrinkage in volume of potato slices fried under different vacuum pressures was shown to decrease with oil temperature in figure 3a. In addition, higher oil temperature caused the potato chip surface to become rigid more rapidly, thus producing increased resistance to volume change suggested that the formation of a rigid surface in atmospheric frying at higher drying rates. [Garayo and Moreira, 2002]

The figure 2.3a also shows that by decreasing the vacuum pressure, the chips shrunk more. Probably, the structured formed in the chips during low vacuum pressure was less rigid than that formed under high pressures thus resulting in less resistance to volume change. Figure 2.3b represents a comparison of the degree of shrinkage in volume for potato chips fried under vacuum and atmospheric conditions. Potato chips showed a higher degree of volume change when fried under vacuum pressure at 3.115 kPa and temperature 144 °C than when fried at atmospheric conditions at temperature 165 °C. This is probably because the product becomes more rigid when fried under atmospheric frying than when fried under vacuum frying.

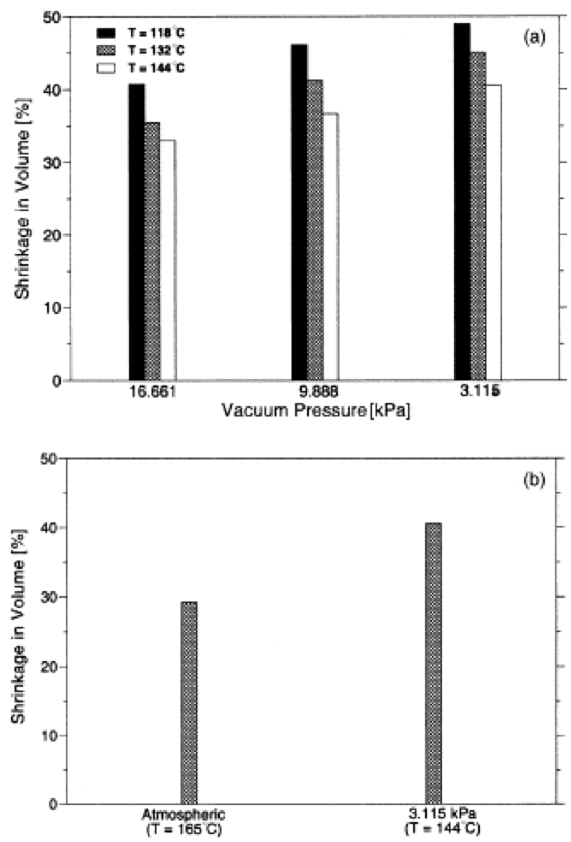

Figure 2.3. Shrinkage in volume of potato chips as function of frying time. (a) Effect of oil temperature and vacuum pressure; (b) comparison between vacuum-fried chips and atmospheric-fried chips.

2.4.2 Color

The second characteristic is color. The color of the potato chips was measured using a Hunter Lab Colorimeter Labscan XE (Hunter Associates Laboratory, Reston, VA). Color was measured in potato chips obtained at the equilibrium moisture content for each condition. Measurements were taken for ten chips of each condition, and two readings were taken for each potato chip. The colorimeter was standardized utilizing a white calibration plate, and a glass plate was used as the standard. The samples were placed always against the same background to obtain the color measurements. The statistical analysis showed that there were no significant differences ($p<0.05$) for lightness (L^*), green-red (a^*), and blue-yellow (b^*) of potato chips as a function of vacuum temperature and pressure. .[Granda et al., 2004]

A comparison of the color attributes of potato chips fried under vacuum and atmospheric conditions is shown in figure 9. The potato chips fried at pressure 3.115 kPa and temperature 144 °C had L^* values that were significantly higher ($p<0.05$) than the values corresponding to the potato chips fried under the atmospheric condition at temperature 165 °C. A higher L^* value indicates a lighter color, which is desirable in potato chips. The a^* values were significantly higher ($p<0.05$) for potato chips fried at atmospheric pressure than for potato chips fried at the vacuum conditions, indicating more Maillard reaction occurred at the atmospheric frying conditions

The blue-yellow (b^*) values were also significantly higher ($p<0.05$) for the potato chips fried at atmospheric pressure and temperature 165 °C than for potato chips fried at vacuum conditions.

Visual observation confirmed the results obtained with the colorimeter, since the potato chips fried under atmospheric conditions were darker, more red, and yellowish than potato chips fried under vacuum. The change in color in fried potato chips is due to the interaction of an amine group with a reducing sugar, which is a non-oxidative browning also known as Maillard reaction.[Granda et al., 2004]

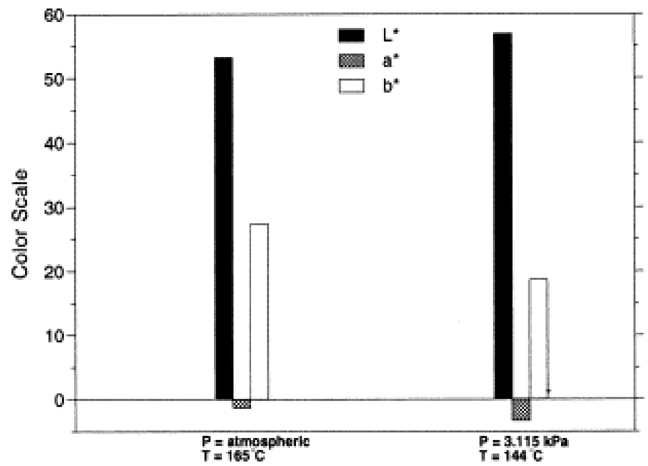

Figure 2.4. Comparison of color of potato chips fried under vacuum pressure and atmospheric pressure.

2.4.3 Texture

The third characteristic is texture. A rupture test was performed on the fried potato chips obtained at different frying times using a TA-XT2 Texture Analyzer (Texture Technologies Corporation, Scardale, New York).Texture was evaluated on samples fried at several times corresponding to different levels of moisture content for each condition. The tests were performed using ten chips per condition. For good experimental practice, all tests were run on the same day the chips were processed. The property used to describe the texture of the samples was hardness, defined as the force at maximum compression.

During frying, most of the water is removed from the potato slices resulting in textural changes. Table 1 shows the effect of pressure and temperature on the texture characteristic of potato chips at the end of frying. The force required to break the chips (hardness) increased for oil temperature range used in this study. However, the oil temperature did not affect significantly ($p<0.05$) the chip's texture.

Higher vacuum levels (lower vacuum pressure) produced chips with lower hardness values. However, the texture was not significantly ($p<0.05$) affected by vacuum pressure.[Granda et al., 2004]

Table 2.1: Effect of frying time on the texture (hardness) of potato chips fried under different operating conditions

T_{oil} (C)	P_{vac} (kPa)	FT (s)	Hardness (N)
118	16.661	600	2.73 ± 0.81^a
118	9.888	600	2.47 ± 0.44^a
118	3.115	600	2.23 ± 0.51^a
132	16.661	480	3.13 ± 0.64^a
132	9.888	480	2.58 ± 0.42^a
132	3.115	480	2.05 ± 0.40^a
144	16.661	360	3.65 ± 0.42^a
144	9.888	360	2.86 ± 0.86^a
144	3.115	360	2.71 ± 0.79^a

For the potato chips fried under atmospheric conditions (Table 2), during the first 50 of frying, their structure was very weak and collapsed easily when applying the rupture test. For the potato chips fried under vacuum conditions, the texture in the initial stages of frying was also leathery, but much more flexible and the chips became brittle very early during the frying process. However, the final hardness values were not significantly different ($p<0.05$) for the potato chips fried at vacuum and atmospheric conditions.[Moreira et al., 1999]

Table 2.2: Comparison of textures values of potato chips fried under atmospheric and vacuum conditions (temperature 144 °C and pressure 3.115 kPa)

T_{oil} (C)	P_{vac} (kPa)	FT (s)	Hardness (N)
165	101.3	30	0.65 ± 0.11^{a}
165	101.3	150	2.65 ± 0.59^{b}
165	101.3	180	2.89 ± 0.91^{b}
165	101.3	240	3.45 ± 0.88^{c}
165	101.3	300	2.88 ± 0.54^{a}
144	3.115	30	3.78 ± 1.83^{a}
144	3.115	150	3.31 ± 0.55^{b}
144	3.115	240	3.17 ± 0.49^{b}
144	3.115	360	2.71 ± 0.79^{b}

2.4.4 Moisture loss

Moisture loss during vacuum frying increased with the frying temperature and was significantly affected by the pre-treatment type. Oil uptake during vacuum frying increased with frying time and was significantly affected by the pre-treatment type. Final oil contents of vacuum fried control and blanched potato chips increased when compared with those fried at atmospheric pressure. However, oil absorption in blanched and dried in vacuum frying was decreased. The drying process of foods is generally characterized by three distinct periods. The first is an initial heat-up period during which the wet solid material absorbs heat from the surrounding media. The product is heated up from its initial temperature to a temperature where the moisture begins to evaporate from the food. In vacuum frying, this initial heat-up period is very short and therefore difficult to quantify. At a vacuum pressure for example, the boiling point of water is around 25 °C. The temperature in the potato slice is slightly higher than the boiling point of water due to the presence of some solutes. Since the temperature of the potato slices prior to frying was at room temperature 23 or 24 °C, the slices only had to warm up a few degrees for the water to start boiling. For this reason, the heat-up period in vacuum frying is very short. Oil absorption rate during vacuum frying of potato chips was related to the moisture loss rate. The highest drying loss rate (thus the highest the oil absorption rate) was obtained with the highest oil temperature 144 °C and lowest vacuum pressure 3.115 kPa. The fryer operating conditions did not affect the final oil content of the vacuum-fried chips. However, results showed that the faster the water loss rate, the higher the oil adhesion at the chips surface and then the higher oil absorption. In addition, as the percentage of free water is depleted in the product, less oil is absorbed. The pressurization step plays an important role in reducing the oil absorption during vacuum frying.[Paulo F.Da Silva and Rosana G.Moreira 2007]

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will provide the detail explanation on the methodology that carries out for this project "Design and development of vacuum fruit frying machine for SMI and SME application" from the beginning till the end. Methodology can properly refer to the theoretical analysis of the methods appropriate to a field of study or to the body of methods and principles particular to a branch of knowledge. The methodology act as the guidance or step that needs to be follow and this will ensure the project done according to the planning. Methodology as an algorithm that finds a solution in the given environment of the multi-layered finite space consisting of literature review, identifying the suitable design, making a Solid work model of the design, Identifying parts and making the part list and fabrication.

3.2 FLOW CHART

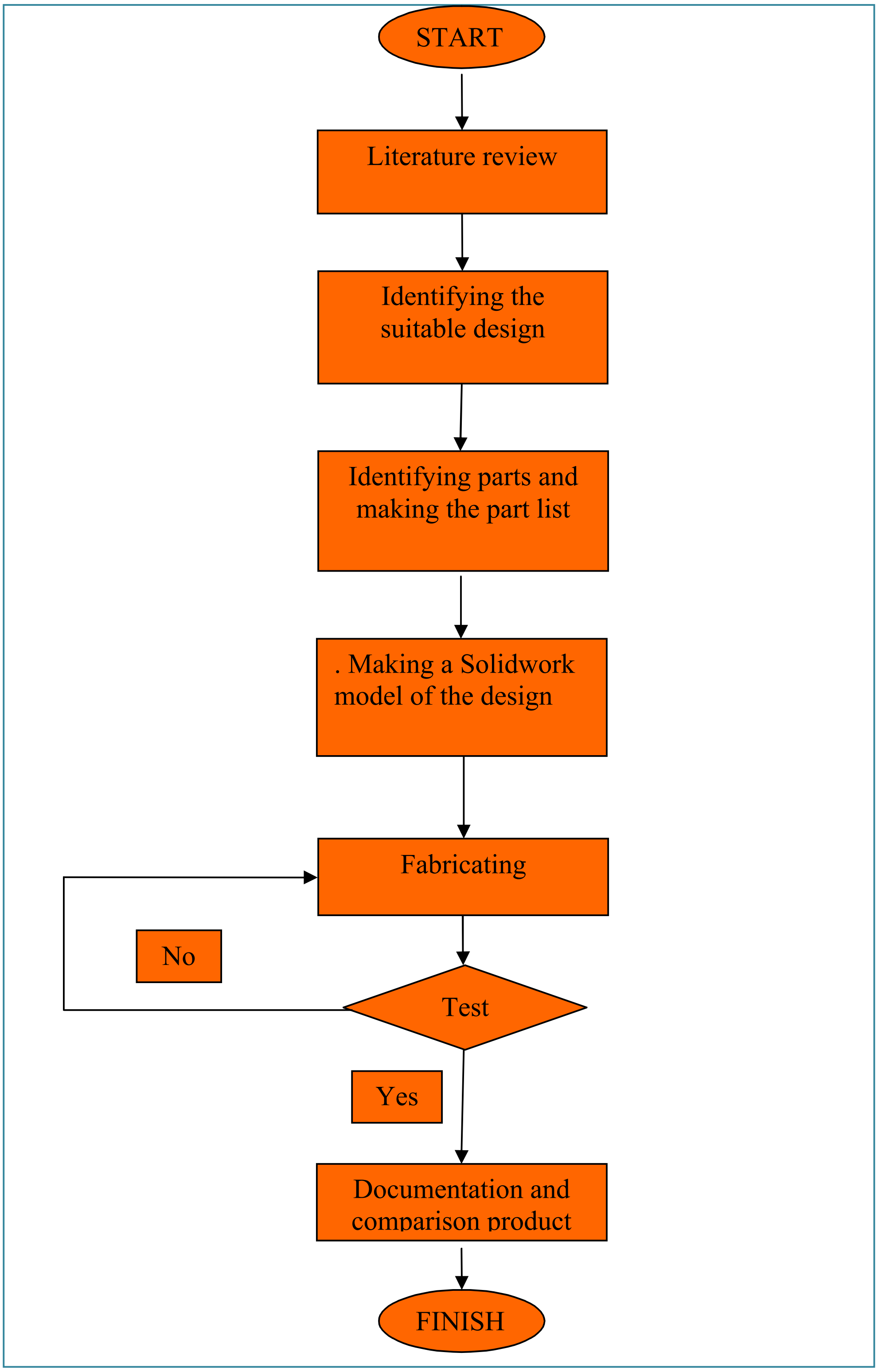

Figure 3.1: Project Flow Chart

In the beginning of this project is receiving title and briefing from supervisor. In order to have better understanding about this project title "Design and development of vacuum fruit frying machine for smi and sme application", several research on internet and market available product was perform. Designing consideration include environmental conditions, friendly, reliability and maintenance. Identify the basic requirement or specific specifications of the vacuum fruit frying machine that can suit the customer for this design.

Define the function of device through explore and understanding the working principles of automatic gate mechanism. The vacuum fruit frying could work under static and dynamic condition and required different operating condition. State the design requirement that possible for this vacuum frying mechanism system. The basic requirement should be able to suit the customer need and reliable.

Propose several alternative design concepts, also called the invention of the concepts or concept design. Various schemes must be proposed in order come out with several option design selection. Evaluate each proposed alternative design. Analysis perform to assess whether the system performance is satisfactory or better, and, if satisfactory, just how well it will perform. Compare and contrast between the advantages and disadvantages. System scheme that do not survive analysis are revised or discarded, those with potential to optimize and determine the best performance of which the scheme is capable. Competing schemes are compared so that the path leading the most competitive product can be chosen.

Complete the design with full dimension and specification so can proceed to the next step for fabrication. The documentation is the final stage by preparing a full report where consist of introduction, literature review, methodology, result and discussion and conclusion.

3.3 SEVERAL EARLY ALTERNATIVE DESIGNS

The design criteria are based on the cost, safety, ease of maintenance, reliability, installation and ease of use. After go through the brainstorming session, few design was constructed with simple sketching or act as the early conceptual design

3.3.1 Design 1

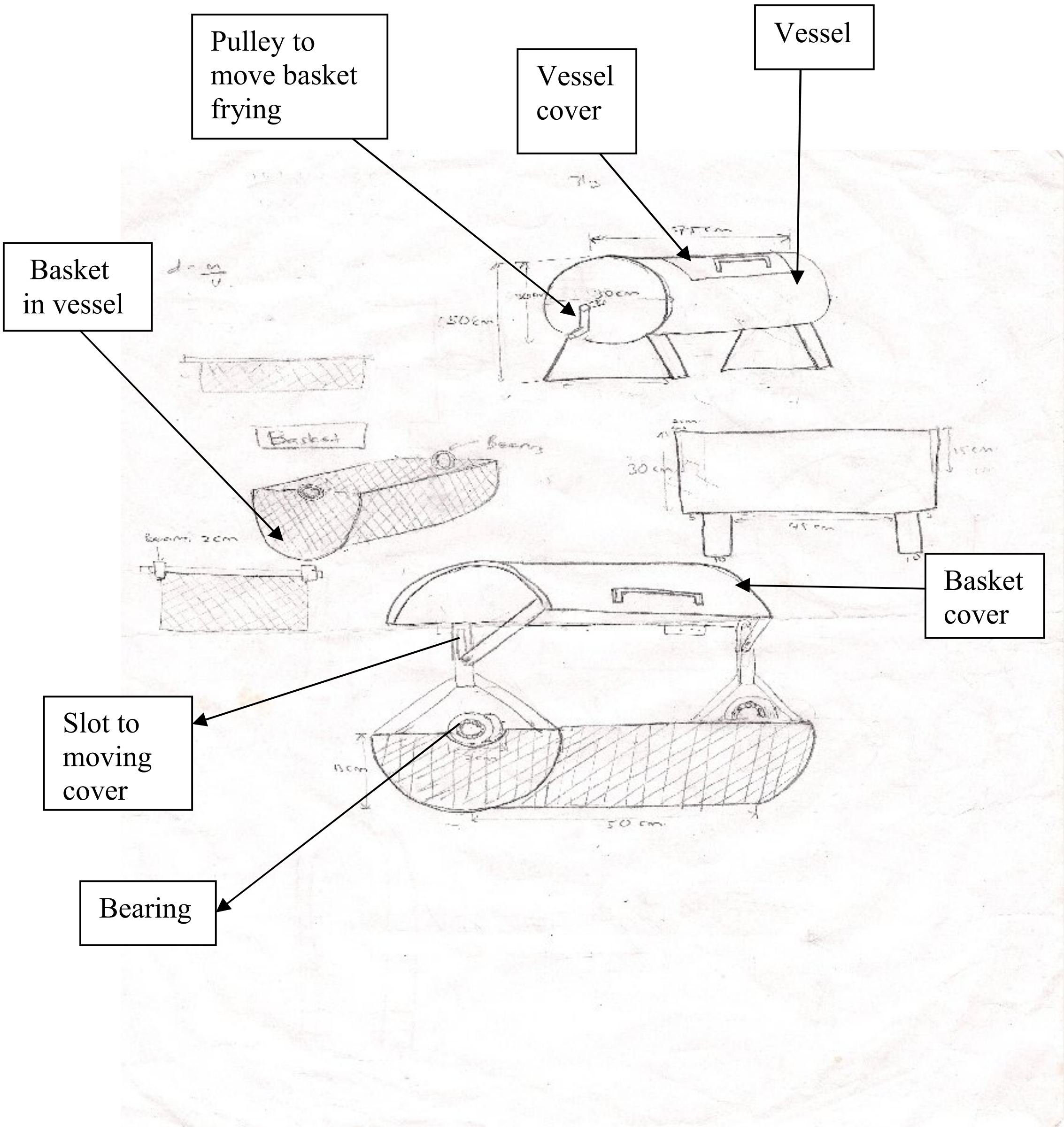

Figure 3.2: Design 1

3.3.2 Design 2

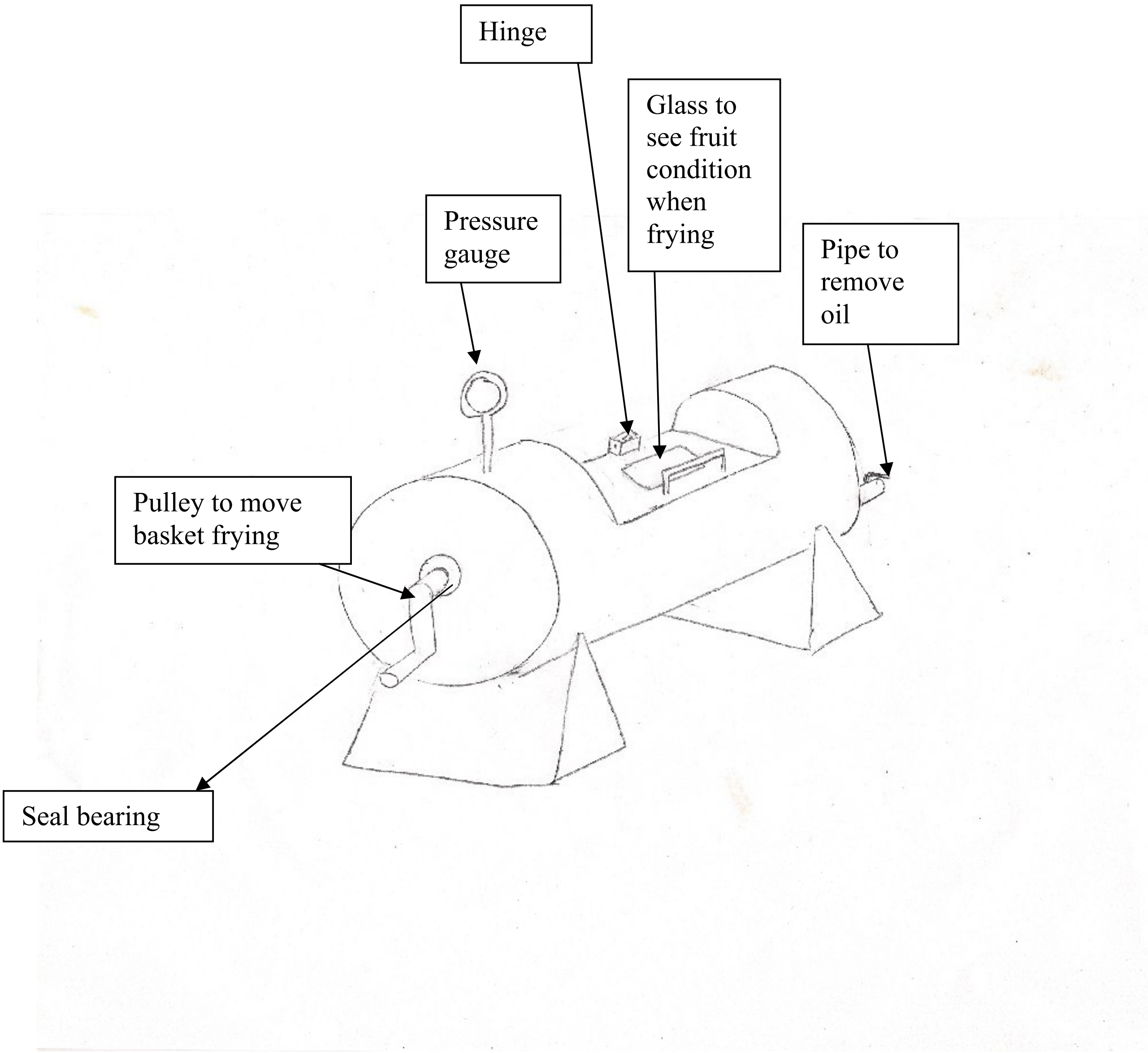

Figure 3.3: Design 2

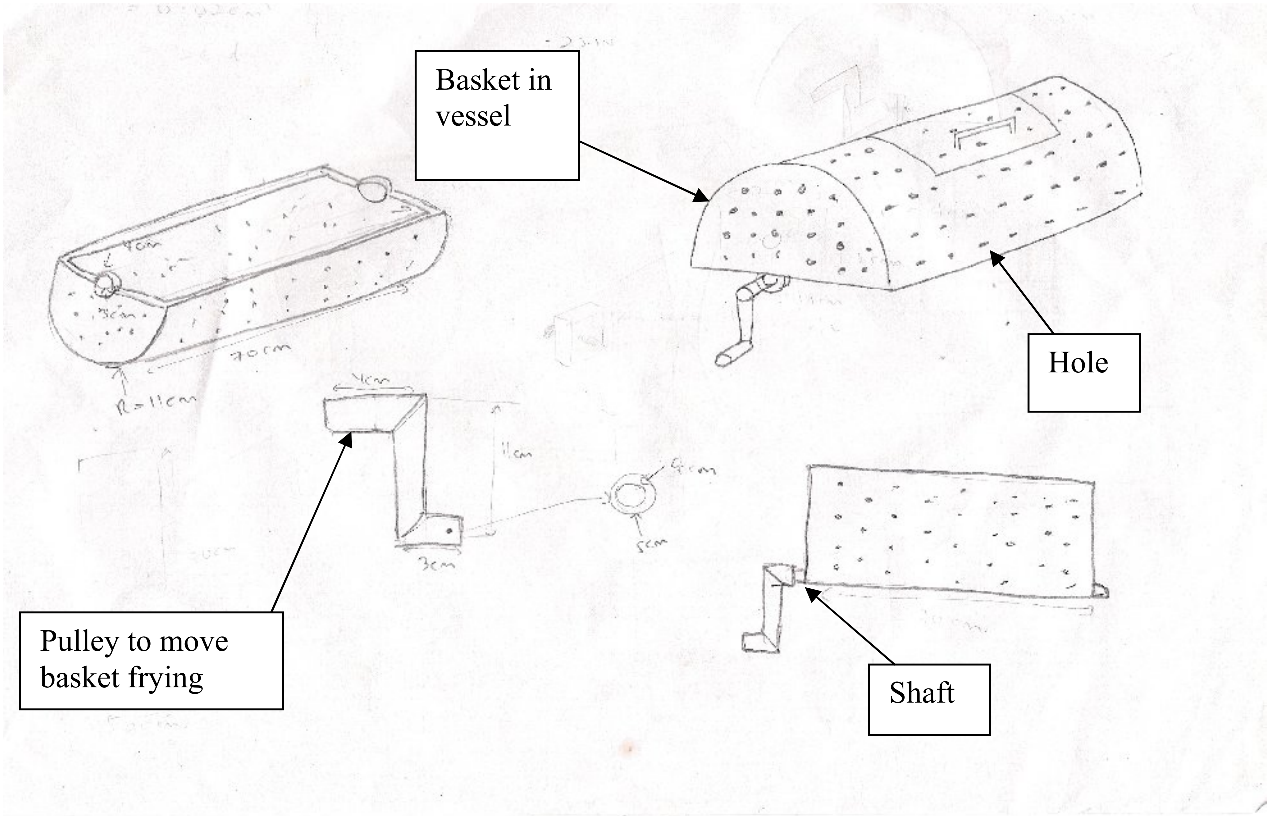

Figure 3.4: Design 2

3.3.3 Design 3

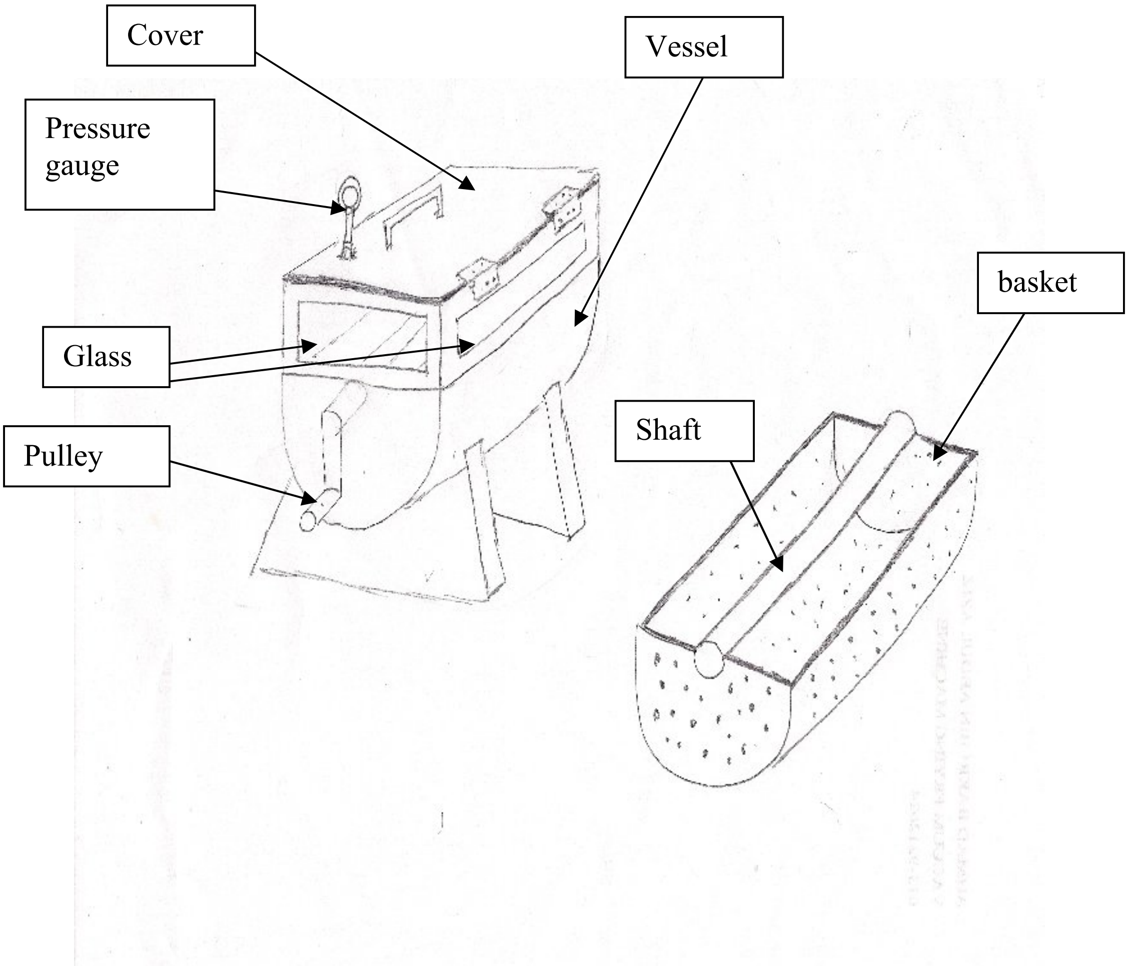

Figure 3.5: Design 3

3.4 DESIGN EVALUATION

Design 1 and design 3 difficult on the installation and the system is complicated for construction and having part that easily to fail. Design 2 was taken for further fabrication after consideration.

3.5 SOLIDWORK MODEL

Solidwork is the global standard in 3D mechanical design software. It helps organization to reduce time to market, design better quality product faster, maintain a competitive advantage, and increase the sales. Soliwork delivers powerful 3D design capabilities, unmatched ease of use, and an affordable cost. Solidwork software allows Autocad user to become rapidly productive using 3D mechanical design and 2D detailing capabilities of Solidworks as well as leveraging 2D legacy data. Solidworks provides tutorials specifically develop for the Autocad user, using familiar terminology to help speed up the learning process. Solidworks provides a data migration wizard and innovative 2D to 3D tools that allow Autocad users to maintain their legacy data or build 3D models from 2D drawings. Before performing the Solidwork model, proper dimension of each component and part need to be measure accurately to avoid problem on the assembly part for this software application. The dimension is important because it will use for future reference when working on the fabrication.

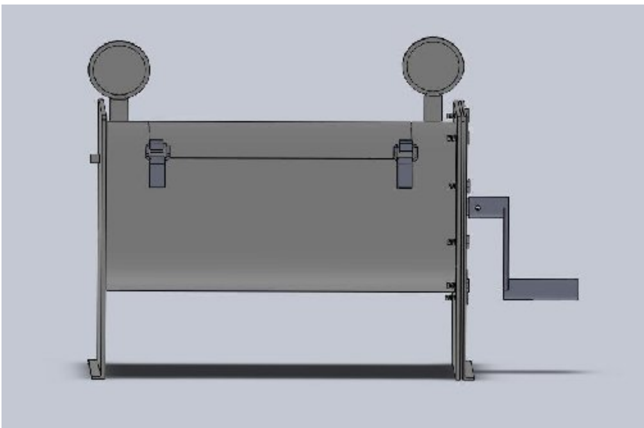

Figure 3.6: Front view

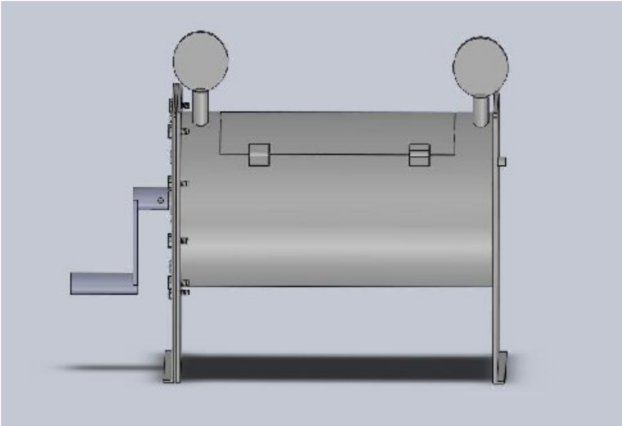

Figure 3.7: Back view

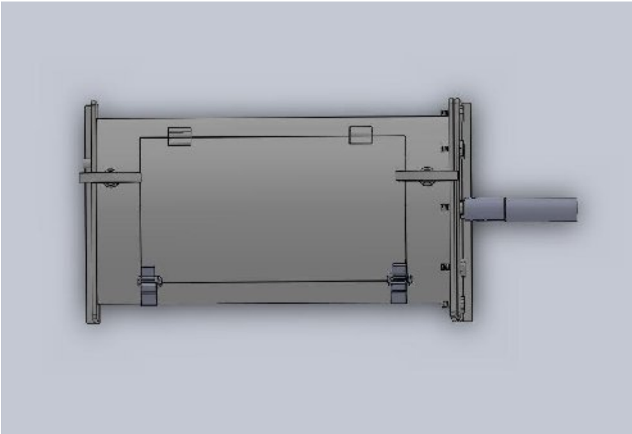

Figure 3.8: Top view

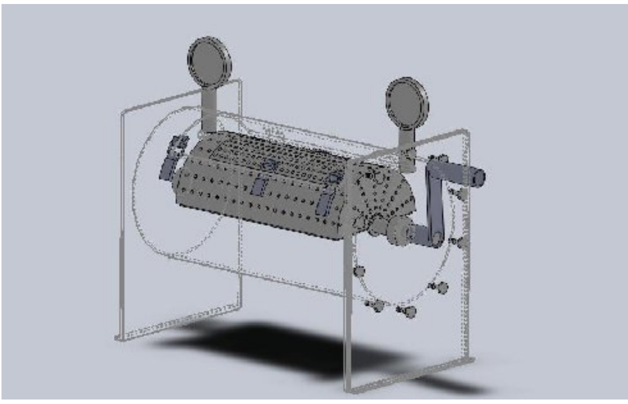

Figure 3.9: Transparent view

3.6 PART OF VACUUM FRYING

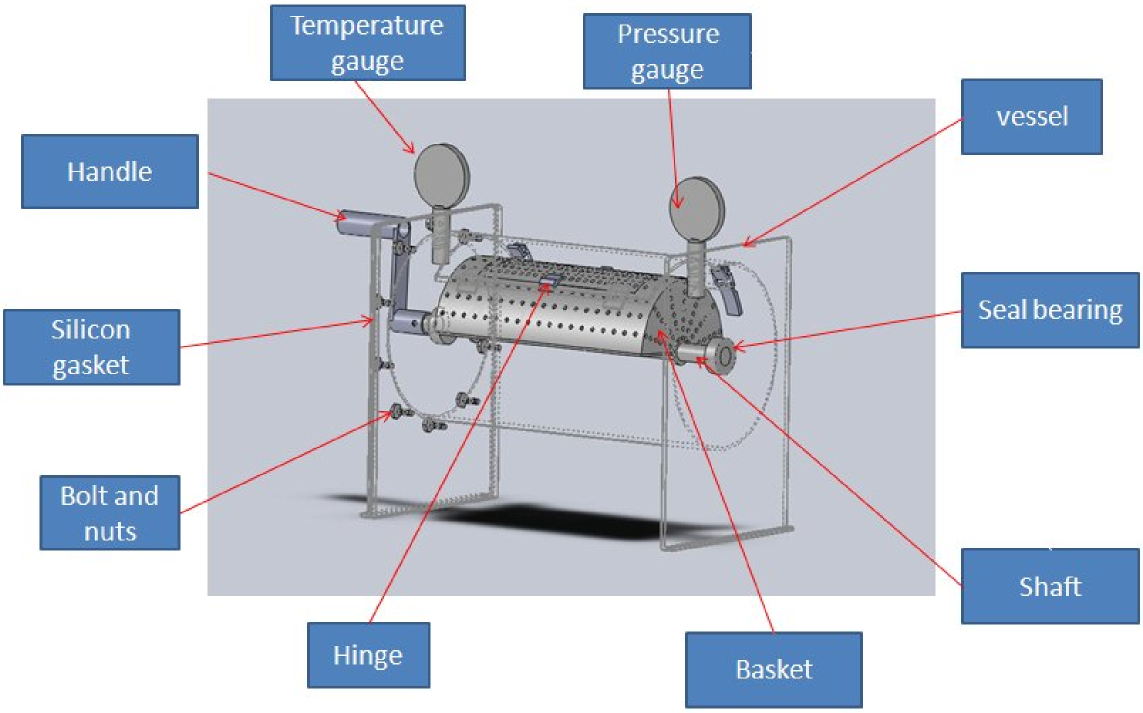

Figure 3.10: Part for vacuum frying

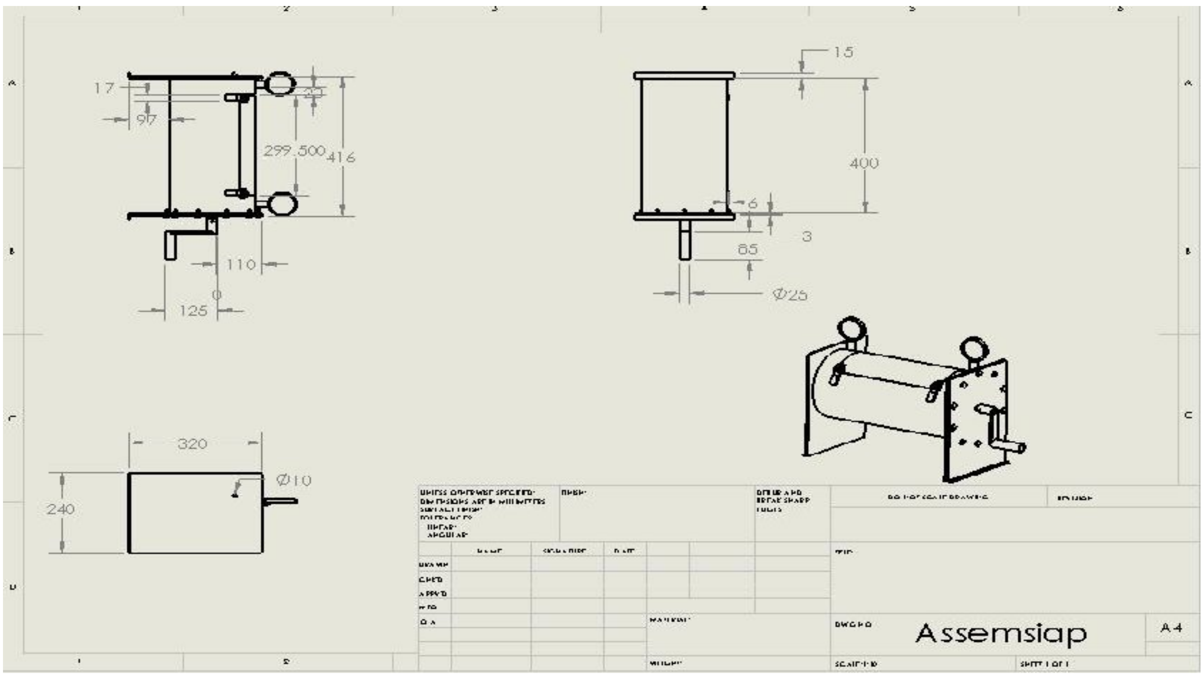

Figure 3.11: Dimension of the vacuum frying

3.7 BILL OF MATERIAL

Part	Size	Quantity
Seal bearing	2 cm(inner diameter)	2 unit
Water pump QB60	25mm x 25mm(Q max=35L/min)	1 unit
Sheet metal 316L	244 cm x 122cm	1 unit
Glass (Borosilikate glass)	20 cm x 8cm	1 unit
Ejector	80mmHG	1 unit
Pressure gauge (negative)	ranges=(-0) - (-10)kpa	1 unit
Rod bar 316L	Length=60 cm Diameter=2 cm	1 unit
Water pipe(metal)	Length =200 cm Diameter =2cm	1 unit
Temperature gauge	Nominal size=50mm Ranges= 0 ºc - 200ºc Measuring system= mercury in steel	1 unit

Figure 3.12: Bill of material

3.8 MATERIAL THAT USE TO MAKE VESSEL

3.8.1 Stainless Steel - Grade 316L

Grade 316 is the standard molybdenum-bearing grade, second in importance to 304 amongst the austenitic stainless steels. The molybdenum gives 316 better overall corrosion resistant properties than Grade 304, particularly higher resistance to pitting and crevice corrosion in chloride environments.

Grade 316L also is the low carbon version of 316 and is immune from sensitization (grain boundary carbide precipitation). Thus it is extensively used in heavy gauge welded components (over about 6mm). There is commonly no appreciable price difference between 316 and 316L stainless steel.

The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures. Compared to chromium-nickel austenitic stainless steels, 316L stainless steel offers higher creep, stress to rupture and tensile strength at elevated temperatures.

3.9 MATERIAL PROPETIES

3.9.1 Corrosion Resistance

The material is excellent in a range of atmospheric environments and many corrosive media - generally more resistant than 304. It subject to pitting and crevice corrosion in warm chloride environments, and to stress corrosion cracking above about 60°C and considered resistant to potable water with up to about 1000mg/L chlorides at ambient temperatures, reducing to about 500mg/L at 60°C.

316 are usually regarded as the standard “marine grade stainless steel”, but it is not resistant to warm sea water. In many marine environments 316 does exhibit surface corrosion, usually visible as brown staining. This is particularly associated with crevices and rough surface finish.

3.9.2 Welding and Machining

It also has an excellent weldability by all standard fusion and resistance methods, both with and without filler metals. Heavy welded sections in Grade 316 require post-weld annealing for maximum corrosion resistance. This is not required for 316L.316L stainless steel is not generally weldable using oxyacetylene welding methods.The 316L stainless steel tends to work harden if machined too quickly. For this reason low speeds and constant feed rates are recommended.316L stainless steel is also easier to machine compared to 316 stainless steel due its lower carbon content.

3.9.3 Hot and Cold Working

The 316L stainless steel can be hot worked using most common hot working techniques. Optimal hot working temperatures should be in the range 1150-1260°C, and certainly should not be less than 930°C. Post work annealing should be carried out to induce maximum corrosion resistance. Most common cold working operations such as shearing, drawing and stamping can be performed on 316L stainless steel. Post work annealing should be carried out to remove internal stresses. The 316L stainless steel does not harden in response to heat treatments. It can be hardened by cold working, which can also result in increased strength.

3.10 MAIN PART THAT USED TO MAKE VESSEL

3.10.1 Ejector

Ejectors are simple pieces of equipment. Nevertheless, many of their possible services are overlooked. They often are used to pump gases and vapors from a system to create a vacuum. Ejectors are employed in the industry in numerous, unique and even sometimes bizarre ways. They can be used singly or in stages. The water ejectors also known as a vacuum pumps and it drive by a high pressure water or similar medium or steam. It use kinetic energy of the driving medium to suck in gases, vapors or other liquids and then discharge the resultant mixture against a counter pressure.

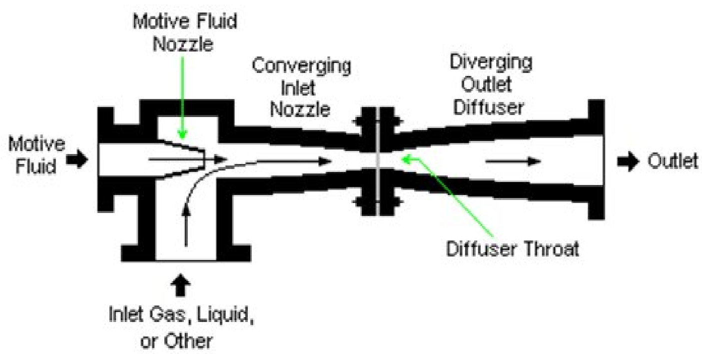

Figure 3.13: Flow in ejector

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter is mainly about the result, analysis and discussion from the finish product. The result is mean by the vacuum frying machine ability to perform the task by the given input. Analysis can be obtained by the performance of the vacuum frying. In the discussion section, the problems occur from the fabrication and performance of the vacuum frying being analysis to get the real factor affecting the vacuum frying performance.

4.2 SPECIFICATION

All the detail specification of the dimension is based on the CAD design. The specification of the parts or components is based on the product that publishes by the company that produced it. The specification of the vacuum frying is obtain by the component that been used in the fabricating the vacuum frying. Overall specification is considering all the components involving in the operating of the vacuum frying machine.

4.3 CALCULATION

The manual calculation is to know total heat requirement for frying process in vacuum condition. The final temperatures get from the frying journal that it suitable to consideration in vacuum frying calculation

4.3.1 Heating the liquid

Initial temperature palm oil, T1 =40° (http://www.andrew.cmu.edu.my)
Final temperature ,T2 =144°c

Temperature is ΔT =T2-T1
=104°c

Volume liquid (ρ) =0.92g/cm³

$\rho = m/v$
$v = 5000g/0.92g/cm^3$
$v = 5434.78cm^3$
$v = 5.43x10^{-3}m^3$

Mass of liquid =5kg
Specific heat (cooking oil), Cp=1.67KJg-1k-1

Heating time (t) =10 minutes
=600s

Q (liquid) =m Cp ΔT/t
=5(1.67) (104)/600
=1.447kw

4.3.2 Heating the tank material

Tank plate thickness =1mm
=0.001m

Volume of stainless steel (v) = $(\pi d^2/4) \times L$
= $(\pi (0.2)^2/4) \times 0.4$
= $0.012567m^3$

Mass of stainless steel 316

$\rho = m/v$
$m = \rho \times v$

ρ stainless steel =8000kg/m³

m=8000 kg/m³ x 0.012567m³
=100.536kg

Cp stainless steel 316 (from http://www.azam.com)= 500 J/kg.k
= 0.5kJ/kg.k

Q tank = (m Cp ΔT)/t
= (100.536(0.5) (0.4))/600
= 8.71 kw

4.3.3 Heat loss from tank sides

Q = UA ΔTm

Heat transfer coefficient from vessel =11w/m².c

Total surface area= [(πd²/4) x 2] + [2πr x p]

= [(π (0.2)²/4) x 2] +[2π(0.1) x 0.4]

= 0.06283 + 0.2513
= 0.3141m³

Tm = (final temperature +initial palm oil temperature)/2
= (144°c + 40°c)/2
= 92°c

Tamb = 27°c(room temperature)

ΔTm =Tm – Tamb
=92°c -27°c
=65°c

U = heat transfer coefficient from vessel =11w/m²°c

Q(sides) =(11 x 0.3141 x 65)/1000
=0.23 kw

4.3.4 Total heat requirement

Q=Q(liquid) + Q(tank material) + Q(tank sides)
= 1.447kw + 8.71kw + 0.22kw
= 10.377kw

4.4 ANALYSIS

The strength and heat transfer analysis using ALGOR is to determine whether the material used is acceptable and suitable to using in fabrication of vacuum frying machine. After complete the analysis, the result shows that this vacuum frying design and material is strong enough and suitable for this type of material handling, then we can move the progress work to the fabrication process. There are two type analyses and material that used to find the suitable material as the material to make the vacuum frying machine. The material that used in this analysis is stainless steel 304 and stainless steel 316L.The first analysis is to know what material use minimum heat transfer in vacuum frying. After get the suitable material, the strength analysis is running to know the material will support minimum and maximum weight of the oil and fruit chip when frying.

4.4.1 Heat flux analysis

The heat flux analysis is to know value of heat transfer between two types of material which is to know what material faster to risk the oil temperature in the vacuum frying while frying and also know the maximum value of heat that support before melt.

Heat flux is defined as the heat transfer per unit time per unit area or the rate of heat transfer per unit area. Therefore, the average heat flux in this case is

$$q = Q/A$$
$$= Q/\pi D^2$$

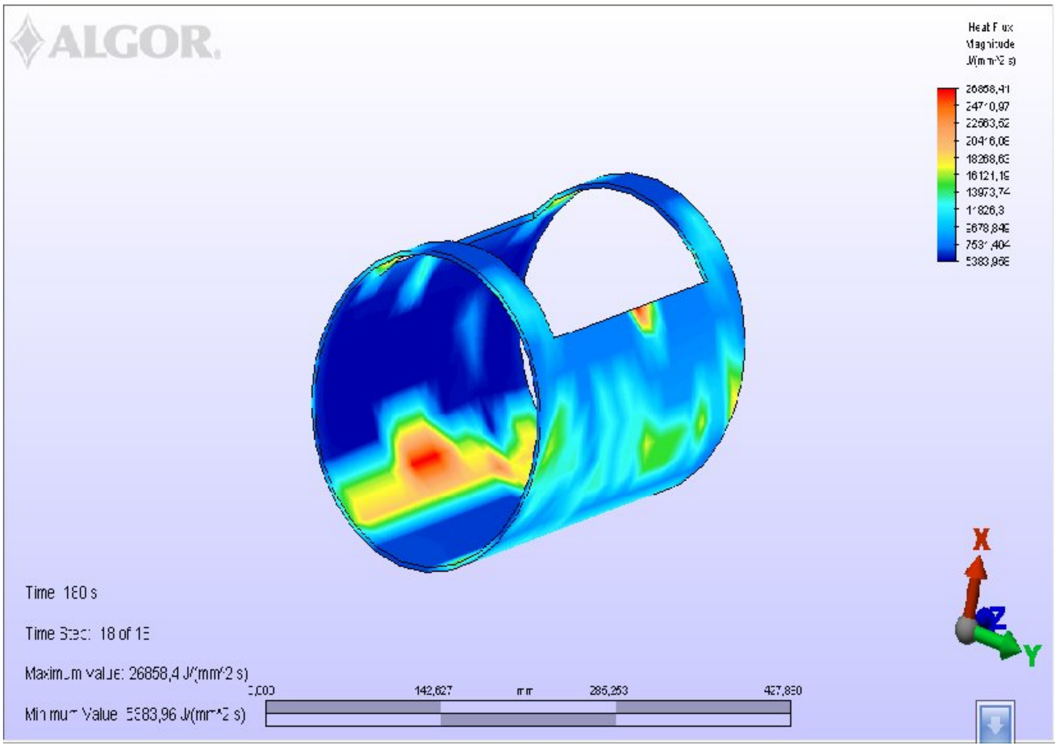

Figure 4.1: Using stainless steel 304

From the figure 4.1, the maximum value that the stainless steel 304 uses to get the ideal temperature for the frying process is 26858.4 J. From the value, the heat transfer value can be calculated.

Total surface area= $[(\pi d^2/4) \times 2] + [2\pi r \times p]$

$= [(\pi (0.2)^2/4) \times 2] + [2\pi(0.1) \times 0.4]$

$= 0.06283 + 0.2513$
$= 0.3141 m^3$

Heat transfer,Q

$Q = q \times A$
$= 26858.4\ J \times 0.3141 m^3$
$= 8436.22\ w/1000$
$=8.436\ kw$

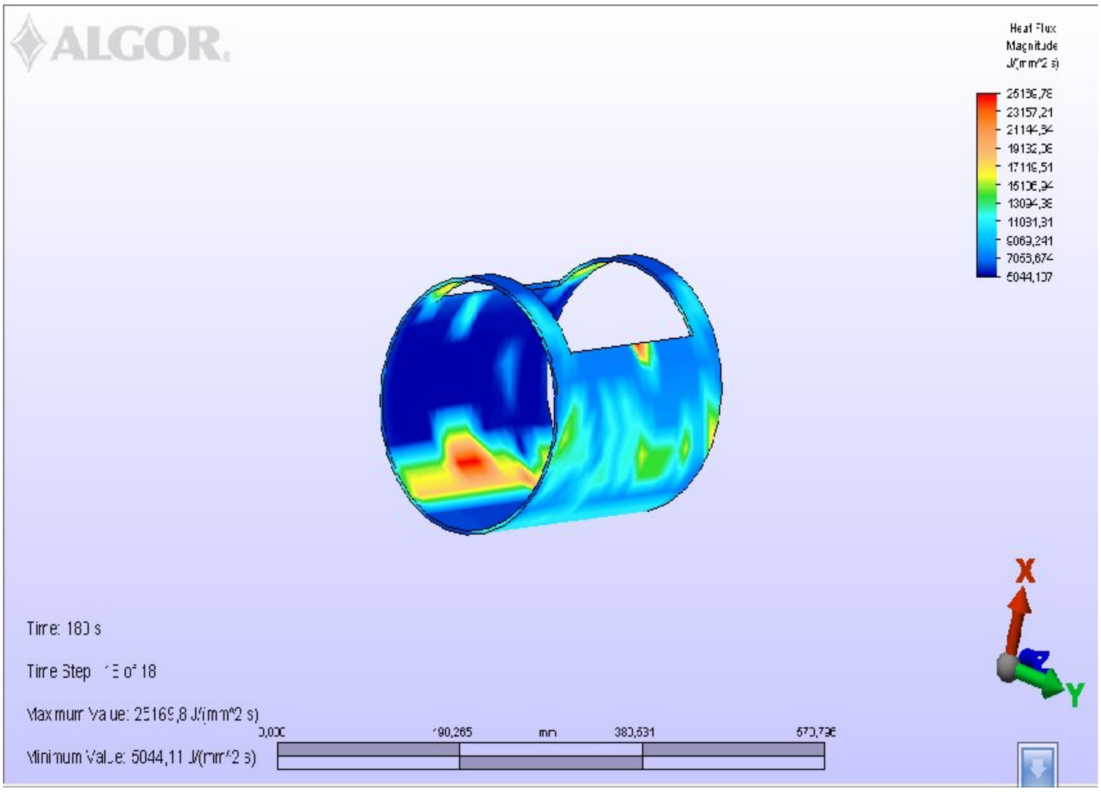

Figure 4.2: Using stainless steel 316L

From the figure 4.2, the maximum value that the stainless steel 316L uses to get the ideal temperature for the frying process is 8436.22 J. From the value, the heat transfer value can be calculate

Total surface area= [(πd²/4) x 2] + [2πr x p]

$= [(\pi (0.2)^2/4) \times 2] + [2\pi(0.1) \times 0.4]$

$= 0.06283 + 0.2513$
$= 0.3141m^3$

Heat transfer,Q

$Q = q \times A$
$= 25169.8\ J \times 0.3141m^3$
$= 8436.22\ w/1000$
$=7.905\ kw$

After get the results from analysis, we make the decision to using stainless steel 316L as a material to perform vacuum frying because it use the small heat transfer value than stainless steel 304 to get the 144°c.

4.4.2 Strength analysis

The type of material is choosing as a material for vacuum frying is stainless steel 316L. The force are applied to the plate are the total weight of oil that fill in the vessel. The force applied to the vessel is 49.05 N.

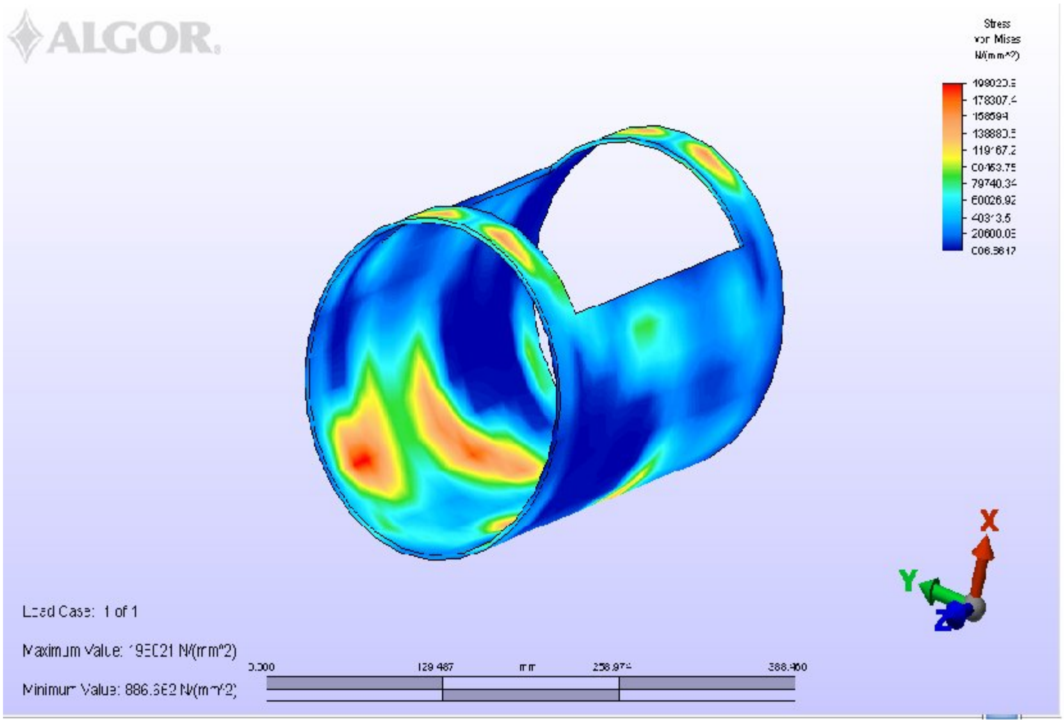

Figure 4.3: Stress von mises

Stress Von Mises is the total force that acting in surface area. The maximum value of Stress Von Mises that can support the force by stainless steel 316L plate is 198020.8 N/ (mm^2). To choose the perfect material as a material to make vacuum frying machine, some criteria needs to consider such as heat transfer, weight, resistant to chemical, corrosion resistance and suitable for food preparation equipment particularly. The Stainless steel 316L have better thermal conductivity and also have good corrosion resistance better than other stainless steel. The Stainless steel 316L also provides greater structural strength in case of mechanical abuse tolerance and does not easily melt or burn.

4.5 FABRICATION

These processes is about using the material Selection and make the product base on the design and by followed the design dimension. Many methods can be used to fabricate a product, like welding, rolling, bending, cutting, drilling and many more method. Fabrication process is difference from manufacturing process in term of production quantity. Fabrication process is a process to make only one product rather then manufacturing process that focus to large scale production. In the project, fabrication process needed to make the vacuum frying by using the stainless steel 316L and the main machine to use is rolling and TIG welding machine.

Figure 4.4: Rolling machine

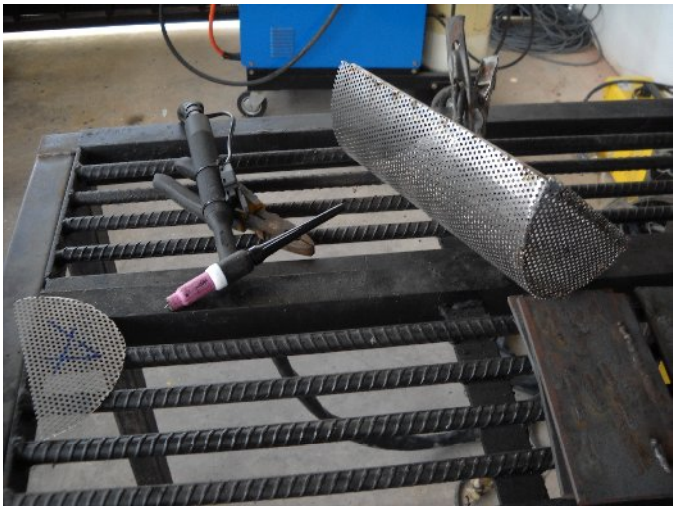

Figure 4.5: TIG welding

4.6 FINISH PRODUCT

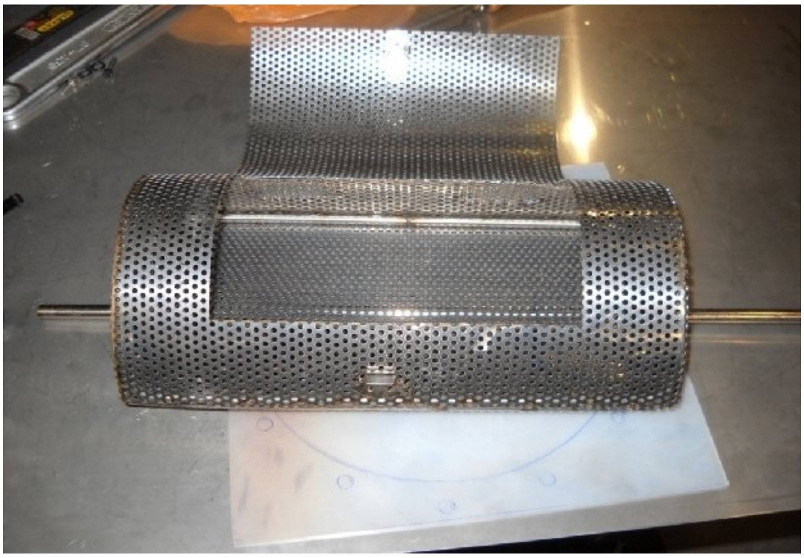

Figure 4.6: Basket in vessel

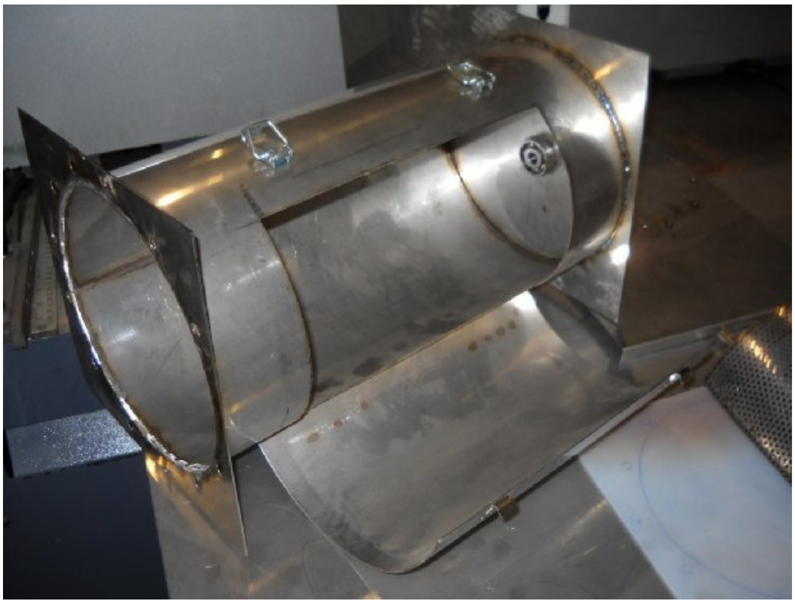

Figure 4.7: Vessel

Figure 4.8: vacuum frying after assemble

Figure 4.9: Full assemble with ejector, pressure and temperature gauge, water pump and vacuum frying machine is already to use

4.7 OUTCOME PRODUCT FROM VACUUM FRYING MACHINE

When lowering of pressure, the boiling points of oil and moisture in the potato chips are lowered, it also can preserve natural color and flavors and it takes a short time for frying. Figure 4.10 and figure 4.11 shows the color different when frying at 3 minutes and frying at 1 minute and at pressure -1 Kpa and 140 °c

Figure 4.10: After 3 minute frying

Figure 4.11: After 1 minute frying

4.8 RESULTS OF FRYING EXPERIMENTS USING POTATO SLICES

Table 4.1: Results of frying experiments

Experiment	Pressure(Kpa)	Oil Temperature(◦c)	Frying time(minute)	Results
1	16.661	118	1	- slightly softer and lighter in color than experiment 1
2	9.888	132	1	- slightly softer and lighter in color than experiment 2
3	3.115	144	1	-slightly softer and lighter in color than experiment 3
4	-1	145	1	-more slightly softer -more lighter in color

4.9 DISCUSSION

From the final product outcome, the vacuum frying machine can operate to frying fruits chips in vacuum condition and 5kg of palm oil can fill in the vacuum frying. First step before frying is fill palm oil in the vessel and after that the whole potato is sliced thin and placed in baskets and baskets closed cover containing fruit pieces and it maintained in top position and water pump is switched on to generate ejector . After the temperature gauge reading shows the desired temperature and pressure gauge shows a negative reading handle used to move the basket containing fruit just now on the circumstances under which it will be submerged in palm oil and to ensure food frying around, handle used to move the basket above and below and this situation is left up to the time required. After carried out the final products, frying in one minute is better than frying in three minutes at same pressure and temperature that pressure is -1KPa and temperature is 140°c. It relates to vacuum frying principle that frying in vacuum condition takes a short times to cook. It was conclude that vacuum frying is a process that could be a feasible alternative to produce potato chips with lower oil content and desirable color and texture

CHAPTER 5

CONCLUSION

5.1 CONCLUSIONS

The development stage of the product started with the background knowledge of the product. All the method in vacuum frying machine, previous research that had been accomplished and mechanism for working is discussed. The second step is by the design concept, detail drawing and fabrication process is carried out. The third step is analyzing the finish product. After all the process is done, the objective of the project is check to see if it is achievable.

The present study successfully indicated that the main objective of the project is achievable .The main purpose of using vacuum frying is this study was evaluate its feasibility for production of low oil content fruit chips.In general ,vacuum fried snack retain more of their natural colors and flavours due to the less oxidatation and lower frying temperatue.When lowering the pressure ,the boiling point of oil and moisture in the fruits chips are lowered ,it also can preserve natural colour and flavours of the products and it take the short time for frying

5.2 RECOMMENDATION FOR THE FUTURE RESEARCH

The first prototype is used to prove that the design concept of the vacuum frying machine can be operated. It needs more improvement to give the better product. Therefore, there are several improvements can be made based on the first prototype that is:

i.) Improve the mechanism while frying
ii.) Using a sensor to make it easier to operate such as when frying is complete.
iii.) Improve the design to make it more easier to use.
iv.) Using the suaitable saiz of pressure and temperature gauge

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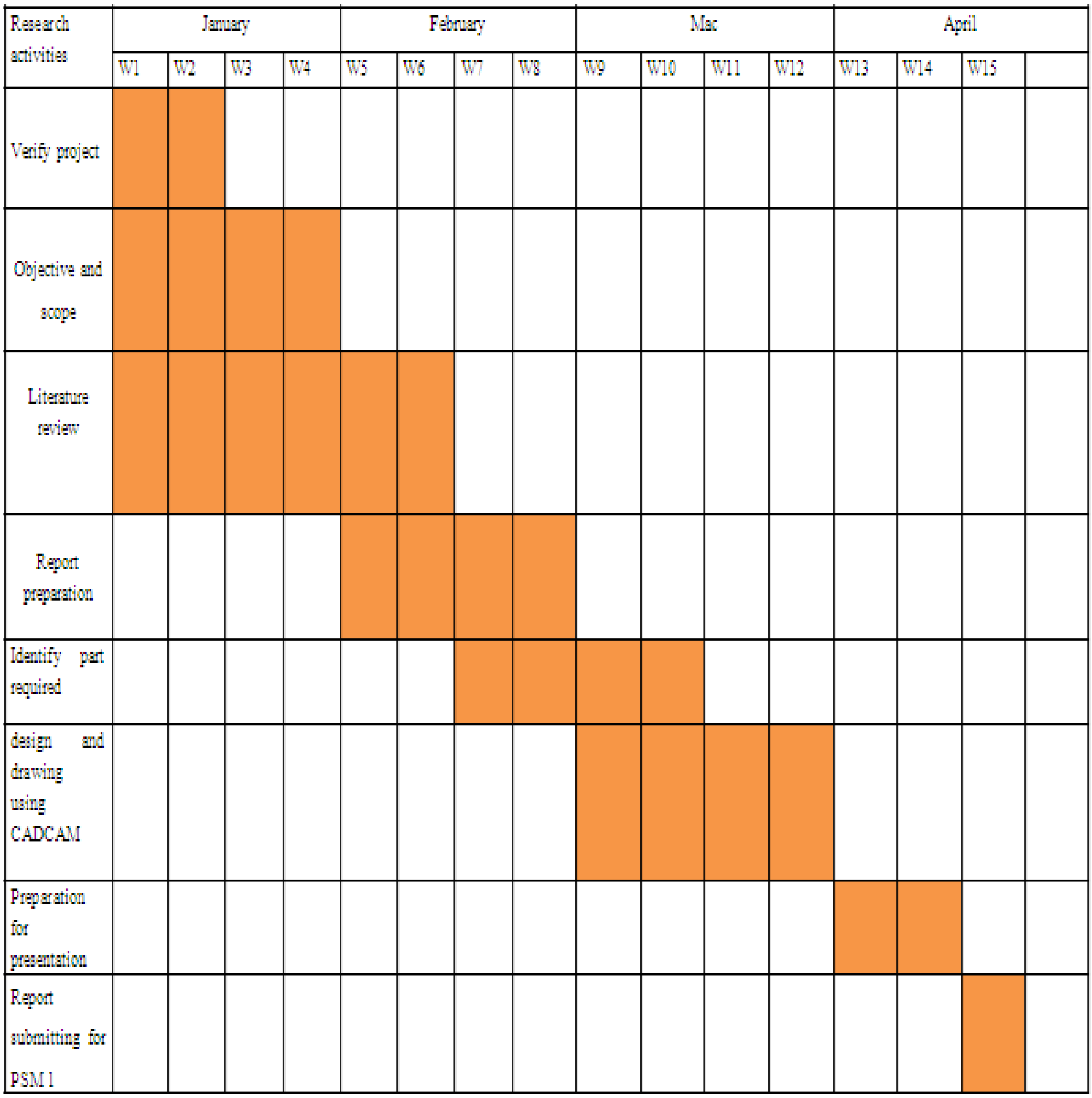
APPENDIX A

Gantt Chart for FYP 1



APPENDIX B

Gantt Chart for FYP 2

Research activities	July				August				September				October			
	W1	W2	W3	W4	W5	W6	W7	W8	W19	W10	W11	W12	W13	W14	W15	
Part surveying and purchasing																
Heat and strength analysis on design																
fabrication																
Test run																
Presentation preparation																
Report submitting for PSM 2																

APPENDIX A1

Gantt Chart for FYP 1

Research activities	January				February				Mac				April			
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	
Verify project	■	■														
Objective and scope	■	■	■	■												
Literature review	■	■	■	■	■	■										
Report preparation					■	■	■	■								
Identify part required							■	■	■	■						
design and drawing using CADCAM									■	■	■	■				
Preparation for presentation													■	■		
Report submitting for PSM 1															■	

APPENDIX A2

Gantt Chart for FYP 2