" I/We* confess that have been read this outstanding piece of works and at my/us* this piece of work is acceptable from the scope and the quality for the awarded Bachelor of Mechanical engineering (design and Innovation)"

Supervisor I

Signature :.....

Name :Prof Madya Ir Mustafar Ab Kadir

Date :27 March 2008

PROF MADYA IR. MUSTAFAR B. AB KADIR
TIMB. DEKAN (AKADEMIK)
Fakulti Kejuruteraan Mekanikal
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200 Ayer Keroh
75450 Melaka

Supervisor II

Signature :.....

Name : Mr Shafizal bin Mat

Date : 27 March 2008

FEASIBILITY STUDY ON VACUUM COOKER FOR DOMESTIC USE

RAIHANAH BINTI ABDULLAH

This Report is submitted
In partial fulfillment for Bachelor of Mechanical Engineering
(Design and Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal MalaysiaMelaka

MAY 2008

"I declare that all parts of this report are the result of my own work, except a few sections which were extracted from other resources as being mentioned."

Student's Signature :.....

Name :Raihanah Abdullah

Date :27 March 2008

Special for my mom and dad, Abdullah Ab Rahman and Rahimah Yaacob

Thesis supervisor, P.M Ir. Mustafar bin Ab Kadir

& Mr Shafizal bin Mat

ACKNOWLEDGEMENT

First of all, I would like to express my grateful thanks to God for the chances to complete this *Projek Sarjana Muda* thesis.

Special thanks to Prof. Ir. Mustafar bin Ab Kadir for accepting me as one of the students under his observation for PSM. He gives me lot of chances during my projects evaluation. I have gained a wealth of knowledge and experience regarding this project. He had been an extremely important guiding force behind me throughout my project, offering me excellent advice as to how to perform task and correcting the mistakes that I had made. He was patient and easy to approach when ever his assistance was sought. I would like to express my deepest gratitude. I also would like to thank my second supervisor, Mr Shafizal bin Mat for all supports and guidance given. My heartiest appreciation dedicated to all lecturers from Faculty of Mechanical Engineering for their kindness and helps. Thank you for the speeches, ideas, and all the opinions for me.

Last but not least, I would like to convey token of my appreciation to my beloved family and friends especially Nor Azimah Mohamad for great moral supports, helps, ideas and critics.

ABSTRACT

A technological innovation used in the field of home appliances has contributed human into a better life. One of product that categorized in home appliances is a cooker. The objective of this project was to investigate a feasibility design of vacuum cooker that can decrease heating time and without destroying the natural grain or structure of the foodstuff as well as its aroma. The design also will be focusing on vacuum cooker that will be used for domestic daily used. This report examines on the part design of vacuum cooker, and functionality. However, this report will not cover on prototyping, circuit, and experimentation. This report involves the design process flow starts with planning, product development, discussion and conclusion. Product development processes includes identifying customer needs, product specification, conceptual design, and detail design. The findings gained from this method are product characteristics of vacuum cooker. The specifications are user-friendly, ease of handling and installing, portable, enough capacity for the home use and have aesthetics value. Currently, the vacuum cooker widely used in factories because it needs a high cost. The particular strength for this research is in providing a vacuum cooker that can be used for domestic cooking.

ABSTRAK

Inovasi penggunaan teknologi dalam bidang peralatan asas rumah telah menyumbang ke arah kehidupan yang lebih baik. Salah satu produk yang dikategorikan sebagai perkakas rumah adalah periuk pemasak. Objektif yang membawa kepada projek ini adalah bagi mengkaji kebarangkalian rekabentuk sebuah periuk pemasak vakum yang dapat mengurangkan masa memasak dan tanpa memusnahkan struktur dan aroma semulajadi bahan makanan. Rekabentuk ini difokuskan bagi penggunaan harian domestik. Kajian ini mendalami bahagian-bahagian rekabentuk periuk pemasak, fungsi dan bahan yang digunakan untuk membina produk tersebut. Walau bagaimanapun, kajian ini tidak menyentuh mengenai penghasilan protaip, litar pam vakum,dan eksperimentasi. Projek ini menggunakan kaedah asas rekabentuk bermula dengan perancangan, pembangunan produk, diskusi dan kesimpulan. Pembangunan produk pula melibatkan analisis kehendak pengguna, produk spesifikasi, rekabentuk konsep dan rekabentuk terperinci. Berdasarkan kaedah-kaedah ini, didapati ciri-ciri rekabentuk produk yang perlu ada pada periuk pemasak vakum adalah mesra pengguna, mudah dikendalikan dan disimpan, mudah alih, kapasiti yang mencukupi untuk kegunaan seisi rumah dan nilai estetika. Penggunaan pemasak vakum pada masa kini adalah berfokuskan kepada kilang-kilang. Kekuatan bagi projek ini apabila rekabentuk yang dihasilkan ini lebih bersesuaian dengan kegunaan harian di rumah.

TABLE OF CONTENT

CHAPTER	CONTENT	PAGE
	DECLARATION	i
	DEDICATION	ii
	ACKNOWLEDGEMENT	iii
	ABSTRACT	iv
	ABSTRAK	v
	TABLE OF CONTENT	vi
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF SYMBOLS	xiii
1.0	INRODUCTION	
	1.1 Background	1
	1.2 Problem statement	2
	1.3 Objectives	2
	1.4 Scopes	2
	1.5 Thesis requirement	3
	1.5.1 Software requirements	3
	1.6 Thesis schedule and milestone	3
	1.6.1 Phase 1 : Planning phase	3
	1.6.2 Phase 2 :Preliminary phase	4

1.6.3 Phase 3 : Analysis phase 4
1.6.4 Phase 4 : Design phase 5
1.6.5 Phase 5 : Implementation phase 5
1.6.6 Phase 6 : Final Phase 5

2.0 LITERATURE REVIEW
2.1 Vacuum systems 7
2.2 Vacuum pumps 8
2.3 Vacuum definition 8
2.4 Vapour elimination 11
2.5 Vacuum frying 11
2.6 Vacuum impregnation 12
2.7 Foods texture fact 13
2.8 Vacuum cooking or warming appliances 14
2.9 Vacuum materials 15
2.9.1 Basic principles 17
2.9.2 Thermal conductivity 18
2.9.3 Heat capacity 20
2.9.4 Thermal diffusivity 22
2.10 Definition on high and low vacuum 22
2.11 Pressure ranges corresponding to _degree of vacuum‘ 23
2.12 _Hard‘ vacuum 24
2.13 Vacuum cooking 24
2.14 Cooker 25
2.14.1 Choosing the right material for cookware 25
2.14.2 Conventional cooker 27
2.14.3 Electric pressure cooker 27
2.15 Comparison between pressure cooking and vacuum cooking 29
2.16 Patent 31
2.16.1 Vacuum Thermal Cooker 31

2.17 Existing product 34
2.17.1 Gastrovac cooker 34

3.0 METHODOLOGY
3.1 Introduction 35
3.1.1 Literature review 36
3.2 Product development 36
3.2.1 Customer needs 37
3.2.2 Product specification 38
3.2.3 Conceptual design 38
3.2.4 Detail design 38
3.3 Result and discussion 38
3.4 Conclusion 39

4.0 PRODUCT DEVELOPMENT
4.1 Introduction 40
4.1.1 Identifying customer needs 41
4.1.2 Product specification 44
4.2 Conceptual design 47
4.2.1 Concept generation 47
4.2.2 Concept selection 50
4.2.3 Concept scoring 52

5.0 RESULT AND DISCUSSION
5.1 Detail design 53
5.1.1 Main body 53
5.1.2 Cooker Lid 54
5.1.3 Spring parts 56

5.1.4 Switch kit 57
5.1.5 Base and hand operated vacuum 58
5.1.6 Cooker handle and safety lock 59
5.1.7 Final product 60
5.2 Discussion
5.2.1 Operation system 61
5.2.2 Static analysis 66
5.2.3 Converting Pressure Pump into Vacuum Pump 69

6.0 CONCLUSION
6.1 Conclusion 70
6.2 Recommendation 70

REFERENCES 71
APPENDICES 74

LIST OF TABLES

Table 2.0	Related units that been used in vacuum pressure.	10
Table 2.1	The porosity of the fruit and vegetables	12
Table 2.2	Thermal conductivity	20
Table 2.3	Specific heat	21
Table 2.4	Thermal diffusivity	22
Table 2.5	Relation of pressure gauge and degrees of vacuum	23
Table 2.6	Comparison between pressure cooking and vacuum cooking	29
Table 4.1	Mission Statement of vacuum cooker	42
Table 4.2	Customer interview	42
Table 4.3	Customer needs on vacuum cooker	43
Table 4.4	List of metric for the vacuum cooker	45
Table 4.5	The needs-metric matrix	46
Table 4.6	Morphology Chart for vacuum cooker	47
Table 4.7	Concept screening matrix for vacuum cooker	51
Table 5.1	Main body parts name and functions	54
Table 5.2	Cover lid parts name and functions	55
Table 5.3	Spring parts name and functions	56
Table 5.4	Switch kit parts name and functions	57
Table 5.5	Base and hand operated vacuum pump parts name and functions	58
Table 5.6	Cooker handle and safety lock parts name and functions	60
Table 5.7	Basic information on material AISI 304	66
Table 5.8	Result of analysis	67

LIST OF FIGURES

Figure 2.0	Vacuum system diagrams	7
Figure 2.1	Fire Resistance Materials for Vacuum Melting Process	15
Figure 2.2	Carbon and graphite fibers for vacuum furnaces	16
Figure 2.3	Graphite Products for Vacuum Furnaces	16
Figure 2.4	Processing Products for High Melting Point Metals	17
Figure 2.5	The temperature of the sheet of steel over gas burner	19
Figure 2.6	Uneven heating on material	19
Figure 2.7	Exploded perspective view of vacuum cooker	28
Figure 2.8	Vacuum thermal cooker	32
Figure 2.9	Exploded perspective view of vacuum cooker	33
Figure 2.10	Gastrovac Vacuum Cooker	34
Figure 4.1	Design process flow	41
Figure 4.2	Conceptual design 1	48
Figure 4.3	Conceptual design 2	48
Figure 4.4	Conceptual design 3	49
Figure 4.5	Conceptual design 4	49
Figure 4.6	Conceptual design 5	50
Figure 4.7	Final concept	52
Figure 5.1	Main body	53
Figure 5.2	Cooker Lid	54
Figure 5.3	Spring parts	56
Figure 5.4	Switch kit	57
Figure 5.5	Base and hand operated vacuum pump	58
Figure 5.6	Cooker handle	59

Figure 5.7	Final product of vacuum Cooker	60
Figure 5.8	Heat transfer to hotplate when pressing button	63
Figure 5.9	Spring element and electricity bar connection	63
Figure 5.10	Safety lock handles	64
Figure 5.11	Air seal	64
Figure 5.12	Graph Pressure vs. Pump down factor F	65
Figure 5.13	Vacuum pump	66
Figure 5.15	Von Misses Stress	66
Figure 5.16	Displacement	67
Figure 5.17	Strain	68
Figure 5.18	Vacuum pump making process	69

LIST OF SYMBOLS

P	=	Pressure (Pa)
F	=	Force (N)
A	=	Area (m^2)
N	=	Newton
kg	=	kilogram
s	=	second
°C	=	Celsius
K	=	Kelvin
mm	=	millimeters
ft	=	feet
Q	=	Amount of heat (kJ)
Cp	=	Specific heat (kJ/kg.K)
σ	=	Stress (MPa)

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Technology has added new dimensions to every aspects of life. The use of technological innovations in the field of home appliances has opened new horizons to industry. As the market for this product is widely opened, many companies came out with product invention and innovation. One of product that is categorized in home appliances is cooker. From the design of simple cooker that used gasses to cook, this design being upgraded into an electrical cooker. People kept facing new design and novelty as times past and industry needs to struggle for showing the best performance of their products. The most common cooker that widely used in domestic is pressure cooker. The structure of foods usually damaged and took almost an hour to cook. The technology also has discovered on vacuum use in cooking method. This thesis focuses on the feasibility study on design of vacuum cooker. It will explain on the effectiveness in using vacuum cooker that it could protect quality of foods as well as saving time and energy.

1.2 PROBLEM STATEMENT

These days, foods which were prepared by direct heats for a long period of times usually its nutrition and structure are destroyed. Foods become flaccid and it also affects its original taste. The original taste, colour, smell and the look of the foods were maintained by implementing the vacuum approach during heating and cooking process. The vacuum that applied towards the food will released the water inside the foods and leaves them crispy and tasty. The existing cooker needs longer time to achieve cooking temperature degree for boiling that is 100°C and this also has effect on electrical energy. The pressure cookers on the other hand are designed focusing on minimizing time to cook, without considering the effects on food. Basically, in this case the foods get cooked in short time due to the high pressure appointed towards them but then high pressure and heating destroy its grain and nutrition.

1.3 OBJECTIVES

The objective of this thesis is to investigate the feasibility study on design of vacuum cooker for domestic use.

1.4 SCOPE

This study presents the detail design of vacuum cooker that can be used in domestic kitchen. This study does not cover on prototyping, electrical circuit, and experimentation.

1.5 THESIS REQUIREMENT

This thesis needs only theoretical design of the vacuum cooker.

1.5.1 SOFTWARE REQUIREMENT

Software requirements cover system‘s design and development tools, operating system and database management system.

i) Microsoft Office 2003 (Word, Excel, Project and Front Page)
ii) Catia V5 R14
iii) CosmosWork

1.6 THESIS SCHEDULE AND MILESTONE

Project schedule define all activity in each phase starting from Identifying Problem phase until detail design phase.

1.6.1 Phase 1: Planning Phase (Introduction to “Projek Sarjana Muda” (PSM))

i) Attend PSM 1 briefing
ii) Find relevant project‘s title with suitable supervisor based on their interest and major
iii) Prepare proposal

iv) Do research on proposed system

v) Define thesis‘s objective.

vi) Present and submit proposal to the supervisor

vii) Attend meeting with supervisor on the next step to be taken

1.6.2 Phase 2: Preliminary Phase (Define Problem Statement)

Carry out Chapter I : Introduction

i) Identify Problem Statement

ii) Define Objective and Scope of the system

iii) Identify Project Significance and Expected Output

iv) Develop Project Schedule and milestones

v) Submit Chapter I

Carry out Chapter 2: Literature Reviews

i) Study process planning and other process that relevant in designing process.

ii) Do research on relevant methodology

iii) Decide on the suitable methodology based on research

iv) Submit Chapter 2.

1.6.3 Phase 3: Analysis Phase

i) Carry Out Chapter 3: Methodology

ii) Study what process need to finish this thesis.

ii) Study how to get the best result at the end of this thesis.

iii) Submit Chapter 3

1.6.3 Phase 4: Design Phase

i) Carry out Chapter 4 : Product Development
ii) Study about product development and design process flow.
iii) Identifying customer needs.
iv) Product Specifications.
v) Conceptual Design.
vi) Concept generations.
vii) Submit chapter 4.

1.6.5 Phase 5: Detail Design Phase

i) Carry Out Chapter 5 : Result
ii) Come out with six (6) concept design.
iii) Concept selections.
iv) Final concept.
v) Conclusion from result.
vi) Submit Chapter 5

1.6.6 Phase 6: Final Phase (Standardize and Finalize the PSM II)

i) Complete PSM II draft report
ii) Submit PSM II final report to supervisor and panel
iii) Final Presentation of Equipment Performance Online Tracking System
iv) Submit PSM II final report to Faculty

CHAPTER 2

LITERATURE REVIEW

Vacuum cooker is a basic cooker that used vacuum for heating process. The pressure inside the vacuum cooker is gradually decreasing during cooking operation until it gets lower than the atmospheric pressure. During this process, vacuum pump takes action to suck out air in the cooker to leave this cooker in the vacuum. Vacuum helps this cooker to boil foodstuff before it reaches the water boiling temperature that is 100°C. The appropriate vacuum cookers can assure the user safety, low energy, and protect the quality of foods.

Based on many researches, vacuum is considered as a mechanism that can help to provide a balance cooking environment besides protecting the quality of foods. Vacuum cooking can reduce the use of energy to boil and this also will reduce the cost. When we apply less energy and heat pressure on foods, the structure of foods is not affected and the quality of foods is protected.

This thesis studies all the possibilities and suitable concept design for vacuum cooker that can be use at home.

2.1 Vacuum system

The vacuum system consist of;

i. Chamber
ii. N2 valve
iii. Main valve
iv. Foreline valve
v. Rotary pump
vi. Roughing valve
vii. Vent valve
viii. Diffusion pump or cryo pump or molucar pump.

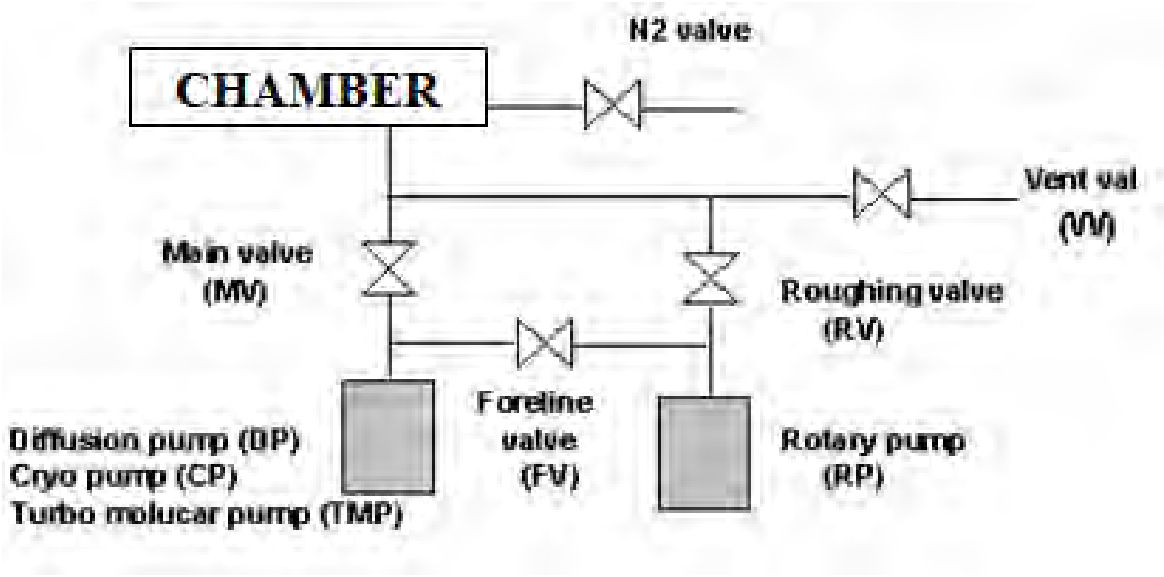

Figure 2.0 Vacuum system diagrams

(Source: Epson)

2.2 Vacuum pumps

Vacuum pumps are used to remove gas molecules in the gas phase from a gas-filled volume and to maintain a required degree of gas rarefaction in that volume. A vacuum pump converts the mechanical input energy of a rotating shaft into pneumatic energy by evacuating the air contained within a system. The internal pressure level thus becomes lower than that of the outside atmosphere. The amount of energy produced depends on the volume evacuated and the pressure difference produced. Mechanical vacuum pumps use the same pumping mechanism as air compressors, except that the unit is installed so that air is drawn from a closed volume and exhausted to the atmosphere. A major difference between a vacuum pump and other types of pumps is that the pressure driving the air into the pump is below atmospheric and becomes vanishingly small at higher vacuum levels. Other differences between air compressors and vacuum pumps are:

- The maximum pressure difference produced by pump action can never be higher than 29.92 in. Hg (14.7 psi), since this represents a perfect vacuum.
- The mass of air drawn into the pump on each suction stroke, and hence the absolute pressure change, decreases as the vacuum level increases.
- At high vacuum levels, there is significantly less air passing through the pump. Therefore, virtually all the heat generated by pump operation will have to be absorbed and dissipated by the pump structure itself.

2.3 Vacuum Definition

Pressure is generally the result of molecules, within a gas or liquid, impacting on their surroundings - usually the walls of the containing vessel. Its magnitude depends on the force of the impacts over a defined area; hence, for example, the Newton per square

metre, given the special name pascal, and the traditional (but obsolete) unit pounds force per square inch. [10]

The relationship between pressure (p), force (F) and area (A) is given by:

$$P = \frac{F}{A}$$

P : Pressure (N/m^2)

F : Force (N)

A : Area (m^2)

This equation applies whether the pressure is very small, such as in outer space, or very large, as in hydraulic systems for example. Thus the word pressure is correct when referring to the entire range of 'force per unit area' measurements, although at extremely low pressures the concept of molecules exerting a force becomes more abstract.

Definition of vacuum is not precise but it is commonly taken to mean pressures below and often considerably below, atmospheric pressure. It does not have separate units and we do not say that _vacuum equals force per unit area'. Thus, strictly, we do not need to talk about both pressure and or vacuum because vacuum is pressure. But the differences are often misunderstood and thus leaving out the word vacuum can falsely imply that the pressure in question is above that of atmospheric pressure.

Another definition of the distinction between pressure and vacuum comes from the industries which use and make pressure and vacuum equipment. Broadly, if the force on the walls of the containing vessel is sufficient to permit its measurement directly, we are dealing with pressure technology but if the force is too small for direct measurement and has to be indirectly inferred, we are in the realm of vacuum technology. This definition is not entirely self-consistent though; for example there is a class of