OPTIMIZATION OF PRODUCT FUNCTION FOR HANDICAPPED PURPOSE USAGE

MOHD FAZREN ASRAF BIN ABDULL TALIB

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

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

SUPERVISOR'S DECLARATION

I hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering Pure.

Signature
Name of Supervisor: HADI ABDUL SALAAM
Position: LECTURER
Date:

STUDENT'S DECLARATION

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

Signature
Name: MOHD FAZREN ASRAF BIN ABDULL TALIB
ID Number: MA06057
Date:

Dedicated to beloved parents, Mr. Abdull Talib b. Daud and Mdm. Juzlina bt. Hj. Jazam and my dearest, Ernie Herwina bt Hamzah for their everlasting love, guidance and support in the whole journey of my life.

ACKNOWLEDGEMENTS

First I would like to express my grateful to ALLAH s.w.t. as for the blessing given that I can finish my project.

In preparing this paper, I have engaged with many people in helping me completing this project. First, I wish to express my sincere appreciation to my main thesis supervisor Mr. Hadi Abdul Salaam, for encouragement, guidance, advices and motivation. Without his continued support and interest, this thesis would not have been the same as presented here.

The next category people who help me to grow further and influence my project are the colleagues who always help me in order to finish this project. I appreciate very much to them because of the idea and information given.

Last but not least I acknowledge without endless love and relentless support from my family, I would not have been here. My father and mother that always support, motivation and encourage me to success.

Thank you all.

ABSTRACT

This thesis elaborates about methods done to optimize product function for handicapped purpose usage. The objectives of this project are to identify suitable general product for the usage of handicap people, redesign and analyze the product to optimize the usage for handicapped usage and to simulate and the design of the product. This thesis gathered information from previous research and study as a guideline to generate suitable concepts for flexible cooker. The concept undergoes several processes in order to determine the best suit concept for both handicap and normal user. Based from the process before, several sketches was sketched on the plain paper and transferred into three-dimensional using Computer-Aided Design tool which is SolidWork. The concept then was chosen using appropriate selection procedure. The concept selection method used is concept screening. After the concept was chosen, the design was analyzed using compatible Finite Element Analysis (FEA) software with different materials. The software used in the project is FEMPRO. Finally, the conclusion and recommendation was stated.

ABSTRAK

Tesis ini menghuraikan tentang kaedah yang dilakukan untuk mengoptimumkan fungsi produk untuk kegunaan orang kurang upaya. Objektif projek ini adalah untuk mengenalpasti produk umum yang sesuai untuk kegunaan orang-orang kurang upaya, menganalisa semula produk untuk mengoptimumkan fungsi untuk kegunaan orang kurang upaya dan untuk mensimulasikan dan menganalisis desain produk. Tesis ini mengumpul maklumat daripada kajian-kajian terdahulu sebagai panduan untuk menghasilkan konsep-konsep yang berpadanan untuk alat memasak fleksibel. Konsep mengalami beberapa proses untuk menentukan konsep yang paling sesuai bagi pengguna yang kurang upaya dan juga normal. Berdasarkan proses yang dijalankan sebelumnya, beberapa sketsa dilukis diatas kertas biasa dan dipindahkan ke dalam lukisan tiga-dimensi menggunakan alatan bantuan melukis iaitu SolidWork. Konsep kemudian dipilih menggunakan prosedur yang sesuai. Kaedah pemilihan yang digunakan adalah konsep penapisan. Setelah konsep dipilih, desain serasi dianalisis menggunakan perisian Finite Element Analysis (FEA) dengan menggunakan empat material yang berlainan. Perisian yang digunakan dalam projek ini adalah FEMPRO. Akhirnya, kesimpulan dan cadangan tersebut dinyatakan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

ι	Pitch Length
μ	Coefficient of Friction
θ	Angle
D_p	Pitch Diameter
F	Force
F_y	Force at y-Axis
M	Moment
T_l	Torque to Raise the Load
T_u	Torque to Lower the Load

LIST OF ABBREVIATIONS

AC	Alternate Current
ADL	Activities of Daily Living
AISI	American Iron and Steel Institute
AMPS	Assessment of Motor and Process Skills
ASTM	American Society for Testing Materials
CAD	Computer Aided Design
CAE	Computer Aided Engineering
DTI	Department of Trade and Industry
ECMT	European Conference of Ministers of Transport
FEA	Finite Element Analysis
FEM	Finite Element Method
FYP	Final Year Project
LLFDI	Late Life Function and Disability Instrument
OTA	Office of Technology Assessment
SCI	Spinal Cord Injury
SMWT	Six-Minute Walk Test
SPPB	Short Physical Performance Battery
UCP	United Cerebral Palsy Association of Michigan

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In this chapter, all important statement was verified such as project background, problem statement, project objectives, project scope and arrangement of report. Basic ideas about the project were determined in project background section to inform briefly about the project. In problem statement section, all problem that handicap faced, requirement and characteristic that needed to optimize product function for handicap purpose usage were stated. At the side of project background and problem statement, the determination of project objectives and project scopes were also stated.

1.2 PROJECT BACKGROUND

A handicap is any condition which result in the person being placed at a disadvantage in coping with and solving the problems of socialization, school, work and independent living. When a person is unable to cope or requires a great deal of extra assistance in coping with the demands of everyday living, then that person is disabled. Some examples of the most common types of disabilities are mobility and physical impairments, mental retardation, blindness, deafness, and cerebral palsy.

In Malaysia, the increment of the number of handicapped person registered with Social Welfare Department from year 2003 to 2005 was announced which from 132,655 persons in year 2003 to 170,455 persons in year 2005. The number of registered person with disability by type of disability was recorded and can be referred in Appendix A.

The subject of the study is mainly focus upon physical impairments which have been the subject of the studies. As a mechanical engineering student, physical impairments including dwarf can be referred as biomechanical relatively, therefore the problem in facing daily activities can be solves using mechanical solution approaches by taking flexible cooker as the product for both normal and handicap person.

1.3 PROBLEM STATEMENT

In Malaysia, the effort done to help handicap person by Malaysian Government still cannot fulfill the need of extra assistance in coping with the demands of everyday activities. Handicap people still need extra assistance because the effort done by Malaysian government only focusing to public needs such as handicapped toilet and footsteps and not to private need such as cooking tools and vacuum cleaner. Thus, the purpose of conducting the project is to help handicap person facing their daily activities by reproducing a product after optimizing its function and at the same time, the product also can be used by normal people.

Optimization of product function especially for handicap people must consider many elements. Firstly, the product must have safety element such as braking systems and blunt angles to avoid any kind of accident from the handicapped because they already facing many problem in daily life activities. Secondly, the products must user friendly because most of the problem that handicapped faced is to handling the product efficiently. Complicated product will spoil them. In addition, the product must also made by suitable material, based on the product purpose. Heavy product will cause problems especially in transporting. Lastly, the ergonomic element also must be applied in order to comfort both normal and handicap user.

1.4 OBJECTIVES

The project covers three objectives which are:

i. Identify suitable general consumer product for handicap person.
ii. Redesign and analyze critical part of the product to optimize the function of the product.
iii. Simulate and analyze the design of the product with different materials.

1.5 PROJECT SCOPES

The scopes of the project are:

i. Minimizing handicap people's needs of extra assistance in performing daily activities especially in cooking.
ii. Redesigning and adding up of several functions and being analyzed using compatible software to optimize product function.
iii. Suitable material selection based on the result of analysis.

1.6 ARRANGEMENT OF REPORT

In Chapter One, overall framework of basic information about this project such project background, problem statement, project objectives and project scopes were mentioned briefly to inform the reader about the project. Basic ideas about the project were determined in project background section to inform briefly about the project. In problem statement section, all problem that handicap faced, requirement and characteristic that needed to optimize product function for handicap purpose usage were stated. Besides project background and problem statement, the determination of project objectives and project scopes were also stated.

Next in chapter two represents a review of various theoretical topics which are related in this project. All important information and theoretical study were explained briefly and mentioned in this chapter as the project reference. Some of the explanations

can give extra information which useful while conducting similar project and can also use as reference for a further study that involving handicap person.

Chapter Three describes the methods used to completing this project. The methods include the process flow chart and gathering information data using several methods such as distributing questionnaire and data from previous study. Solid modeling, material selection and design concept and criteria also were discussed in this chapter.

The report followed by chapter four which consist of the result gathered from the questionnaire, the concept selection process and the analysis of the concepts. The analyses for the solid model were done using ALGOR within several selected materials. The material were chosen as to it availability in the market and at present of general machining in factory shop. All the results then discussed about the additional feature that can fit the concept and the alteration that can be made for the concept design.

Finally, chapter five will conclude the project and briefly enlightened about the recommendation that can be applied to the project. The conclusion were done according to the appropriate result obtain from previous analyses and important questionnaire. The project was in logical and scientifically manner believed to achieve its objectives. Hence, the recommendations in order to extend and critically improve the product function were stated for future project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a review of various theoretical topics which are related in this project. All important information and theoretical study were explained briefly and mentioned in this chapter as the project reference. Some of the explanations can give extra information which useful while conducting similar project and can also use as reference for a further study that involving handicap person.

2.2 DEFINITION OF OPTIMIZATION OF PRODUCT FUNCTION

The word ‘optimization’ is taken from the verb ‘optimize’ which can be define to make the best or most effective use of some situations or resources, and in this project most of the focus is to optimize cooking tools for person who have physical impairment and at the same time, can be use by normal people. Optimization process must considered many elements including identifying customer needs, redesign and analysis of new design and ergonomic elements especially for the purpose of the product and the categories of user.

2.3 DEFINITION OF HANDICAP PEOPLE

A handicap is any condition which results in the person being placed at a disadvantage in coping with and solving the problems of socialization, school, work and independent living (Fotheringham). The term of handicap mostly used to refer to

individual functioning including physical impairment, sensory impairment, cognitive impairment, mental illness, deafness, blindness and various type of chronic disease.

Figure 2.1: International symbol of accessibility.

Source: *http://www.usa-traffic-signs.com/Handicap_s*

There are several types of disability including various physical and mental impairments which can minimize the ability of a person and requires a great deal of extra assistance in coping with the demands of everyday living activities.

Physical disability can be either an in-born or acquired with age problem. The effect of diseases such as diabetes and cancer also listed as the cause of disability. Besides that, people who had been involved in an accident and have broken bone also fall into this category of disability. Spinal cord injury (SCI) mostly occurs due to severe accidents. Sometimes, these types of injury can lead to lifelong disabilities. The injury can be either complete or incomplete. In an incomplete injury, the messages conveyed by the spinal cord not completely lost while a complete injury results a total dis-functioning of the sensory organs. Peoples that are completely or partially deaf are categorized in deafness. Deafness can be evident at birth or occur later in life from several biologic causes, for example meningitis can damage the auditory nerve or the cochlea. While scratched cornea, scratched on the sclera, diabetes related eye conditions, dry eyes and corneal graft are listed as common vision impairments.

2.4 PREVIOUS RESEARCH

Development of product for handicapped purpose usage has been taken as one of the requirement through the development of latest technologies. However, the problem faced by handicap peoples must be identified before the developing processes are proceeding in order to suit handicap people with the new product.

The research covers the problem and limitation faced by handicap people especially in managing daily life, the effectiveness of progress to improve accessibility and the anthropometry factor related to handicap people. The study is then tabulated in Table 2.1 for quick reviews. The source and the simple description are also mentioned in the table.

A study done by the DTI Consumer Affairs Directorate of Government Consumer Safety Research of United Kingdom has been concerned with promoting "safety in the design" of consumer products in order to reduce accidental injuries. The title of the study is 'A Study of the Difficulties Disabled People Have When Using Everyday Consumer Products'. So far the concern has been mainly with children, adults and the elderly population. This study aimed to identify the nature of the problems that disabled people have with consumer products and to determine what characteristics and capabilities should be measured. The Institute of Occupational Therapy uses two methods in their assessment of Activities of Daily Living (ADL). The first 'BARTEL' was not considered to be useful in aiding the project's investigation, on the advice of the Institute of Occupational Therapy, who recommended the second method 'the Assessment of Motor and Process Skills' (AMPS). Whilst this is basically a method of assessing ability in relation to ADL, it was felt that its basic principles and methodology could be used to access the difficulties that disabled people have with consumer products and to identify related functional issues. AMPS motor and process skill items that could be extrapolated to the product use were kept, while others, of less relevance to product use, were discarded. The motor skill items retained were manipulate, lift, grip, transport and reach. The process skill items retained were sequences, notices, uses, and terminates. The scoring scale was expanded from four point AMPS scoring scale to five point rating scales to reflect the needs of the survey as follow:

1 = competent

2 = adequate-with some difficulty

3 = adequate with much difficulty

4 = ineffective

5 = deficit

The interview and the assessment study highlighted a number of products that caused difficulty for disabled people including packaging household utensils, machine controls and large and heavy machine such as vacuum cleaners. The detailed analysis of the problem participants had with those task and products selected for assessment give clear indication of the nature and type of functional demands such products make on disabled people. As a result of this analysis the characteristics and capabilities of disabled people that need to be measured was identified.

Secondly, the purpose of the study on relationships among impairments in lower-extremity strength and power, functional limitations, and disability in older adults was to examine how impairments in lower-extremity strength and power are related to functional limitations and disability in community-dwelling older result. People well known that during the aging process, older adults may experience a loss of strength and power, which then may lead to functional limitations and disability. This study takes thirty older adults which are twenty-five women and five men with mild to moderate functional limitations as a subject of study. Lower-extremity strength, peak power, power at low relative intensity, and power at a high relative intensity were measured with pneumatic resistance leg press. Functional limitations and disability were assessed with the Short Physical Performance Battery (SPPB), the Six-Minute Walk Test (SMWT), and the Late Life Function and Disability Instrument (LLFDI). All measures of strength and power were related to functional limitations. Peak power demonstrated the strongest relationship with SMWT, the SPPB gait speed subscale, and the LLFDI functional limitation component. Power at a high relative intensity demonstrated the strongest relationships to the SPPB total score and the SPPB sit-to-stand subscale score. All measures of strength and power were indirectly related to the LLFDI disability component.

Technology exerts a powerful influence over the lives of everyone, making life easier, more fulfilling, but sometimes more painful and frustrating. This statement is especially true for people with disabilities. According to the study of 'Technology and Handicapped People', the appropriate application of technologies to diminishing the limitations and extending the capabilities of disabled and handicapped person is one of the prime social and economic goals of public policy. The Senate Committee on Labor and Human Resource of United State of America requested the Office of Technology Assessment (OTA) to conduct a study of technology for handicapped individuals. OTA and the requesting committee both recognized the extremely broad and complex range of issues that could be addressed in such study. Therefore, OTA conducted a planning study. Using the result of that study, OTA prepared a proposal for a full assessment on technology and handicapped people, which was approved by the Technology Assessment Board in September 1980. The study examined the specific factors that affect the research and development, evaluation, diffusion and marketing, delivery, use, and financing of technologies directly related to disabled people. The problems and processes of the development and use of technologies were analyzed in the context of societal allocation of resource and the setting of goals for public policy. The study concentrated on two critical matching processes: between technological needs and technological capabilities; and between allocation goals or intentions and resource capabilities. The objectives of the assessment and planning system are to provide data for determination of eligibility for services, determination of services required, and evaluation of the effectiveness of services provided.

This European Conference of Ministers of Transport (ECMT) publication titled 'Transport for People with Mobility Handicaps Policy and Achievements in Europe' has three main objectives. These are first, to bring the issues concerning accessible transport to the attention of a wide audience. Second objective is to describe the progress that is being made nationally and internationally to improve accessibility. Third, to set out principal challenges and problems that remains. People with mobility handicaps need to be able to reach their workplaces. This is an essential element of their professional and economic situation. Without accessible local transport, apparently simple activities such as medical or dental appointments, or household shopping, may have to be planned well in advance and assisted by other people. Social life and recreational activities are

frequently curtailed. The implementation of all the changes which have been recommended is no mean task. Many of these changes will necessarily take several years to complete, not least in waiting for old vehicles to be phased out of services and new, more accessible, ones to become the norm. In some cases, technical innovation can only follow intensive further research. It is important that no opportunity be lost to make improvements throughout each transport system, especially when other modifications or improvements are being made, towards the goal of chains of wholly accessible transport for any type of journey. On a more general topic, it is clear that further work needs to be carried out in the field of information and communications both for and about the needs of people with mobility handicaps. It is clear from earlier research that there is little coherence of approach to this topic at present, and yet providing information goes a long way towards giving many disabled people the confidence which they currently lack to undertake a journey.

The ‘Handicapped Children and Handicapped Families’ article is concerned with the interaction between children with an obvious handicap and their families and its result on them both, with a discussion of some parent-oriented assistance programs. The effect of the family on the child’s achievement is emphasized as many handicapped children would not become disabled or their disability lessened by appropriate parental behavior. Because of the importance of the family as teaching environment, for the preschool child in particular, three home-oriented programs are out-lined as possible models that other might find useful. These programs attempt to capitalize on the mother’s continued contact with the child and her ability to supply a one-to-one teaching arrangement during the time when the child is most susceptible to change.

The Developmental Disabilities Institute at Wayne State University, in collaboration with United Cerebral Palsy Association of Michigan (UCP), conducted a one-year study titled ‘A Michigan Study on Women with Physical Disabilities’ to investigate the prevalence, correlates, and service system capacity related to domestic abuse among women with physical disabilities in Michigan. Studies have shown that people with developmental disabilities have a four of ten times higher risk of becoming crime victims than persons without disabilities. This study examined domestic violence among Michigan women with physical disabilities by addressing several question

including the prevalence of domestic violence, potential factors for domestic violence and the capacity of existing support programs to assist women with disabilities.

Anthropometry of people with disabilities is receiving an increasing amount of attention. Thus, three-day conference title ‘The Anthropometrics of Disability: An International Workshop’ was held in Buffalo, New York and attended by 40 invited participants and featured 20 presentations by researchers and practitioners from around the world who are experts in the areas field of anthropometry and anthropometric issues related to people with disabilities. The point of the report is to summarize the papers, discussion and recommendations and to communicate it to a diverse audience. The report consists three sections. The first section includes short summaries of the papers and the key points presented in every paper session. It follows by summarization of discussion and recommendations made by participants to advance the field. The last section presents a proposed agenda for action to follow through with many of the recommendations and identifies specific implications for the two sponsors, the U.S. Access Board and the National Institute of Disability and Rehabilitation Research. The presentations of each group related to topical area were immediately followed by discussion. The discussion and the recommendations finally being summarize into ten main themes which are:

i. Increasing standardization in methods.
ii. Increasing use of functional approaches to research.
iii. Better organization of knowledge.
iv. Identifying research priorities.
v. Developing computer simulation models.
vi. Incorporation behavioral and social factors.
vii. Improving sampling.
viii. Improving cast effectiveness of research.
ix. Improving data collection methods.
x. Increasing communications and dialogue.

Table 2.1: Previous research.

Author/Publisher	Description
Department of Trade and Industry (DTI) of United Kingdom	Classify the nature of the problems that disabled people have with consumer products and to establish the result of characteristics and capabilities should be measured.
Puthoff, M.L. Nielsen, D.H.	Observe towards the authority of impairments in lower-extremity strength and power to functional limitations and disability in community-dwelling older result.
Office of Technology Assessment, Congress of the United States	The study examined the specific factors that affect the research and development, evaluation, diffusion and marketing, delivery, use, and financing of technologies directly related to disabled people.
European Conference of Ministers of Transport (ECMT)	The objective is to bring the issues concerning accessible transport to the attention of a wide audience, to describe the progress that is being made nationally and internationally to improve accessibility and to set out principal challenges and problems that remain.
Fotheringham J.B.	Covers the influence of characteristic of family members towards how they manage the stress such as having a handicapped child and how to cope with the problem.
Milberger, S. LeRoy, B. Martin, A. Israel, N. Potter, L. Patchak-Schuster, P.	This study examined domestic violence among Michigan women with physical disabilities by addressing several question including the prevalence of domestic violence, potential factors for domestic violence and the capacity of existing support programs to assist women with disabilities.

Table 2.1: Previous research (continued).

Author/Publisher	Description
Steinfeld, E., Lenker, J. and Paquet, V. 2002.	Workshop attended by 40 invited participants and featured 20 presentations by researchers and practitioners from around the world who are experts in the areas field to summarize the papers, discussion and recommendations and to communicate it to a diverse audience

2.5 IDENTIFYING CUSTOMER NEEDS

The philosophy behind the method is to create a high-quality information channel that runs directly between customers in the target market and the developers of the product. This philosophy is built on the premise that those who directly control the details of the product, including the engineers and industrial designers. Without this direct experience, technical trade-offs are not likely to be made correctly, innovative solutions to customer needs may never be discovered, and the development team may never develop a deep commitment to meeting customer needs. The goals of the method are to:

i. Ensure that the product is focused on customer needs.
ii. Identify latent or hidden need as well as explicit needs.
iii. Provide a fact base for justifying the product specifications.
iv. Create an archival record of the need activity of the development process.
v. Ensure that no critical customer need is missed or forgotten.
vi. Develop a common understanding of customer needs among members of the development team.

The process of identifying customer needs is an integral part of the larger product development process and is most closely related to concept generation, concept

selection, competitive benchmarking, and the establishment of product specifications (Ulrich and Eppinger, 2008).

2.6 CONCEPT SELECTION

Concept selection is the process of evaluating concepts with respect to customer needs and other criteria, comparing the relative strengths and weaknesses of the concepts, and selecting one or more concepts for further investigation, testing, or development (Ulrich and Eppinger, 2008).

Concept selection is often performed in two stages as a way to manage complexity of evaluating dozens of product concepts. The first stage is called concept screening and the second stage is called concept scoring. Each is supported by decision matrixes which used by the team to rate, rank, and select the best concept (Ulrich and Eppinger, 2008).

Nevertheless, both concept screening and concept scoring follow a six-step process which leads the team through the concept selection activity. The steps are:

i. Prepare the selection matrix.
ii. Rate the concepts.
iii. Rank the concepts.
iv. Combine and improve the concepts.
v. Select one or more concepts.
vi. Reflect on the result and the process.

2.6.1 Concept Screening

Concept screening is based on a method developed by late Stuart Pugh in the 1980s and often called Pugh concept selection (Pugh, 1990). The purposes of this stage are to narrow the number of concepts quickly and to improve the concepts (Ulrich and Eppinger, 2008).

2.6.2 Concept Scoring

Concept scoring is used when increased resolution will better differentiate among competing concepts. In this stage, the team weighs the relative importance of the selection criteria and focuses on more refined comparisons with respect to each criterion (Ulrich and Eppinger, 2008).

2.6.3 Specification of Material

A material specification is the characteristic and the engineering detail regarded on the material. Such information was available throughout data sheet and supplier catalog. In response with the project, the material in interest will be AISI 1018 hot rolled (annealed), Aluminum Alloy 1100 – H14, Grey Cast Iron, ASTM A48 (annealed), Titanium Ti-6Al-4V (annealed) and AISI 1010 cold drown.

AISI 1018 is a low carbon steel. It has good hardening properties but fair machinability. Usually come in readily brazed and welded from supplier.

Aluminum alloy 1100 is wrought type of alloy. It is an extremely useful low temperature alloy due to their strength increase while preserve their ductility. It has strong resistance to corrosion, high electrical conductivity and can be cast in any form known.

ASTM A48 is the most popular gray iron casting specification. It's tends to be brittle. It has excellent machinability, castability, resistance to deformation and wear resistance.

Titanium is a white metal, and has the best strength to weight ratio among the metals. It is 40% lighter than steel and 60% heavier than aluminum. This combination of high strength and low weight make it a very useful structural metal. It is also an excellent corrosion resistance.

2.7 QUANTITATIVE THEORIES OF HARDWARE

2.7.1 Theories of Load Calculations for Link

Theories apply on load calculation for link was based on Newton's third law which is every action acted on object will have reaction force which is equal in magnitude unless the equilibrium is upset.

Hence the formula that will guide the theories will be total vertical forces is equal to zero. This was expressed in Eq. (2.1),

$$\sum F_y = 0 \tag{2.1}$$

When there are existences forces with certain length from center of rotation or a point, the rotating action occur, as it called moment. The apply force when the condition is equilibrium also based on Newtonian principle. Therefore, the theories will be expressed as in Eq. (2.2),

$$\sum M = 0 \tag{2.2}$$

2.7.2 Theories of Torque for Power Screw

Power screws are sued for providing linear motion in a smooth uniform manner. Power screws are used in order to obtain high mechanical advantage in order to move large loads with minimum effort, generate large forces and to obtain precise axial movements.

Typical power screw will be used in this project is square form due to the usage of jacking table where the need for power/force transmission is crucial. Furthermore it is the most efficient conventional power screw form.

Figure 2.1 presents the square form power screw.

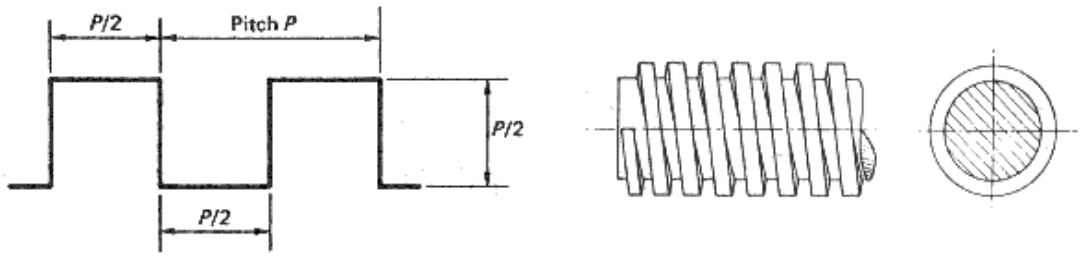


Figure 2.2: Square form power screw.

Source: http://www.roymech.co.uk/

The equations that govern the translation on vertical axis are exhibit in Eq, (2.3) for upward lifting and Eq. (2.4) for lowering motion respectively.

$$T_u = \frac{FD_p}{2}\left(\frac{\tan\theta + \mu}{1 - \mu \cdot \tan\theta}\right) \tag{2.3}$$

$$T_u = \frac{FD_p}{2}\left(\frac{\mu - \tan\theta}{1 + \mu \cdot \tan\theta}\right) \tag{2.4}$$

2.8 COMPUTER AIDED ENGINEERING

Computer-aided engineering (CAE) is the use of information technology to support engineers in tasks such as analysis, simulation, design, manufacture, planning, diagnosis, and repair. CAE tools are being used for example, to analyze the performance of components and assemblies. The term encompasses simulation, validation, and optimization of products and manufacturing tools. CAE areas covered include, stress analysis on components and assemblies using FEA, thermal and fluid flow analysis computational fluid dynamics and optimization of the product or process.

The finite element method (FEM) sometimes referred as finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. A boundary value problem is a mathematical problem in

which one or more dependent variables must satisfy a differential equation everywhere within known domain of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems. Depending on the type of physical problem being analyzed, the field variables may include physical displacement, temperature, heat flux, and fluid velocity (Hutton, 2004).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter explained the process used in implementation of this project. The practice consists of process flow chart and gathering information data, the concept generation, material selection and concept selection. Solid modeling, material and design concept selection also were discussed in this chapter.

3.2 PROCESS FLOW CHART

Process flow chart will explain the step pursued when conducting the project. Flow chart is important as a guide step to avoid losses from the proper path. The project begins with conformation and declaration of project titles, project objectives, problem statement and project scopes. Declaration of the important outline is prepared with the supervisor.

After satisfied with the declaration, the project proceeds with the next process. The next process is determination of literature review. This process determined the definition of handicap people and also includes previous study as the reference for the project. Revision books, journals and reports from the conference related to handicap people are taken as the reference study and being stated in chapter two. The optimizations were not only including the information from previous study, but also relevant data from selected reference books.

The optimization proceeds to the next stages, which was identifying customer needs especially in gaining the opinion about the flexible cooker for handicap people. Attaining statistics was gained by distributing nine questions of questionnaire to handicapped population around dense attention area in Kuantan and Pekan. The questionnaire can be divided into three sections in order to attain the opinion regarding to the flexible cooker. The responses from the questionnaire then being analyze and as a result, several concept designs were sketched on the plain paper.

Each concept designs are using difference mechanical approach such as hydraulic actuator and AC motor. As a solution, the specifications of each component are defined based in the catalog. Then, the sketch was submitted to the supervisor and discussion on the sketch and possible modification were done. After supervisor agreed with the sketch of concept designs, the designs is convert into solid modeling model using computer aided design (CAD) tools. The CAD tool used in the project is SolidWork. On the other hand, if the sketch was not accepted, the sketching process will be repeated.

The dimension of each designs were drawn into exact dimension for further appliances. The next step is analyzing process with helps from the finite element analysis (FEA) tools. The FEA tools used in the project is FEMPRO. During the process, each critical part is being analyzed with different applied load based on the function, location of the parts and from the free body diagram analysis of each part. The process followed by concept selection process. Concept screening was used to select the best concept due to quick, approximate evaluation aimed at producing a few viable alternatives. As results, the best concept design was selected based from the criteria evaluation. At last, the report writing and recommendation regarding to the project were preceded. In addition, the development processes marked in Gantt chart as attached in Appendix B.

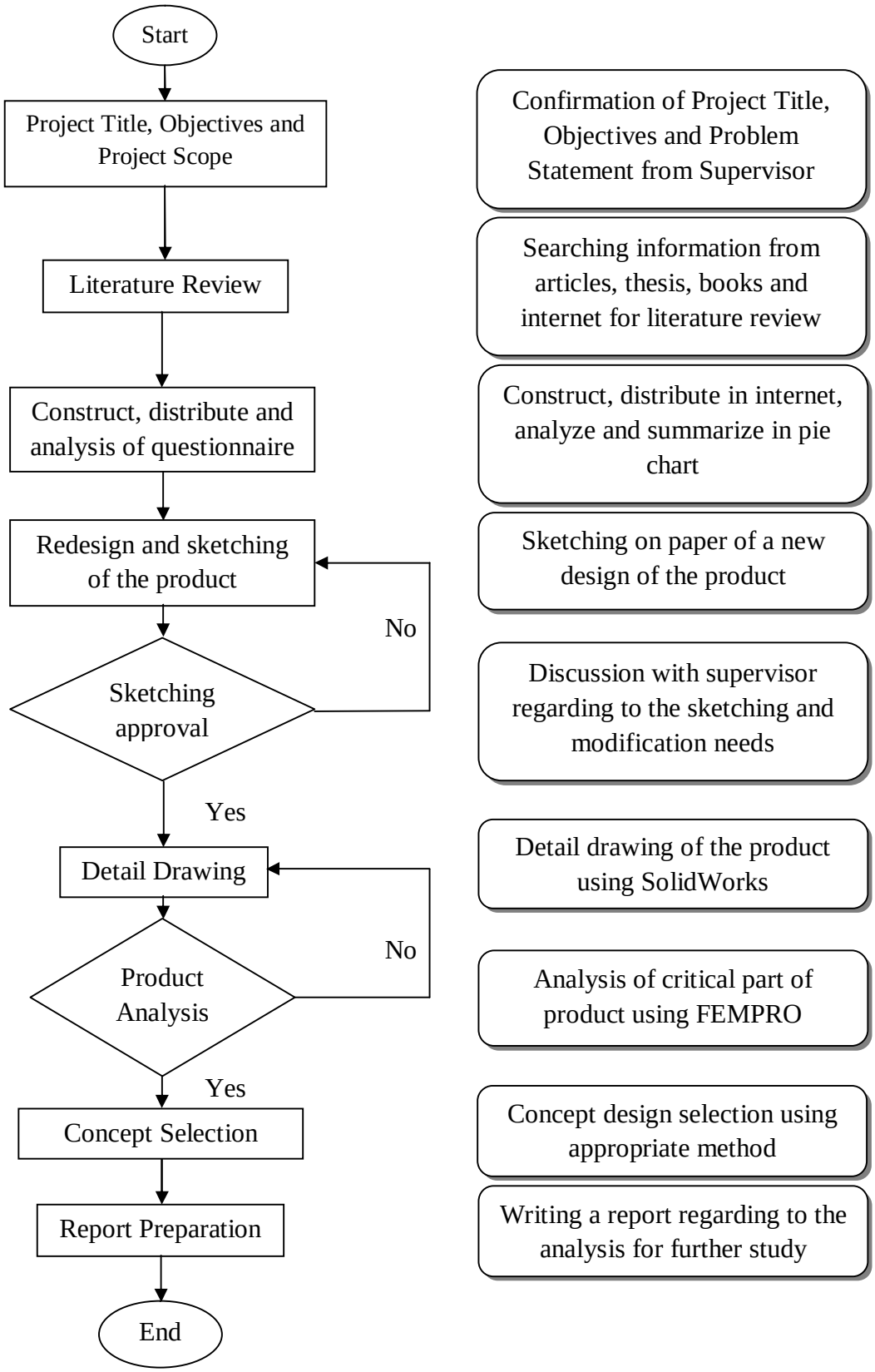


Figure 3.1: Process Flow Chart.

3.3 IDENTIFYING CUSTOMER NEEDS

Gathering information data process is prepared by distributing questionnaire. The questionnaire is distribute by captivating the advantages from technology of internet and also distribute to handicap's population in Kuantan especially in public center of attention such as Hospital Tunku Ampuan Afzan and Teruntum Shopping Complex. The questionnaire consist nine questions which related to the study especially in preparing own meals for handicap people's situations. The response then are evaluate for further process. The sample of the questionnaire is attached in the Appendix C.

(a)

(b)

Figure 3.2: (a) Respondent answering the questionnaire and (b) Interviewed process with handicap people.

3.4 DESIGN CONCEPT AND CRITERIA

Design concept and criteria of flexible cooking tools may be classified in several ways. Firstly, modification of table design by applying adjustable height concept by using either foot pump, scissor mechanism powered by hydraulic actuator or power screw or manually rose up. Then, the standard gas cooker is changed to induction cooker because induction cooker is more safe and capable to avoid accidental injuries towards to high temperature applications. Standard material such as alloy steel for the frame is use for durability, lower cost and is acceptable for many applications. Besides alloy steel, ceramic layer is used as thermal insulator. Electrical power is used due to the application of induction cooker. After used cleaning must be considered which means the product can be clean easily. Lastly, additional element such as electrical griller and chair can improve the function of the product.

3.5 3D MODEL DRAWING

Information gathered from the questionnaire used to optimize the function of the product and few simple sketches was sketched on plain paper. Then, all the sketching was brought forward to drawing board with specific dimension and drawn into solid model using CAD software. The model is drawn according to actual dimension. This process gives 3D perspectives of the design and enabled the simulation to be applied on each concept designs. In this project, SolidWork was used to model the design.

3.6 MATERIAL SELECTION

Material Selection is based on several criteria. This is including the function of the parts, features of the component, machining capability, and material availability. Function of the parts is important in determining the material for the part. If the component is use in hard or extreme condition thus a material that can comprehend those conditions is to be determined. The properties of the material can be referred in Appendix D for further applications.

Table 3.1: Material selection for flexible cooker component.

Types of Material	Application	Justification
Grey Cast Iron ASTM A 48	Body Frame, Link	Price is relatively low while it provides material properties that are acceptable for many applications. It is neither brittle nor ductile. However, mild steel has a relatively low tensile strength and malleable.
Ferritic Stainless Steel (446)	Grills Griddle	Relatively low in cost, excellent corrosion resistance in many environments.
Copper Alloy (C80500)	Heater	High electrical and thermal conductivity, good corrosion resistance, medium tensile strength, controllable annealing properties.
Ceramic	Surface of Induction Cooker, Surface layer for upper part.	Relatively brittle, good electrical and thermal insulator.

Source: Smith. and Hashemi, 2006.

3.7 CONCEPT GENERATION OF FLEXIBLE COOKER

A concept is usually expressed as a sketch or as a rough three-three dimensional model and is often accompanied by a briefly textual description. A good concept is sometimes poorly implemented in subsequence development phases, but a poor concept can rarely be manipulated to achieve commercial success.

3.7.1 First Concept – Cooking Table with Scissors Lift using AC Motor

As a result from the data analyzed from the questionnaire come out with four different concepts. First concept is using the application of scissor mechanism and powered by AC motor. The ideas come from the basic car jack with additional of AC motor. The height of the cooker can be raised up or lowered by rotating the center bar. The frame of the product are made from grey cast iron and layered by the thin ceramic surface. The purpose of caster installed at the bottom of the design is to increase the mobility of cooking table. Figure 3.3 shows the design and the features of the concept design.

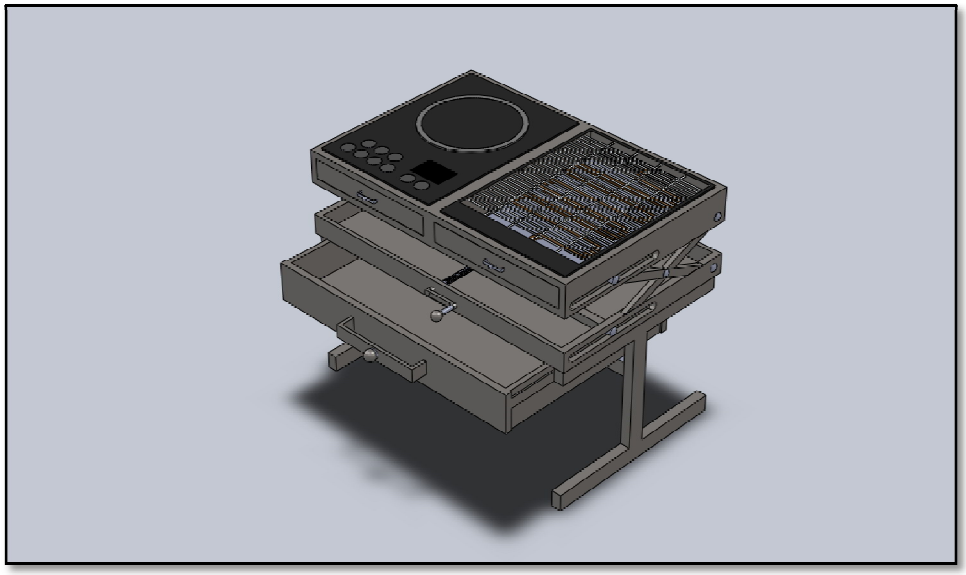


Figure 3.3: Cooking table with scissors lift using motoring system.

Table 3.2: Standard features and desired specifications for first concept.

Features	Descriptions
Load Capacity	250 lbs. – 500lbs.
Lift Stroke	40cm from 70cm to 110cm table height.
Lifting	Rotating handle bar.
Lowering	Rotating handle bar.

Table 3.2: Standard features and desired specifications for first concept (continued).

Features	Descriptions
Table Size	60cm x 90cm.
Construction	Welded tubular cast iron for frame and link, surface layered by ceramic.
Casters	Two total-lock swivel casters, two rear caster swivel 360 degree for tight aisles maneuvering.

Table 3.3: AC single phase motor.

Features	Descriptions
Horse Power	1/500
Unloaded Motor Speed RPM	1800
Voltage	115 (60 Hz)
Watts	1.5
Weight kg	0.65

3.7.2 Second Concept – Cooking Table with Foot Pump Table Lift

The second concept is based on the foot pump hydraulic table. This height of the table can be raised up and lowered by step on the foot pedal and lowered by the separate foot pedals. Same as the first concept, this concept use grey cast iron as a construction and the installed of casters to increase its mobility.

Figure 3.4: Cooking table with foot pump table lift.

Table 3.4: Standard features and desired specifications for second concept.

Features	Description
Load Capacity	250 lbs. - 500 lbs.
Lift Stroke	40cm from 70cm to 110cm table height.
Lifting	Foot pedal provides 40cm travel with 12 strokes for 250-lb. capacity and 21 strokes for 500-lb.
Lowering	Infinitely adjustable down-speed activated by separate foot pedal.
Table Size	60cm x 90 cm.
Construction	Welded tubular cast iron for frame, surface layered by ceramic.
Casters	Two total-lock swivel casters, two rear caster swivel 360 degree for tight aisles maneuvering.
Hydraulics	Foot-pedal hydraulic lift.

3.7.3 Third Concept – Cooking Table with Electro Hydraulic Pump

The idea of the third concept is taken from the motorcycle platform jack which is application of hydraulic actuator to raise the height of the platform. Same as concept design before, the purpose of casters installed is to increase the mobility. In this concept design, the Kayaba Mini Motion Package was choosing because of its characteristics which are compact, safe and reliable, completely integrated and easy to install. The design and the features of the third concept are shown in the Figure 3.5. For further reference, the Kayaba Mini Motion Package Catalogue is attached in the Appendix E.

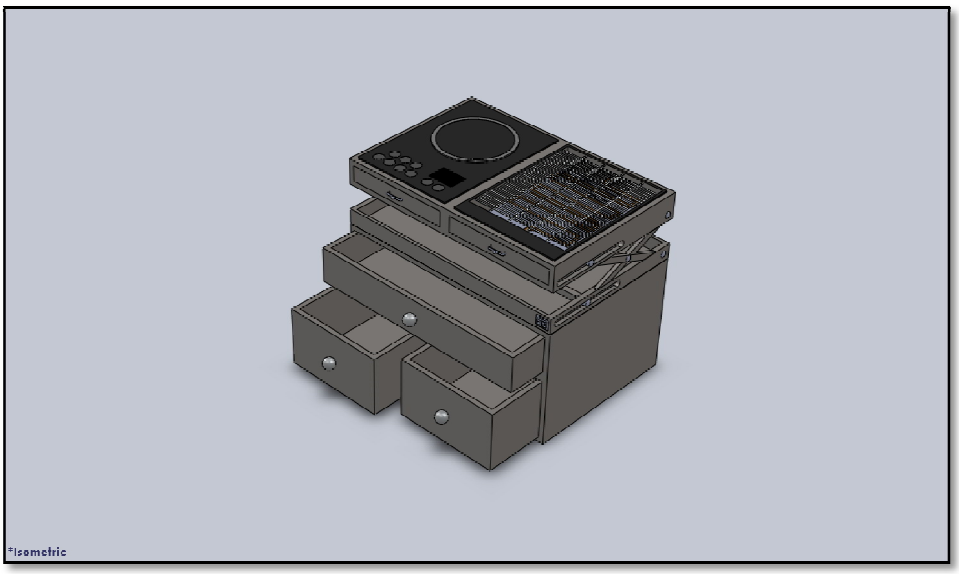


Figure 3.5: Cooking table with electro-hydraulic pump.

Table 3.5: Standard features and desired specifications for third concept.

Features	Descriptions
Load Capacity	250lbs. – 500lbs.
Lift Stroke	40cm from 70cm to 110cm table height.
Lifting	Generated by hydraulic actuator connected with 4/3 way Push-button valve.
Lowering	Generated by hydraulic actuator connected with 4/3 way Push-button valve.

Table 3.5: Standard features and desired specifications for third concept (continued).

Features	Descriptions
Table Size	60 cm x 90cm.
Construction	Welded tubular cast iron for frame and link, surface layered by ceramic.
Caster	Two total-lock swivel casters, two rear caster swivel 360 degree for tight aisles maneuvering.
Hydraulic	KYB's Mini Motion Package: -Compact, Completely Integrated -Safe and Reliable -Simple Installation

Figure 3.6: Mini-motion package hydraulic.

Source: Kayaba mini motion package catalogue.

Table 3.6: Specification of electrical motor of mini-motion package hydraulic.

	Specifications
Rated Output	250W
Rated Voltage	DC24V
Rated Current	11A
Duty Cycle	30 sec
Protection	Circuit breaker in electric motor

Source: Kayaba mini motion package catalogue.

Table 3.7: Specification of hydraulic circuit of mini-motion package hydraulic.

	Specifications
Rated Flow Rate	1.1L/min.
Rated Pressure	496 psi.
Relief Set Pressure	598 psi.
Max. Retaining Pressure	13.7 MPa (overload Relief Valve Preset Pressure).
Cylinder Size	Ø40-Ø20.
Cylinder Stroke	150mm.
Hydraulic Operating Fluid	ISO VG 32 WR.

Source: Kayaba mini motion catalogue.

3.7.4 Fourth Concept – Cooking Table with Level Slot

The concept design is taken from the canopy stand. The height can be adjust by raise the upper part of the component and pinned. The frame construction is made from alloy steel. Same as the other design, the purpose of casters installed are to increase the mobility of the design. The features and specification of the design are list in Table 3.8.

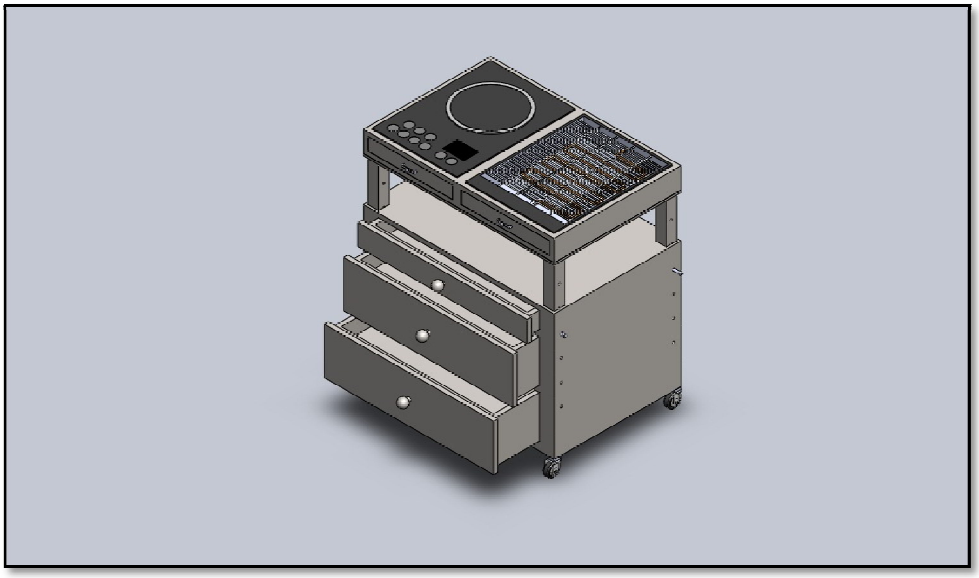


Figure 3.7: Cooking table with level slot (manual system).

Table 3.8: Standard features and desired specifications for fourth concept.

Features	Descriptions
Load Capacity	250 lbs. – 500lbs.
Lift Stroke	40cm from 70cm to 110cm table height.
Lifting	Rise manually by lever slot and pin.
Lowering	Lowered manually by lever slot and pin.
Table Size	60cm x 90cm.
Construction	Welded tubular cast iron for frame, surface layered by ceramic.

Table 3.8: Standard features and desired specifications for fourth concept (continued).

Features	Descriptions
Casters	Two total-lock swivel casters, two rear caster swivel 360 degree for tight aisles maneuvering.

3.7.5 Fifth Concept – Standard Table

The fifth concept is as the reference for differencing the characteristic and the features added to the other design. The design is select based from the usual cooking table which may be made by wood or steel. For this condition, the material selected in load analysis is set to steel 1015, because of the material properties and usual application which is for frame. Figure 3.8 shows the design of standard table.

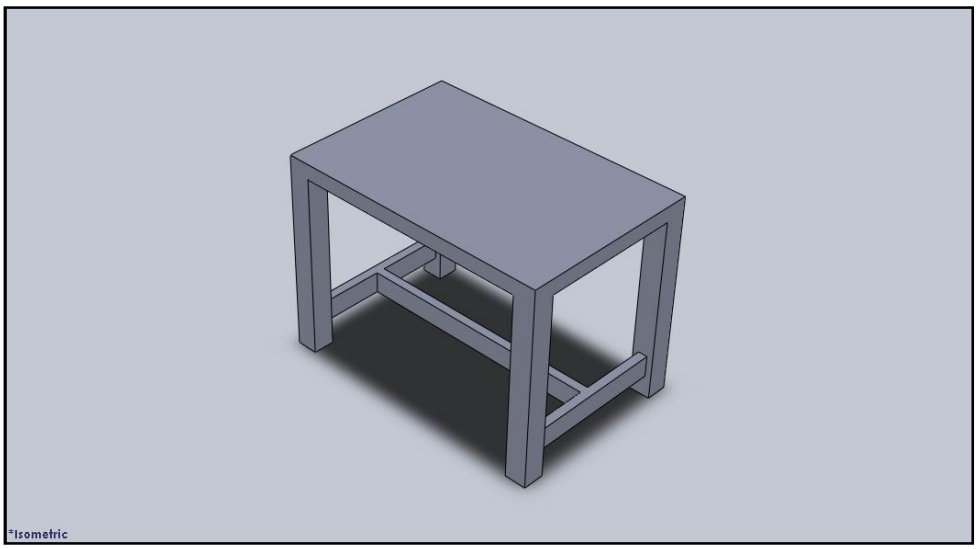


Figure 3.8: Standard table (reference).

3.8 CONCEPT SELECTION

For this project, the first stage which is concept screening is used as concept selection methodology, although the first stage may suffice for simple design decisions. Screening is a quick, approximate evaluation aimed at producing a few viable alternatives.

3.8.1 Prepare the Selection Matrix

The selection concept process begins with entering the input data into the matrix. The concepts that have been identified for analysis are entered on the top of the matrix. Although possibly generated by different individual, concepts should be presented at the same level of detail for meaningful comparison and unbiased selection. The concepts are entered along the top of the matrix, using graphical or textual labels of some kind. Sample of the selection matrix are attached in the Appendix F.

3.8.2 Rate the Concepts

For the flexible cooker concept design, the concept is rated against the reference concept using a simple code which are + for 'better than', 0 for 'same as', and – for 'worse than' in order to identify some concepts for further consideration (Ulrich and Eppinger, 2008).

3.8.3 Rank the Concepts

After rating all the concepts, the sums of the number of 'better than', 'same as' and 'worse than' scores is calculated and enters in the lower row of the matrix based on each categories. Once the summation is completed, the concept is rank-ordered. Obviously, in general those concepts with more pluses and fewer minutes are ranked higher (Ulrich and Eppinger, 2008).

3.8.4 Combine and Improve the Concepts

Rated and ranked the concepts verify that the result make sense and then consider if there are ways to combine and improve certain concept. Combined and improved concepts are then added to the matrix, rated by the team, and ranked along with original concepts (Ulrich and Eppinger, 2008).

3.8.5 Select One or More Concepts

After convince and understanding each concepts and its relative quality, decision on selecting which concepts are to be selected for further refinement and analysis. The number of concept selected for further review will be limited by team resources (Ulrich and Eppinger, 2008).

3.8.6 Reflect on the Results and the Process

An explicit consideration of whether the result make sense to everyone reduce the likelihood of making a mistake and increase the likelihood that the entire team will be solidly committed to the subsequent development activities (Ulrich and Eppinger, 2008).

3.9 QUANTITATIVE ANALYSIS OF LOAD DISTRIBUTION

The load applied to the part is differs from each other due to the location and the application of the parts. The limits of the distributed load applied to the top of the cooker are set to 150 N for each concept design. However, the first and third designs are using the application of scissors mechanism, thus, the load applied to the scissor links are calculated separately. For the second design, the load is applied to the center of the part since the location of the part which located at the bottom of the design. All the calculation is made based on free body diagram of 2D view for each part.

3.9.1 Load Calculation for Scissor Link 1 and Link 2

Before the load analysis begins, the load calculation using free body diagram must be calculated using the summation of force at y-axis and the summation of moment. The formula of the summation force and summation of moment are shown in the Eq. (1.1) and Eq. (1.2).

$$\sum F_y = 0 \qquad \text{(Upward positive)}$$

$$\sum M = 0 \qquad \text{(Counter-clockwise Positive)}$$

The load is calculated based from the free body diagram. The load applied is shown in Figure 3.9 and the free body diagram is shown in Figure 3.10, Figure 3.11 and Figure 3.12.

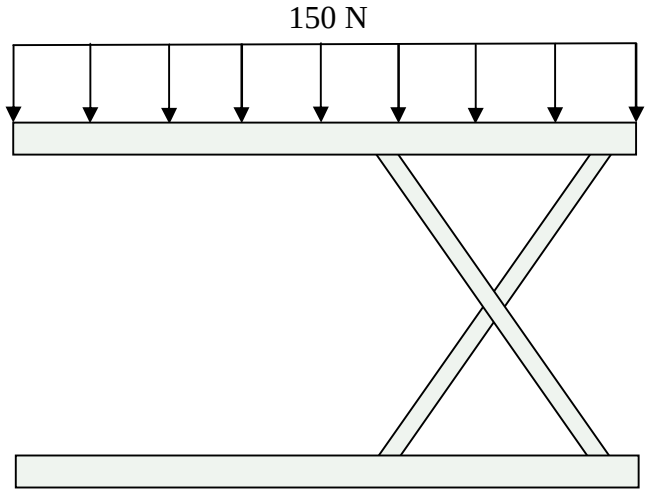


Figure 3.9: Load applied to the cooker.

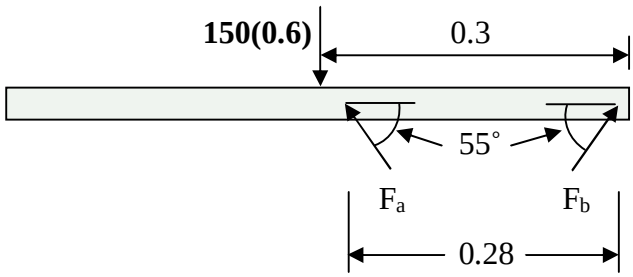


Figure 3.10: Free body diagram of platform.

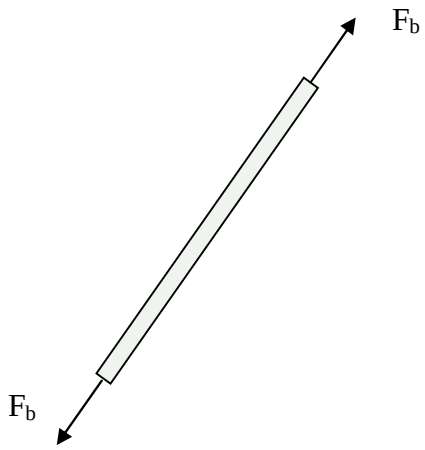


Figure 3.11: Free body diagram of link 1.

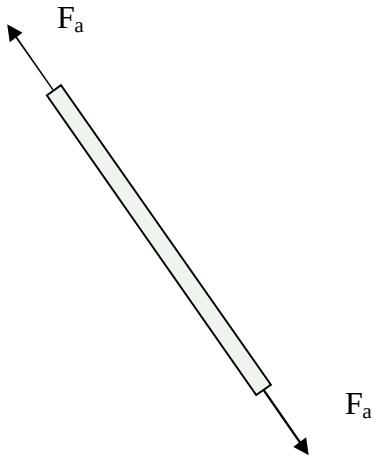


Figure 3.12: Free body diagram of link 2.

The value of F_a and F_b is defined using summation of force in y-axis and summation of moment and neglecting the mass of the upper platform.

$$\sum F_y = 0$$

$$F_a sin\,55 + F_b sin\,55 - 150N = 0 \quad (1.3)$$

$$\sum M_b = 0$$

$$(-F_a \sin 55)(0.28) + (150 \times 0.6 \times 0.3) = 0 \quad (1.4)$$

$$F_a = \frac{150 \times 0.6 \times 0.3}{0.28 sin\, 55} = 117.72\ N$$

Substituting F_a =117.72 *N* into Eq. (1.4).

$$F_b = \frac{150 - 96.43}{\sin 55} = 65.40\ N$$

3.9.2 Load Calculation for Table Leg

Force applied to table leg is calculated based on the free body diagram in Figure 3.14. The force applied is differing because the load includes the upper platform and the mass of the hydraulic jack. The mass of hydraulic jack is assumed to be 50 *N* and the upper part is set to 150 *N*, same as the other design. Thus, the total force applied is 200 *N*.

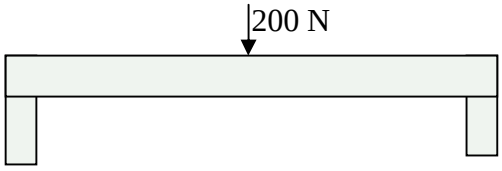


Figure 3.13: Load applied to the table leg.

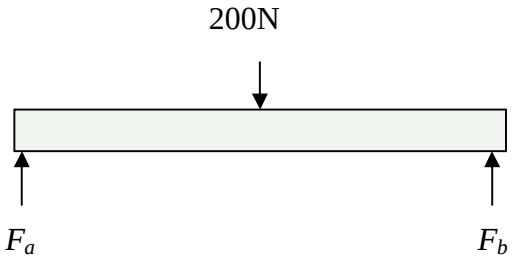


Figure 3.14: Free body diagram of table leg.

$$\sum F_y = 0$$

$$F_a + F_b - 200 = 0 \qquad (1.5)$$

$$\sum M_a = 0$$

$$-(200 \times 0.3) + (0.6)F_b = 0$$

$$F_b = \frac{200 \times 0.3}{0.6} = 100\ N$$

Substituting F_b into Eq. (1.5),

$$F_a = 100\ N$$

3.9.3 Load Calculation for Column Slot Part

Load applied for the column slot part is differs from the other part due to its location. The total forced applied to the upper part is 150 *N*. However, for the column slot part, the load applied is a distributed load and shown in Figure 3.15. Thus, the load calculation is calculated based from free body diagram as shown in Figure 3.16.

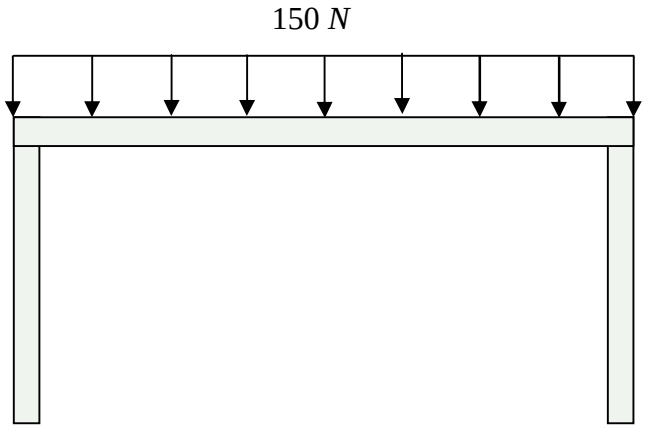


Figure 3.15: Distributed load applied to column slot.

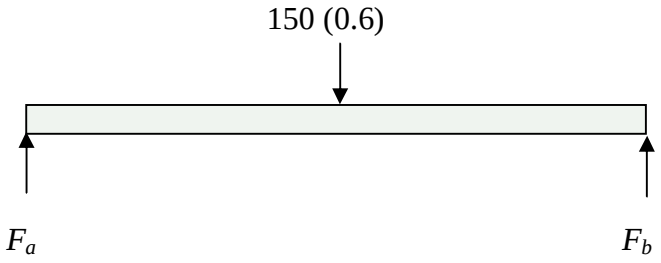


Figure 3.16: Free body diagram of column slot.

$$F_a + F_b - (150 \times 0.6) = 0 \quad (1.6)$$

$$\sum F_y = 0$$

$$\sum M_a = 0$$

$$-(150 \times 0.6 \times 0.3) + F_b(0.6) = 0$$

$$F_b = \frac{150 \times 0.6 \times 0.3}{0.6} = 45\ N$$

Substituting F_b = 45 into Eq. (1.6),

$$F_a = (150 \times 0.6) - 45 = 45\ N$$

3.10 TORQUE OF POWER SCREW

Power screw is a vital aspect installed in the cooker. The initial specifications were in need to used power screw as a method of jacking up or lower down the cooker table. In relation to the torque calculation appropriate motor than can be selected in order to let the system work electrically. Square thread power screw are used.

3.10.1 Torque to Raise the Load

According to quantitative theories for torque need to raise the load, the preliminary calculation initiated.

$$T_u = \frac{FD_p}{2}\left(\frac{\tan\theta + \mu}{1 - \mu \cdot \tan\theta}\right)$$

Given load to be raised is 200 *N*, coefficient of friction is equal to 0.05, pitch diameter is 0.02 m. The pitch distance is 3 x 10^{-3} m.

$$\tan\theta = \frac{\iota}{\pi D_p}$$

$$\tan\theta = \frac{2\ x\ 10^{-3}}{\pi \cdot 0.02} = 0.0318$$

$$T_u = \frac{200\ x\ 0.02}{2}\left(\frac{0.0318\ + 0.05}{1 - 0.05\ \cdot 0.0318}\right) = 0.164\ Nm$$

3.10.2 Torque to Lower the Load

In order to lower the load, the similar manual approach has been taken. Same properties are considered which the table weight is 200 *N*, 0.05 for coefficient of friction, 0.02 m pitch diameter and pitch length equal to 3 x 10^{-3} m.

$$T_l = \frac{FD_p}{2}\left(\frac{\mu - \tan\theta}{1 + \mu \cdot \tan\theta}\right)$$

$$T_l = \frac{200\ x\ 0.02}{2}\left(\frac{0.05 - 0.0318}{1 + 0.05\ \cdot 0.0318}\right) = 0.036\ Nm$$

3.10.3 Motor Torque Selection

With the value obtain from torque calculation; the specification of motor with suitable torque will be chose. Criteria in consider is the torque need to raise or lower the table; which one is maximum.

3.11 SIMULATION AND ANALYSIS

Using SolidWork software, the actual dimension of the designs was drawn into three dimensional for further appliance. All of the part are separated and measure before drawing process. Then, some of the critical parts are being analyzed by applying force and temperature using Finite Element Method (FEM).

The critical part of each concept designs are being analyze using four different materials with different applied load due to the function and location of each parts. The loads applied are the made from the assumption from the function of each part. Each of the part then meshed to forty-percent-fine. The load applied to each critical part can be referred in the table below.

Table 3.9: Load applied to critical parts.

Critical Part	**Load Applied, *N***
Scissor Link 1	65.4
Scissor Link 2	117.72
Table Leg	100
Column Slot	45

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter consists of the result gathered from the questionnaire, the concept selection process and the analysis of the concepts. The questionnaire interested on respondent's background such as the ethnicity, marital status, type of disability and personal assistance service. The inquiries then follow to their needs of being independence such as in preparing meals and type of problem they need to face when doing so. The meant of the optimization for cooker then justify in how it will aid up the daily life of respondent. The analyses for the solid model were done using ALGOR within several selected materials. The material were chosen as to it availability in the market and at present of general machining in factory shop. All the results then discussed about the additional feature that can fit the concept and the alteration that can be made for the concept design.

4.2 ANALYSIS OF QUESTIONNAIRE

There are 30 respondent are participate in this process. Respondent are selected randomly among UMP students and the handicap population in Kuantan especially in public center of attention such as Tunku Ampuan Azfan Hospital and Teruntum Shopping Plaza. The questionnaire consist nine simple questions and the respondent are required to answer the entire question. The results of the analysis are shown in the Figure 4.1 until Figure 4.8.

In order to gain information data from the handicap people, the questionnaire are divided into three sections which are basic background, the types of disability and the problem faced by handicap people in coping with daily activities and basic information about the project.

The first question is related to the ethnicity of the respondent. Twenty-one out of thirty respondents are Malay, followed by six person are Chinese and three persons are Indian. Next question is related to respondent marital status. As a result, twenty-eight of the respondents are single while the rest are married.

The second part which is the third question is about the type of the disability of the respondent. As a result, ten of them are suffered from amputation followed by seven person be diagnosed with a stroke, four persons having a visual impairments or blindness, two persons from arthritis, and one from hearing impairments or known as deafness. While the rest of them, which are six persons are suffered from spinal muscular atrophy type II, dwarf and other physical disability. The question followed by the needs of extra assistance service. Twelve of the respondent needs assistance service to moving around their home, ten persons need assistance in preparing a meal, eight person in dressing, seven person in both of toileting and getting out of bed, six person in personal hygiene, five person in both eating or feeding and taking medication. Two of them need assistance in home maintenance while the rest, four person need assistance in others including reaching higher place and exercise.

The last part is related to the project. The first question in this part is the number of respondent does prepared meal themselves. As a result, twenty-six of them are not while the rest do prepare meal themselves. Next question are followed by the problem faced by the handicap people while preparing meal. Seventeen of them faced lifting problem, fifteen persons having a problem with handling, followed by four persons in transporting and three persons are others including incapable to stand for a long period of time and unreachable problem. The second last question is about the necessity of optimization of cooker. Eighteen out of thirty person agreed that the project is very need, seven of them choose to needed, four of them agreed with less useful and one of them says unable to aid. Lastly, the question asks about how far the flexible cooker

could aid the handicap user. Eighteen of them choose to less accident, seven of them agreed with cooking faster and two of them choose save time and energy. However, sixteen of them choose others which are ease to clean after use, reachable and easy to operate. The summary of the results of the questionnaire are shown in figure below.

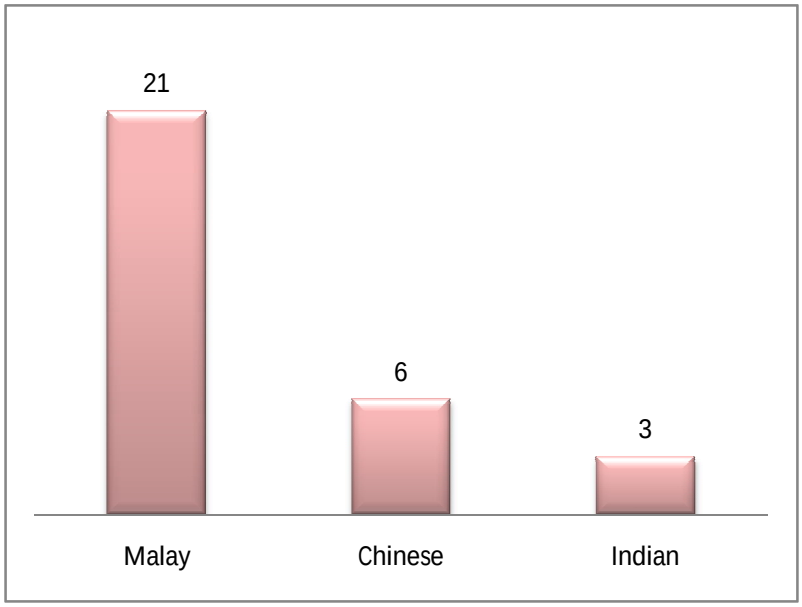


Figure 4.1: Respondent's ethnicity.

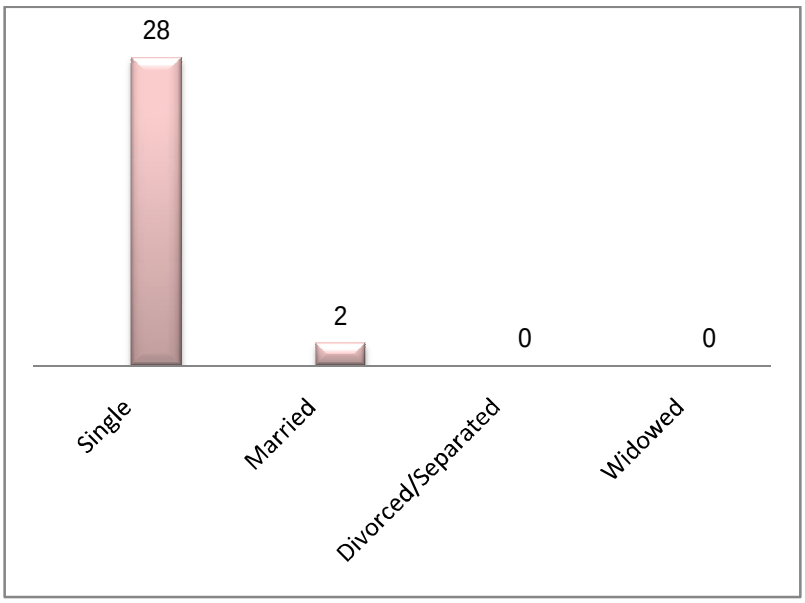


Figure 4.2: Respondent's marital status.

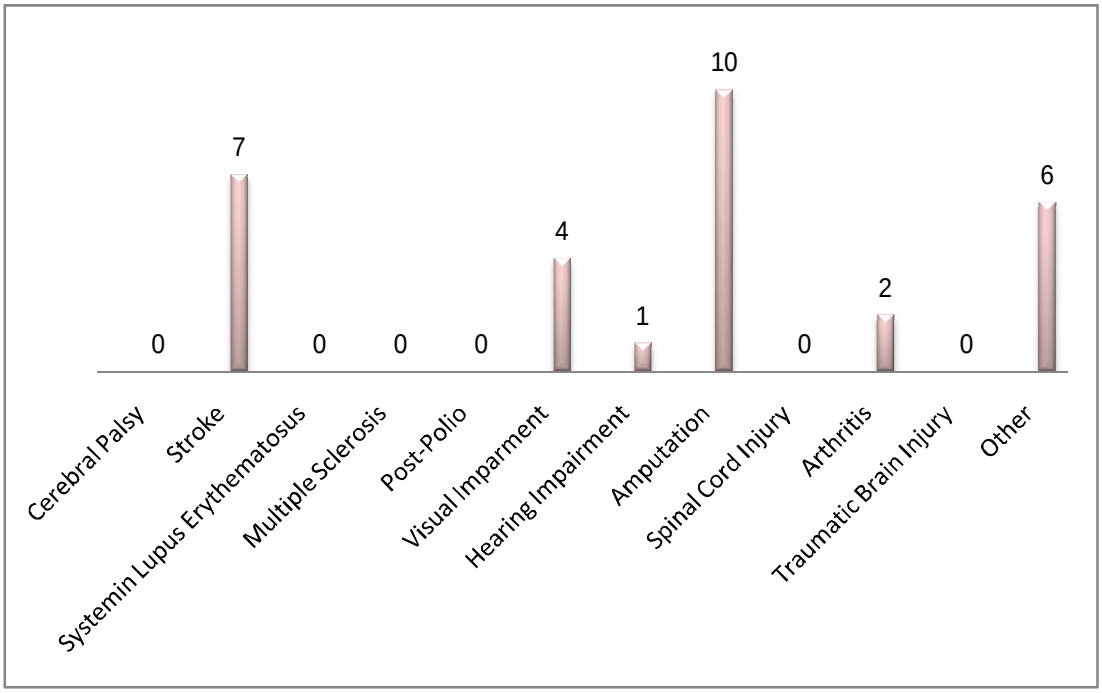


Figure 4.3: Respondent's type of disability.

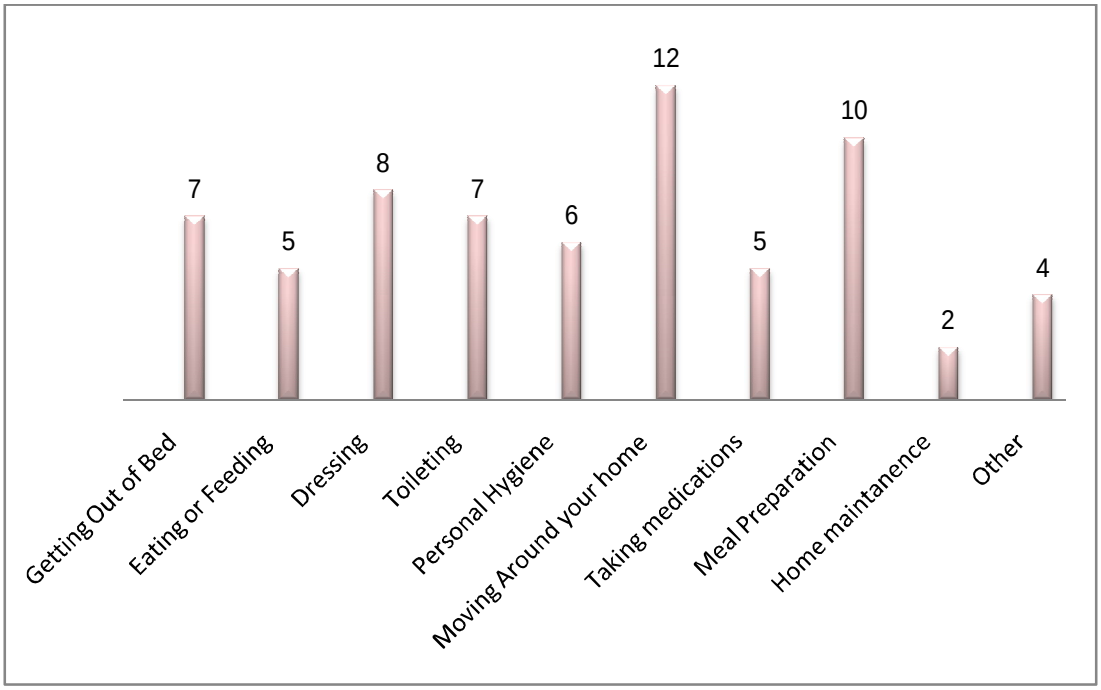


Figure 4.4: Respondent's personal assistance service.

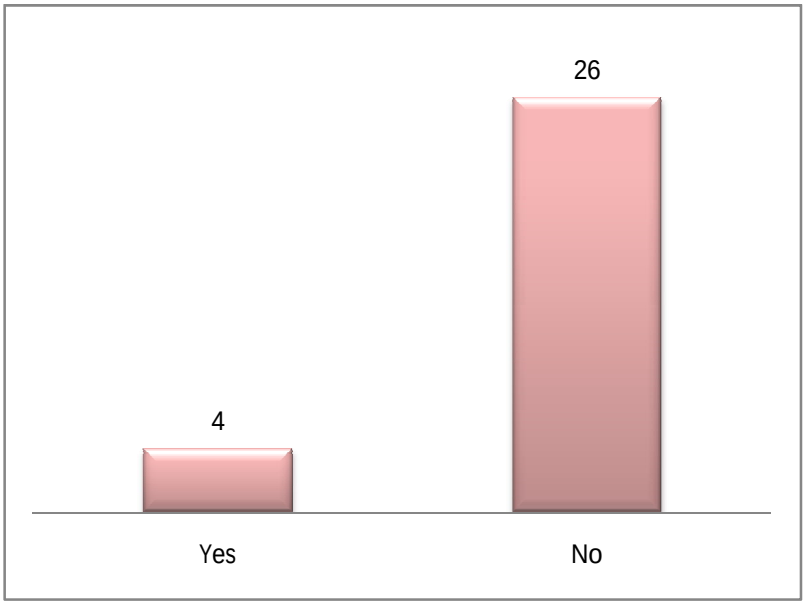


Figure 4.5: Number of respondent does prepare meal themselves.

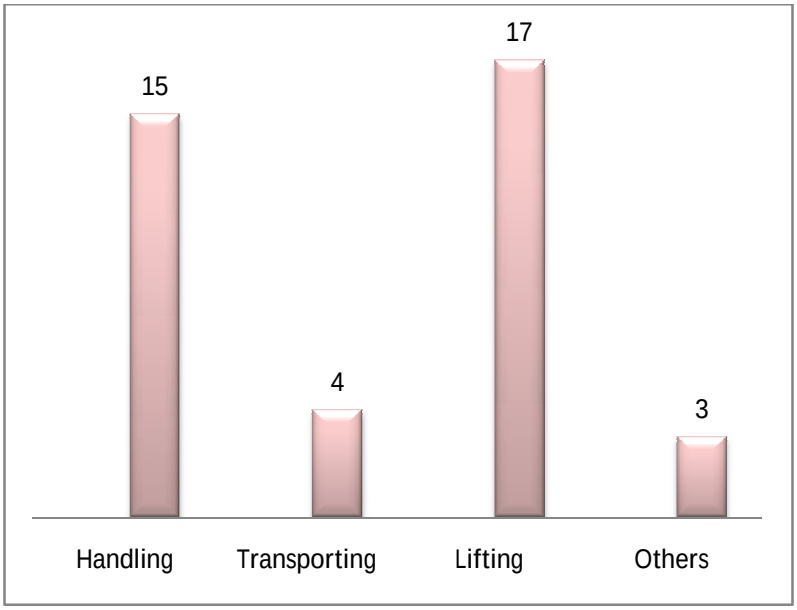


Figure 4.6: Problems when preparing meal.

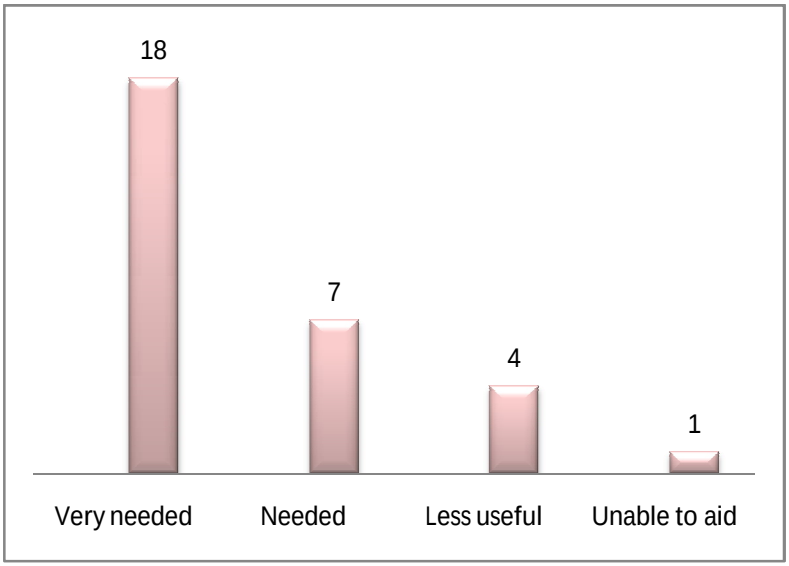


Figure 4.7: Necessity of optimization of cooker.

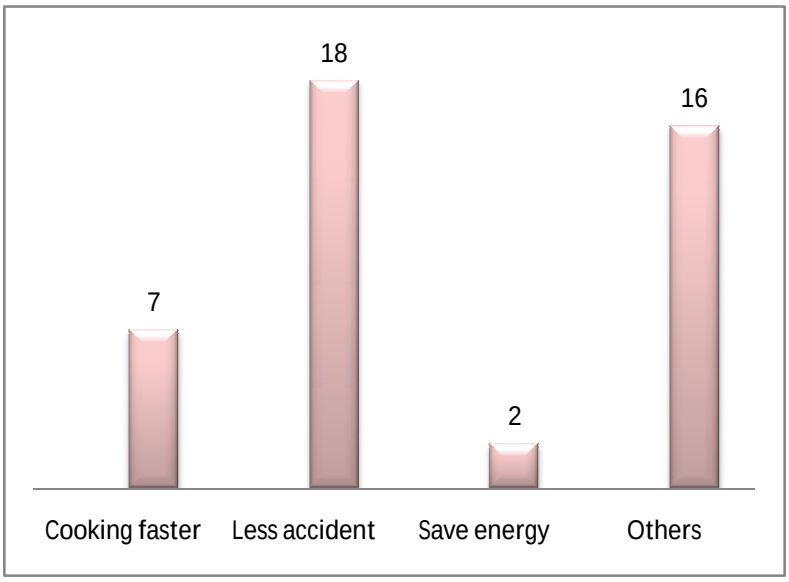


Figure 4.8: How far flexible cooker could aid the handicap user.

4.3 ANALYSIS RESULTS

The processes proceed with analyzing critical parts of each concepts design. All the parts are analyzed using Finite Element Analysis (FEA) tools which is ALGOR FEMPRO. The assumption load of each part is made due to the function and location of the part and can be referred in Table 3.3. Since the first and the third concept are using

similar type of mechanism, but different component attached, the critical part are assumed to be same. Each of the part is then analyzed using different materials which are low-carbon steel AISI 1018 HR, Aluminum Alloy 1100 H14, Grey Cast Iron ASTM A-48 and Titanium Ti-6Al-4V. The results of the analysis are shown in Table 4.1 until Table 4.4.

Table 4.1: Analysis results of scissors link 1 for 1st and 3rd design.

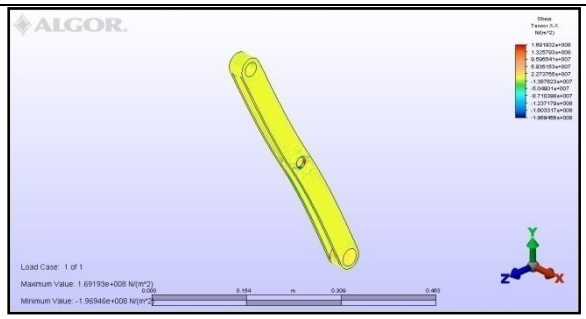
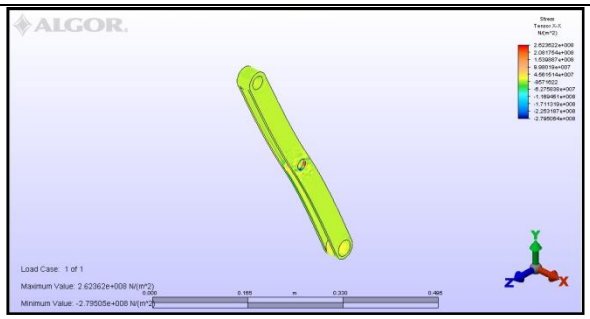
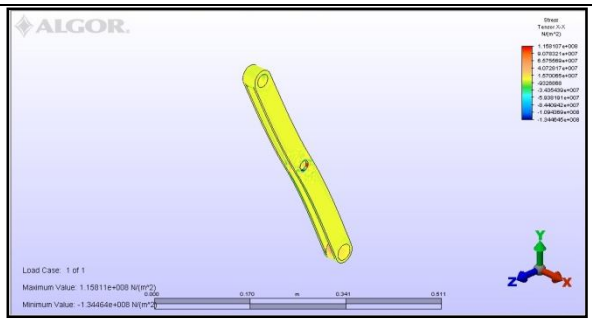
Materials	**Stress X-X (N/m^2)**
AISI 1018 Hot-Rolled, Quenched, Tempered	 Max. Value: 1.69193×10^8 Min. Value: -1.96946×10^8
Aluminum Alloy 1100 – H14	 Max Value: 2.62362×10^8 Min Value: -2.79505×10^8
Iron, Grey Cast ASTM A 48 Grade 25	 Max Value: 1.15811×10^8 Min Value: -1.34464×10^8

Table 4.1: Analysis results of scissors link 1 for 1st and 3rd design (Continued).

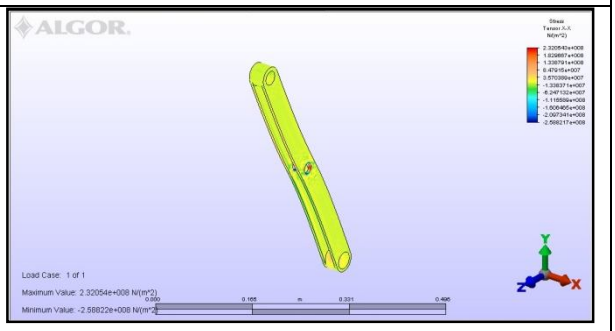
Materials	Stress X-X (N/m^2)
Titanium Ti-6Al-4V, Annealed	 Max Value: 2.32054×10^8 Min Value: -2.58822×10^8

Table 4.2: Analysis results of scissors link 2 for 1st and 3rd design.

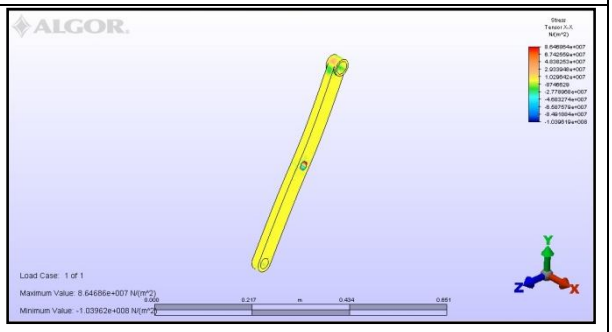
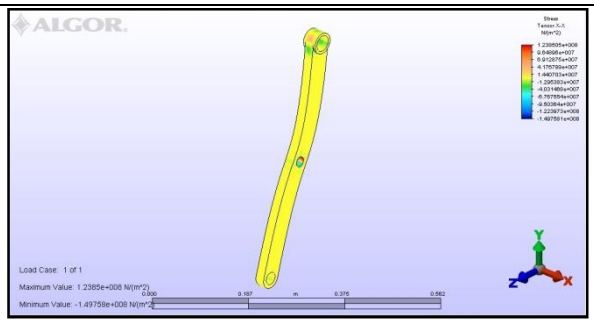
Materials	Stress X-X (N/m^2)
AISI 1018 Hot-Rolled, Quenched, Tempered	 Max. Value: 8.64686×10^7 Min. Value: -1.03962×10^8
Aluminum Alloy 1100 – H14	 Max. Value: 1.2385×10^8 Min. Value: -1.49758×10^8

Table 4.2: Analysis results of scissors link 2 for 1st and 3rd design (Continued).

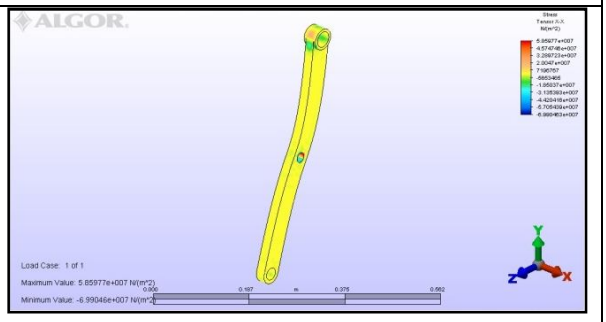
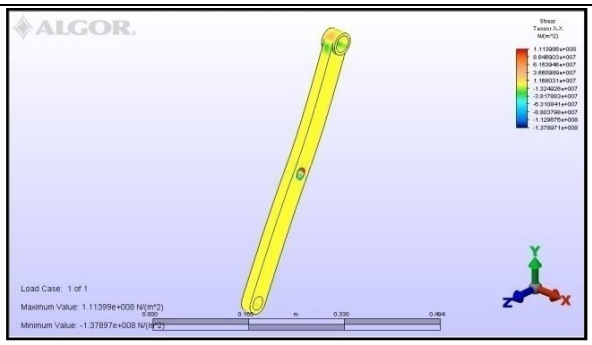
Materials	Stress X-X (N/m^2)
Iron, Grey Cast ASTM A 48 Grade 25	 Max. Value: 5.85977 x 10^7 Min. Value: -6.99046 x 10^7
Titanium Ti-6Al-4V, Annealed	 Max. Value: 1.11399 x 10^8 Min. Value: -1.37897 x 10^8

Table 4.3: Analysis results of table legs for 2nd design.

.

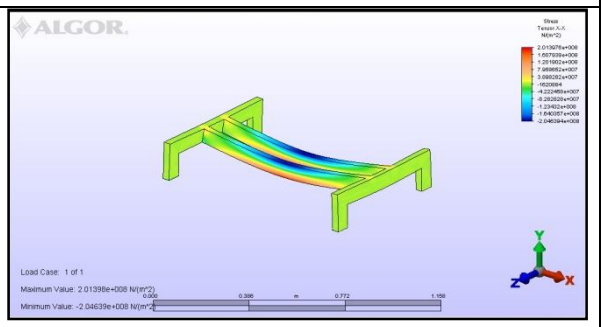
Material	Stress X-X (N/m^2)
AISI 1018 Hot-Rolled, Quenched, Tempered	 Max. Value: 2.01398 x 10^8 Min. Value: -2.04639 x 10^8

Table 4.3: Analysis results of table legs for 2nd design (Continued).

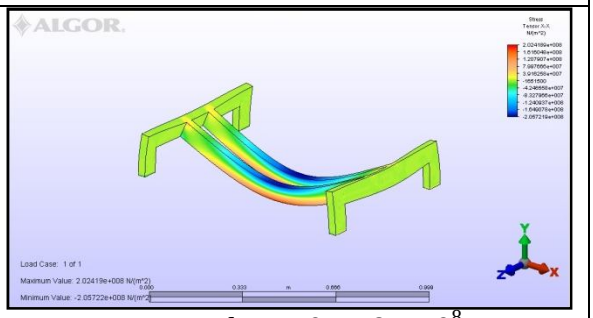
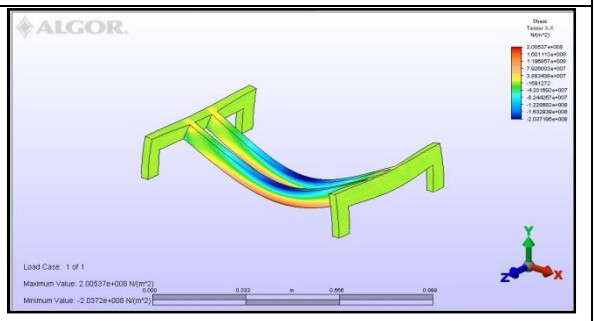
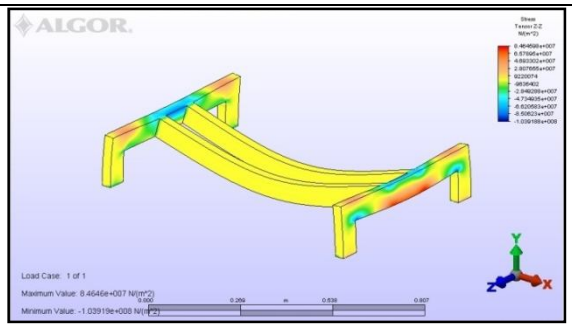
Material	Stress X-X (N/m^2)
Aluminum Alloy 1100 – H14	 Max. Value: 2.02419×10^8 Min. Value: -2.05722×10^8
Iron, Grey Cast ASTM A 48 Grade 25	 Max. Value: 2.00537×10^8 Min. Value: -2.0372×10^8
Titanium Ti-6Al-4V, Annealed	 Max. Value: 8.4646×10^7 Min. Value:-1.03919×10^8

Table 4.4: Analysis result of column slot for 4th design.

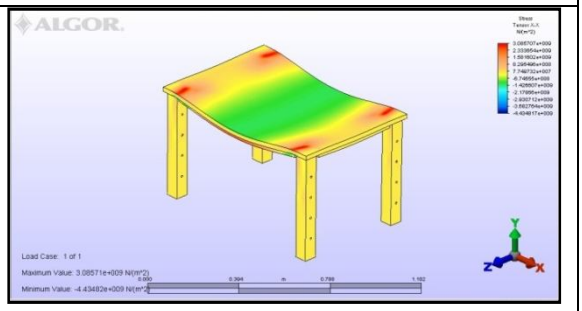
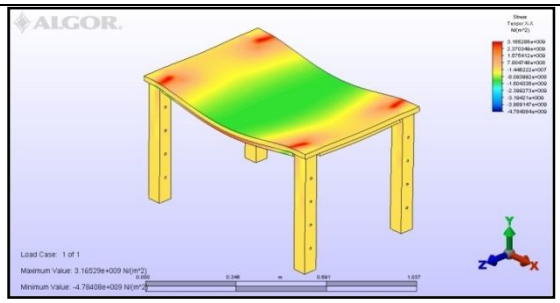
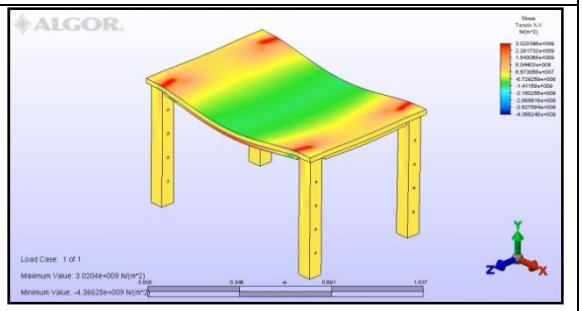
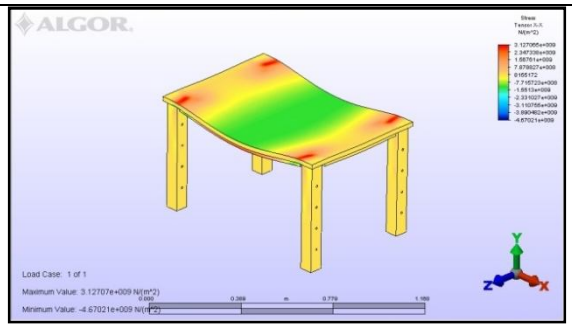
Material	Stress X-X (N/m^2)
AISI 1018 Hot-Rolled, Quenched, Tempered	 Max. Value: 3.08571×10^9 Min. Value: -4.43482×10^9
Aluminum Alloy 1100 – H14	 Max. Value: 3.16529×10^9 Min. Value: -4.78408×10^9
Iron, Grey Cast ASTM A 48 Grade 25	 Max. Value: 3.0204×10^9 Min. Value: -4.36625×10^9

Table 4.4: Analysis Result of Column Slot (Continued).

Material	Stress X-X (N/m^2)
Titanium Ti-6Al-4V, Annealed	 Max. Value: 3.12707×10^9 Min. Value: -4.67021×10^9

4.4 CONCEPT SELECTION

Concept selection is the process of evaluating concepts with respect to customer needs and other criteria, comparing the relative strengths and weaknesses of the concepts, and selecting one or more concepts for further investigation, testing, or development. Table below shows the result of concept screening matrix. Table 4.5 shows the concept screening selection matrix for flexible cooker.

Table 4.5: Concept screening matrix for flexible cooker.

Selection Criteria	Concepts				
	1st Design (motor)	**2nd Design (foot pump)**	**3rd Design (hydraulics)**	**4th Design (column slot)**	**5th Design (reference)**
Adjustable Height	+	+	+	+	0
Cost	+	+	+	0	0
Durability	0	0	0	0	0
Ease for Handling	+	+	+	-	0
Mobility	+	+	+	+	0
Storage Area	+	0	+	+	0
Sum +'s	5	4	4	3	0
Sum 0's	1	2	1	2	7
Sum –'s	0	0	0	1	0
Net Score	5	4	4	2	0
Rank	1	2	2	5	4
Continue?	Yes	Combine	Revise	No	Combine

4.5 FINALIZED DESIGN

From the result, the design chosen then is finalized. The solid model then selected with additional specification were add on. The specification of cooker then determined where the motor used will be able to supply minimum torque of 0.164 *Nm* which is 164 x 10^{-3} *N-m*.

The selected motor is KS5FN-3060 with available torque equal to 217.06 x 10^{-3} *Nm* and efficiency of 74 %. It can supply effective torque equal to 196.54 x 10-3 Nm which is obviously sufficient to operate the lifting and lowering mechanism of the cooker table. Motor datasheet can be referred in appendices section.

4.6 DISCUSSION

4.6.1 Discussion of FEA Results

Determination of the result due to the stand able load applied is done after the analysis process. Based on the results of the analysis, the fourth concepts have the lowest stress on the X-X plane than the other concepts. The results shows that even though the material used for the critical part of fourth concepts design is titanium Ti-6Al-4V, annealed, it still have the lowest values of stress in X-X plane than the other parts with the same material. Thus, the fourth concept is taken as the revision concept.

Focus on the scissors link 1 and link 2, the best material to be used is grey cast iron ASTM A-48 Grade 25 because the stress value of the parts is the lowest among the other materials. However, the results differ for table leg part. From the analysis, the best material to be used is titanium Ti-6A1-4V, followed by grey cast iron ASTM A-48 Grade 25, alloy steel AISI 1018 hot-rolled, quenched and finally by aluminum alloy 1100 H-14. Thus, the best suitable part to be used is scissors mechanisms with grey cast iron ASTM A-48 grade 25 as the material for the parts.

The other criteria that need to be considered in selecting the best product are the cost to fabricating the product. From the concept generation, small motor component are used in the first concept and the electro hydraulic system are used in the third concept. However, the electro-hydraulic system gave the greater result in the costing than the small motor component. Thus, the concept with the application of small motor component is chosen as the best suitable design for handicap purpose usage.

4.6.2 Discussion of Concept Screening Result

The result out yield that the first design was chosen to be continue. The preferred design surpasses other design by net score of 5. The features added to the first design with other initial specification prove to be positive characteristic; a sign of good concept.

Minor modification related to the other design that was chosen to be combine are recommended to be add in. Such features may include feature from 2nd design; which is foot pump. Foot pump operated using hydraulic system similar to hydraulic jack. The additional extension to 1st design is to aid the function when the power supply to its motor somehow disconnected. Manual operated foot pump could be attached to pre-installed valve to spin the rotary system manually and jack up the table.

The 3rd design considered for revision. The hydraulic systems are practical but in term of optimization of product function for handicap people, the manual approach for operation is not reasonable. But the concept is can be revised in order to see whether in the future, automated version of this concept is available.

The column slot version is discontinued due to the unsatisfactory concept screening result. The weight is very limited since the additional weight centralized in the middle of cooker. Column slot may not be appropriated for heavy cooking. The heating factor may contribute to column strength and will affect the structure in overall. For handicap people, such deficiency could be harmful and dangerous to them.

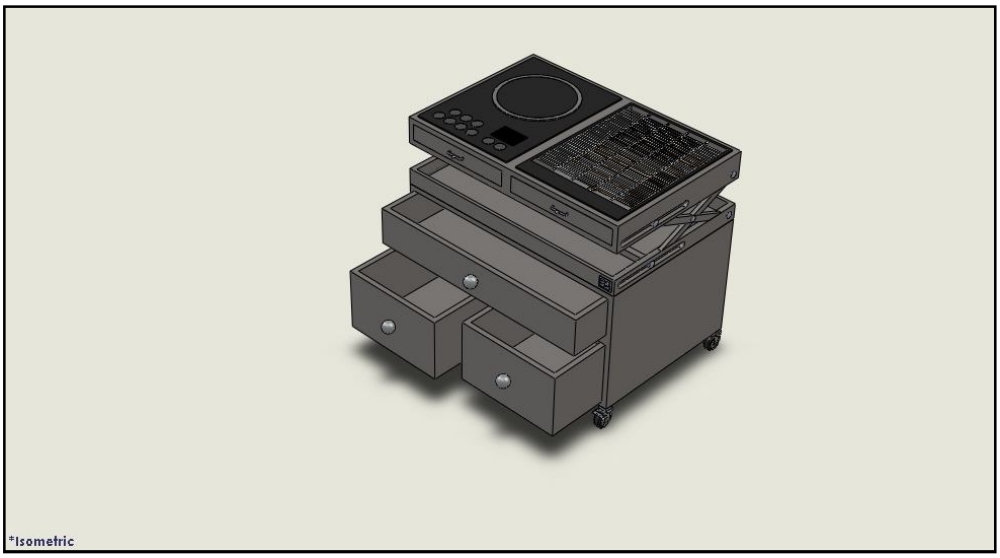


Figure 4.9: Finalize design of flexible cooker.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter will conclude the project and briefly enlightened about the recommendation that can be applied to the project. The conclusion were done according to the appropriate result obtain from previous analyses and important questionnaire. From the result, the objective stated were compared and panelized whether it is achieved or not. If the current situation suggest that the objective is fulfilled the recommendation were then optional especially for upcoming project. If circumstances were not, then the recommendation to improve the methodology and troubleshot the situation will be stated within recommendation section. The project was in logical and scientifically manner believed to achieve its objectives. Hence, the recommendations in order to extend and critically improve the product function were stated for future project.

5.2 Conclusion

Technology exerts a powerful influence over the lives of everyone, making life easier, more fulfilling even though the painful and frustrating still existed. Same goes to handicap people. However, the revolution of technology has ignored the essential to facilitate handicap people especially in coping with daily activity.

Previous studies have discovered the problem faced by handicap people especially in mobility and dealing with daily activities such as using everyday consumer product. Since the handicap's problem is related to biomechanical relatively, the

necessity of transformation and optimization of product function can be made using appropriate methods of technology.

Suitable daily product that can be customized for special purpose especially for handicap people was identified by gathering information data from handicap people. In this study, the product chosen was cooker. Then, the concepts undergo several processes in order to select the best concept including concepts generation, material selection and concept selection. The design also being analyze with different materials using compatible software and proven as the best design due to the features mounted and good ergonomic characteristic.

5.3 Recommendation

The development of the project still has to carry forward to improve the accuracy of the result. During concept generation, several factors are not considered in the design analysis and the further work strongly recommended:

i. Application of future technology – automatic height adjustment according to the user's height with the help of sensors.
ii. Material modification – light component with high strength to increase mobility and durability.
iii. Additional features – application of mini refrigerator to ease handicap people reach the raw ingredient and foldable chair.
iv. Replacement of conventional square form to recirculating ball screw. The detail can be referred in Appendix G.

REFERENCES

Department of Trade and Industry (DTI), Government Consumer Safety Research of United Kingdom. *A study of the difficulties disabled people have when using everyday consumer products.*

European Conference of Ministry of Transport (ECMT). 1991. *Transport for people with mobility handicaps, Policy and Achievement in Europe.*

Fotheringham, J.B., *Handicapped children and handicapped families.* North York.

Hutton, D.V., 2004. *Fundamental of Finite Element Analysis.* ISBN: 007-124160-4. Singapore: McGraw Hill.

Milberger, S., LeRoy, B., Martin, A., Israel, N., Potter, L., and Patchak-Schuster, P. 2002. Michigan study on women with physical disability. Final Report. Michigan: 2000-WT-VX-0018.

Office of Technology Assessment (OTA), 1982, *Technology and Handicapped People*. PB83-172056.

Puthoff, M.L. and Nielsen, D.H. 2007. Relationship among impairments in lower-extremity strength and power, functional limitations, and disability in older adults. **87**: 1334-1337.

Smith, W.F. and Hashemi, J. 2006. *Foundations of Materials Science and Engineering.* ISBN: 007-125690-3. Fourth Edition. Singapore: McGraw Hill.

Steinfeld, E., Lenker, J. and Paquet, V. 2002. *The Anthropometrics of Disability: An International Workshop.* Technical Report. New York. 14214-3087

Ulrich, K.T. and Eppinger, S.D. 2008. *Product Design and Development.* ISBN: 978-007-125947-7. Fourth Edition. Singapore: McGraw-Hill/Irwin.

http://www.roymech.co.uk/

http://www.savethechildren.org.uk/en/55_4997.htm

Appendix A

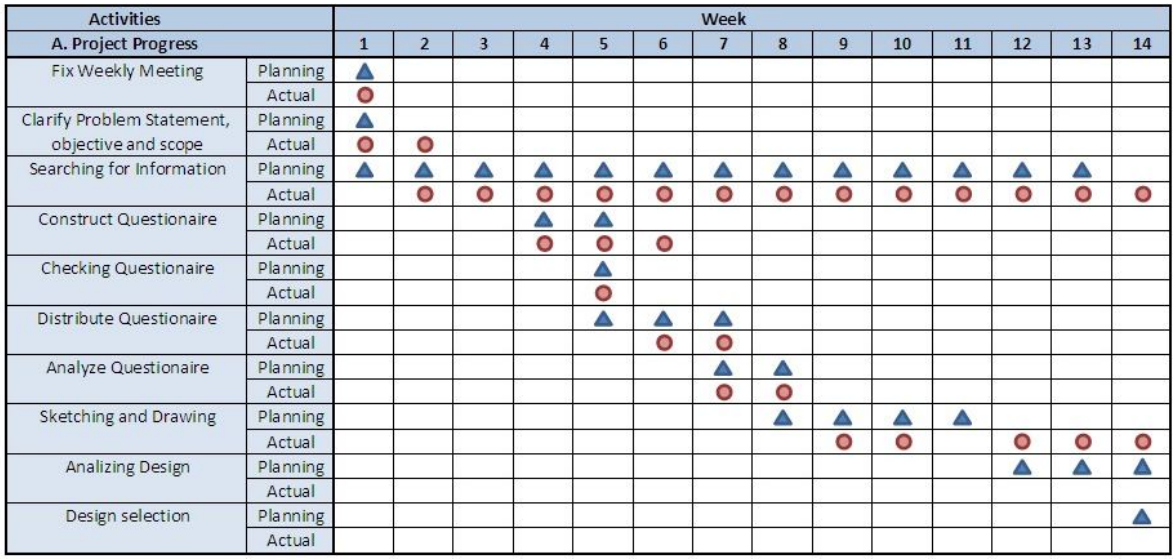
Table 6.1: Registration of persons with disability by types of disability.

Source: Social Welfare Department of Malaysia website.

Type of Disabilities	2003	2004	2005
Physical disability	45,356	51,090	56,738
Deafness	22,728	24,712	26,294
Blindness	14,154	15,364	16,302
Learning Disability	-	57,483	66,130
Cerebral Palsy	-	34	623
Others Disability	1,077	1,934	4,368

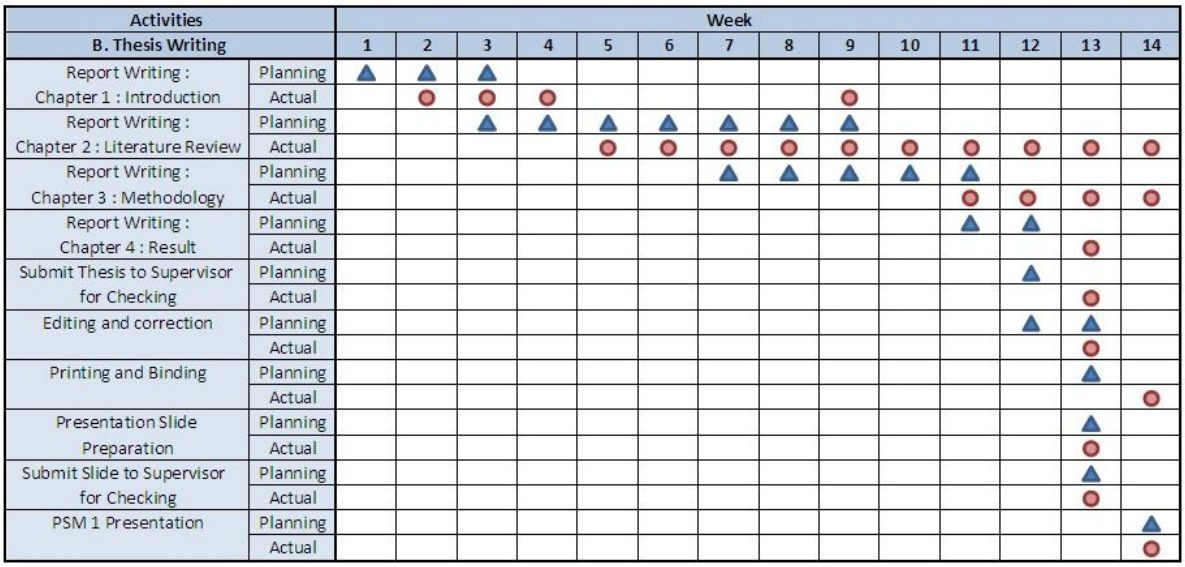
Appendix B

Gantt Chart



Activities		Week													
A. Project Progress		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fix Weekly Meeting	Planning	▲													
	Actual	○													
Clarify Problem Statement, objective and scope	Planning	▲													
	Actual	○	○												
Searching for Information	Planning	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
	Actual		○	○	○	○	○	○	○	○	○	○	○	○	○
Construct Questionaire	Planning				▲	▲									
	Actual				○	○	○								
Checking Questionaire	Planning					▲									
	Actual					○									
Distribute Questionaire	Planning					▲	▲	▲							
	Actual						○	○							
Analyze Questionaire	Planning							▲	▲						
	Actual							○	○						
Sketching and Drawing	Planning								▲	▲	▲	▲			
	Actual									○	○		○	○	○
Analizing Design	Planning												▲	▲	▲
	Actual														
Design selection	Planning														▲
	Actual														

Figure 6.1: Project progress gantt chart for FYP 1.



Activities		Week													
B. Thesis Writing		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Report Writing : Chapter 1 : Introduction	Planning	▲	▲	▲											
	Actual		○	○	○					○					
Report Writing : Chapter 2 : Literature Review	Planning			▲	▲	▲	▲	▲	▲	▲					
	Actual					○	○	○	○	○	○	○	○	○	○
Report Writing : Chapter 3 : Methodology	Planning							▲	▲	▲	▲	▲			
	Actual											○	○	○	○
Report Writing : Chapter 4 : Result	Planning											▲	▲		
	Actual													○	
Submit Thesis to Supervisor for Checking	Planning												▲		
	Actual													○	
Editing and correction	Planning												▲	▲	
	Actual													○	
Printing and Binding	Planning													▲	
	Actual														○
Presentation Slide Preparation	Planning													▲	
	Actual													○	
Submit Slide to Supervisor for Checking	Planning													▲	
	Actual													○	
PSM 1 Presentation	Planning														▲
	Actual														○

Figure 6.2: Thesis writing gantt chart for FYP 1.

Appendix B

Gantt Chart

Activities		Week													
A. Project Progress		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Searching for Information	Planning	▲	▲	▲	▲	▲									
	Actual	○	○	○	○	○		○	○	○		○	○	○	
Detail Drawing	Planning	▲	▲	▲	▲	▲	▲	▲	▲						
	Actual				○	○	○	○	○	○	○	○		○	
Analysis of Drawing	Planning								▲	▲	▲	▲	▲		
	Actual											○	○	○	
Design Selection	Planning												▲		
	Actual														○

Figure 6.3: Project progress gantt chart for FYP 2.

Activities		Week													
B. Thesis Writing		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Report Writing	Planning	▲	▲	▲	▲										
Chapter 2 : Literature Review	Actual		○	○	○	○	○		○	○	○				
Report Writing	Planning	▲	▲	▲	▲	▲	▲	▲							
Chapter 3 : Methodology	Actual					○	○	○	○	○	○	○			
Report Writing	Planning							▲	▲	▲	▲	▲			
Chaper 4 : Result	Actual					○				○	○	○	○	○	
Submit Thesis to Supervisor	Planning											▲	▲		
for Checking	Actual												○	○	
Editing and Correction	Planning											▲	▲		
	Actual													○	
Printing and Binding	Planning												▲		
	Actual													○	
Presentation Slide	Planning													▲	
Preparation	Actual													○	
Submit Slide to Supervisor	Planning													▲	
for Checking	Actual													○	
PSM 2 Presentation	Planning														▲
	Actual														○

Figure 6.4: Report writing gantt chart for FYP 2.

Appendix C

Sample of Questionnaire of Flexible Cooker

Figure 6.5: Electric grill and induction cooker.

People do eating to get alive. Same goes to handicap people. However, handicap people always facing a problem when preparing their own meal and enforce them to get extra assistance. The purpose of this questionnaire is to gather information from handicap people regarding to optimization process of the function of cooker for both normal and handicap people.

1. Ethnicity
   Malay ( )
   Chinese ( )
   Indian ( )

2. Marital Status
   Single ( )
   Married ( )
   Divorced/Separated ( )
   Widowed ( )

3. Type of Disability
   Cerebral Palsy ( ) Stroke ( ) Systemic Lupus Erythematosus ( )
   Multiple Sclerosis ( ) Post-Polio ( ) Visual Impairment ( )

Hearing Impairment ( ) Amputation ( ) Spinal Cord Injury ( )
Arthritis ( ) Traumatic Brain Injury ( ) Other ( )

4. Personal Assistance Services (mark all that apply)
   Getting out of bed ( ) Eating or feeding ( ) Dressing ( ) Toileting ( )
   Personal hygiene ( ) Moving around your home ( ) Taking medications ( )
   Meal preparation ( ) Home maintenance ( )Other_____

5. Do you prepare your meal by yourself?
   Yes ( )
   No ( )

6. Main problem do you faces when preparing your meal.
   Handling ( )
   Transporting ( )
   Lifting ( )
   Others _____

7. The necessity of optimization of cooker for handicap people.
   Very needed ( ) Needed ( )
   Less Useful ( ) Unable to aid ( )

8. How far a flexible cooker could aid the handicap people when preparing their meal. (mark all that apply)
   Cooking Faster ( ) Less accident ( )
   Save energy ( ) Others_____

9. Suggestion to optimize the function of cooker.
   _____
   _____
   _____

   Thank you for your cooperation.

Appendix D

Typical Properties of Selected Materials Used In Engineering

Material	Density kg/m³	Ultimate Strength			Yield Strength[3]		Modulus of Elasticity, GPa	Modulus of Rigidity, GPa	Coefficient of Thermal Expansion, 10^{-6}/°C	Ductility, Percent Elongation in 50 mm
		Tension, MPa	Compression,[2] MPa	Shear, MPa	Tension, MPa	Shear, MPa				
Steel										
Structural (ASTM-A36)	7860	400			250	145	200	77.2	11.7	21
High-strength-low-alloy										
ASTM-A709 Grade 345	7860	450			345		200	77.2	11.7	21
ASTM-A913 Grade 450	7860	550			450		200	77.2	11.7	17
ASTM-A992 Grade 345	7860	450			345		200	77.2	11.7	21
Quenched & tempered										
ASTM-A709 Grade 690	7860	760			690		200	77.2	11.7	18
Stainless, AISI 302										
Cold-rolled	7920	860			520		190	75	17.3	12
Annealed	7920	655			260	150	190	75	17.3	50
Reinforcing Steel										
Medium strength	7860	480			275		200	77	11.7	
High strength	7860	620			415		200	77	11.7	
Cast Iron										
Gray Cast Iron										
4.5% C, ASTM A-48	7200	170	655	240			69	28	12.1	0.5
Malleable Cast Iron										
2% C, 1% Si, ASTM A-47	7300	345	620	330	230		165	65	12.1	10
Aluminum										
Alloy 1100-H14										
(99% Al)	2710	110		70	95	55	70	26	23.6	9
Alloy 2014-T6	2800	455		275	400	230	75	27	23.0	13
Alloy-2024-T4	2800	470		280	325		73		23.2	19
Alloy-5456-H116	2630	315		185	230	130	72		23.9	16
Alloy 6061-T6	2710	260		165	240	140	70	26	23.6	17
Alloy 7075-T6	2800	570		330	500		72	28	23.6	11
Copper										
Oxygen-free copper (99.9% Cu)										
Annealed	8910	220		150	70		120	44	16.9	45
Hard-drawn	8910	390		200	265		120	44	16.9	4
Yellow-Brass (65% Cu, 35% Zn)										
Cold-rolled	8470	510		300	410	250	105	39	20.9	8
Annealed	8470	320		220	100	60	105	39	20.9	65
Red Brass (85% Cu, 15% Zn)										
Cold-rolled	8740	585		320	435		120	44	18.7	3
Annealed	8740	270		210	70		120	44	18.7	48
Tin bronze (88 Cu, 8Sn, 4Zn)	8800	310			145		95		18.0	30
Manganese bronze (63 Cu, 25 Zn, 6 Al, 3 Mn, 3 Fe)	8360	655			330		105		21.6	20
Aluminum bronze (81 Cu, 4 Ni, 4 Fe, 11 Al)	8330	620	900		275		110	42	16.2	6

Figure 6.6: Typical properties of selected materials used in engineering.

Appendix E

KAYABA Mini-Motion Package

KYB® MINI-MOTION PACKAGE

INNOVATIVE TECHNOLOGY

KYB's MINI-MOTION PACKAGE (MMP) is an electric over hydraulic linear actuator which completely integrates a DC motor, hydraulic pump, valve and cylinder. The MMP is an entirely self-contained unit with no external piping, thus eliminating the possibility of oil leakage. The MMP is lightweight and compact, and is suitable for both indoor and outdoor applications.

FEATURES

Compact, Completely Integrated

- Lightweight
- Small size for greater installation versatility
- Completely sealed to prevent leakage
- Mounting flexibility in any position

Safe and Reliable

- Recommended for indoor and outdoor applications
- Weather proof to IP67
- Electric motor protected by a circuit breaker
- Integrated check valve assures load-holding
- Overload relief valve protects system
- Manual release valve for emergency operation of cylinder

Simple Installation

- "Plug-and-Play" requires only an external power source and switch

Many Options Available

HOW TO ORDER

EXAMPLE: **MMP3 - B 3 B 350 B C -**

MINI-MOTION PACKAGE

Electric Motor Output
A: 250W+598 psi
B: 250W+1035 psi

Electric Power Source
1: DC 12V
2: DC 24V
3: DC 100V

Cylinder Size
A: Ø30-Ø20
B: Ø40-Ø20

Cylinder Stroke
150: 150mm
200: 200mm
250: 250mm (Ø40 only)
300: 300mm (Ø40 only)
350: 350mm (Ø40 only)

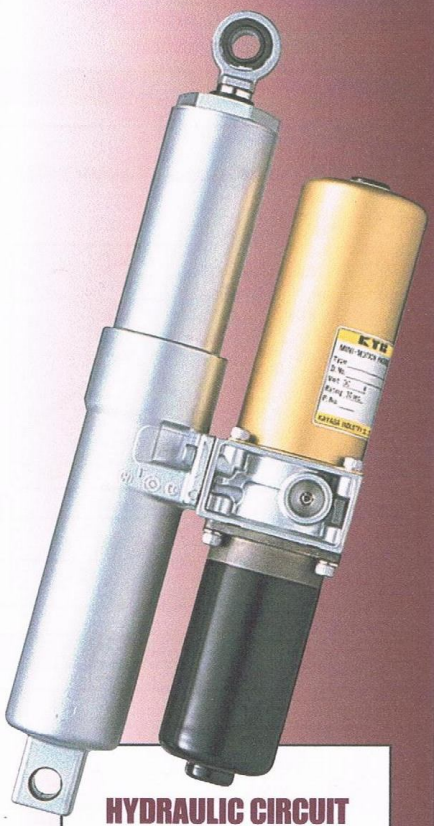
Optional Specification
No Symbol: Standard

B Port Slow Return Valve
A: None
B: Ø0.8
C: Ø0.6

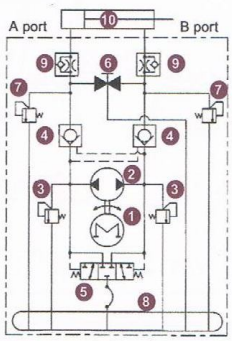
A Port Slow Return Valve
A: None
B: Ø0.8
C: Ø0.6

SPECIFICATIONS

		A. Relief Valve Pressure 598 psi			B. Relief Valve Pressure 1035 psi		
Electric Motor	Rated Output	(250W)			250W		
	Rated Voltage	DC12V	DC24V	DC100V	DC12V	DC24V	DC100V
	Rated Current	23A	11A	2.6A	40.8A	18.5A	5.6A
	Duty Cycle	30sec					
	Protection	Circuit breaker in electric motor					
Hydraulic Circuit	Rated Flow Rate	1.1L/min			0.9L/min		
	Rated Pressure	496 psi			933 psi		
	Relief Set Pressure	598 psi			1035 psi		
	Max. Retaining Pressure	13.7MPa (overload Relief Valve Preset Pressure)					
	Cylinder Size	ø30-ø20, ø40-ø20					
	Cylinder Stroke	150mm, 200mm, 250mm, 300mm, 350mm					
	Temperature	– 4 ~ 122°F					
	Hydraulic Operating Fluid	ISO VG 32 WR					
External Finish		Black Paint					

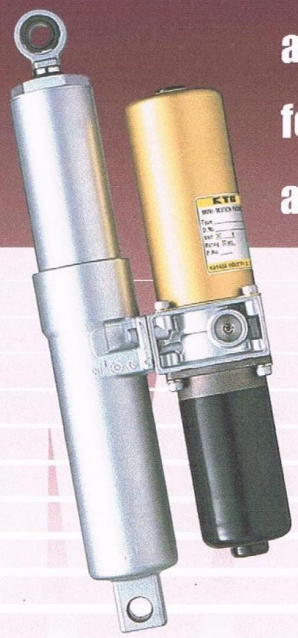


HYDRAULIC CIRCUIT



1. Electric Motor
2. Gear Pump
3. Relief Valve
4. Pilot-Operated Check Valve
5. Control Valve
6. Manual Release Valve
7. Overload Relief Valve
8. Oil Tank
9. Slow Return Valve
10. Cylinder

Proven to be both
an economical and
a resilient solution
for unlimited
applications... MINI-MOTION PACKAGE



KYB®
America LLC

140 N. Mitchell Court • Addison, IL 60101

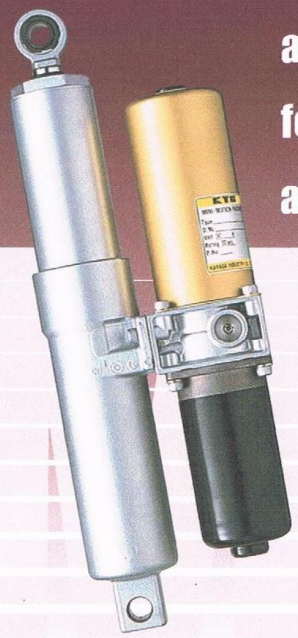
Phone: 630/620-5555 Fax: 630/620-8133
Website: www.kyb.com email: hyd@kyb.com

KYB America, LLC is a subsidiary company of
KAYABA INDUSTRY CO., LTD.
World Trade Center Building
4-1, Hamamatsu-cho, 2-chome
Minato-ku, Tokyo 105-6111 Japan

APPLICATIONS

- Automated Machinery for Industrial Use
- Conveyor Equipment
- Lifting and Clamping Devices
- ATV / UTV Power Attachments
- UTV Bed Tilt
- Emergency Vehicles
- Commercial Mowers
- Agriculture Machines

Proven to be both
an economical and
a resilient solution
for unlimited
applications... MINI-MOTION PACKAGE



KYB®
America LLC

140 N. Mitchell Court • Addison, IL 60101

Phone: 630/620-5555 Fax: 630/620-8133
Website: www.kyb.com email: hyd@kyb.com

KYB America, LLC is a subsidiary company of
KAYABA INDUSTRY CO., LTD.
World Trade Center Building
4-1, Hamamatsu-cho, 2-chome
Minato-ku, Tokyo 105-6111 Japan

APPLICATIONS

- Automated Machinery for Industrial Use
- Conveyor Equipment
- Lifting and Clamping Devices
- ATV / UTV Power Attachments
- UTV Bed Tilt
- Emergency Vehicles
- Commercial Mowers
- Agriculture Machines

Appendix F

Table 6.2: Sample of concept selection matrix.

Selection Criteria	**Concepts**			
	A Scissor Mechanism with Power Screw	**B Foot Pump**	**C Scissor Mechanism with Hydraulic Pump**	**D (Reference) Pinned Slot**
Adjustable Height Cost Durability Ease for Handling Readability to Setting Easy of Manufacture Mobility Storage Area Stand Applied Force				
Sum +'s Sum 0's Sum –'s				
Net Score Rank Continue?				

Appendix G

Recirculating Ball Screw

This type of power screw is used for high speed high efficiency duties. The ball screw is used for more and more applications previously completed by the conventional power screws.

The ball screw assembly is as shown below and includes a circular shaped groove cut in a helix on the shaft. The ball nut also includes an internal circular shaped groove which matches the shaft groove. The nut is retained in position on the shaft by balls moving within the groove. When the nut rotates relative to the shaft the balls move in one direction along the groove supporting any axial load. When the balls reach one end of the nut they are directed back to the other end via ball guides. The balls are therefore being continuously recirculated.

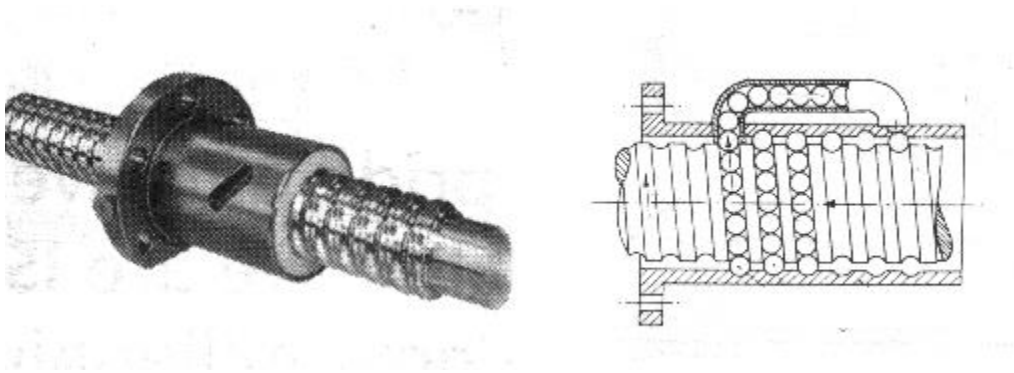


Figure 6.7: Recirculating ball screw.

The recirculated ball screw has the following advantages:

i. High Efficiency - Over 90%
ii. Predictable life expectancy.
iii. Precise and repeatable movement.
iv. No tendency for slip-stick.
v. Minimum thermal effects.

vi. Easily preloaded to eliminate backlash-with minimum friction penalty.
vii. Smoother movement over full travel range.
viii. Smaller size for same load.