

DESIGN AND DEVELOPMENT OF A MANUAL BREAST PUMP: AN
ERGONOMICS APPROACH

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We certify that the project entitled “*Design and development of manual breast pump: an ergonomics approach*” is written by *Nur Atiqah binti Ramlan*. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering

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STUDENT'S DECLARATION

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

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ABSTRACT

This thesis deals with design and development of a manual breast pump with an ergonomic approach. This project is the further study of the previous project which is the preliminary design of the manual breast pump. The purpose of this study is to prevent the musculoskeletal disorder problems among mothers who expressed the breast milk using manual breast pump. The objectives of this study is to design a manual breast pump with ergonomics approach using Solidworks, to make a prototype of the designed manual breast pump using Rapid Prototyping machine and to validate the designed manual breast pump using simulation process and manual calculation. The scope of this project is that the developed manual breast pump is only a prototype and is not readily functional as a commercial product. While the validations of the manual breast pump through the simulation software is considered precise. The strategy of validation of finite element analysis was developed for this project. The finite element analysis was then performed using ALGOR and the bottle part of the design was analyzed using the static stress with linear material model. The other part of the design which is the pressure pump was also manually calculated. The obtained results indicate that the maximum value of the result shows in the bottom of the bottle due to the surface boundary condition. The manual calculation of the pressure pump shows that the design just can produce the maximum pressure of about 4,000 Pa. While a good manual breast pump should produce at least about 2,000 Pa. However the area is not suitable to be reducing in a great number due to the ergonomics condition.

ABSTRAK

Tesis ini membentangkan rekapipta dan penghasilan *breast pump* manual dengan menggunakan kaedah ergonomik. Projek ini adalah lanjutan kajian sebelumnya iaitu rekapipta pendahuluan *breast pump* manual. Tujuan kajian ini adalah untuk mengatasi masalah otot atau *musculoskeletal disorder* di kalangan ibu-ibu yang menggunakan bantuan *breast pump* manual untuk menyusukan anak. Objektif kajian ini ialah merekecipta *breast pump* manual mengikut aspek ergonomik menggunakan Solidwork, membuat prototaip dari rekaan *breast pump* menggunakan mesin *Rapid Prototyping* dan untuk mengesahkan rekaan menggunakan proses simulasi dan kiraan manual. Skop projek ini adalah penghasilan *breast pump* manual yang masih belum sesuai berfungsi sebagai produk komersial. Sementara pengesahan dari *breast pump* manual melalui perisian simulasi dianggap tepat. Strategi validasi terhadap analisa unsur terhingga digunakan untuk projek ini. Analisa elemen dijalankan dengan menggunakan ALGOR dan rekaan bahagian botol dianalisa menggunakan tekanan statik dengan model bahan linier atau *static stress with linear material model*. Bahagian lain dari rekaan iaitu pam tekanan juga dikira secara manual. Hasil yang diperolehi menunjukkan bahawa nilai maksimum teletak pada bahagian bawah botol kerana keadaan batas permukaan atau *surface boundary condition*. Pengiraan pam tekanan menunjukkan bahawa rekaan ini hanya dapat mnghasilkan tekanan maksimum sekitar 4,000 Pa. Sementara *breast pump* yang baik seharusnya menghasilkan sekurang-kurangnya tekanan sebanyak 2,000 Pa. Namun yang demikian, luas pam ini tidak sesuai untu dikurangkan dalam jumlah yang besar atas faktor ergonomik.

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LIST OF ABBREVIATIONS

A	Contact surface Area
ABS	Acrylonitrile Butadiene Styrene
CAD	Computer-Aided Design
F	Force exerted to the hand
FEA	Finite Element Analysis
MSD	Musculoskeletal Disorders
P	Pressure
RP	Rapid Prototyping

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

As a mother, one of the greatest things they can do for their infant is breastfeeding. Breast milk is always fresh, perfectly clean, just has the right temperature and is a healthy choice at the minimum cost. Breastfeeding can give benefits to both mother and baby. Breast milk provides the main source of nutrition for newborns before they are able to eat and digest other solid foods. Besides, the activity of sucking at the breast enhances development of baby's oral muscles, facial bones and aids in optimal dental development. Lack of breastfeeding increases the risk to the infant of ear infections, childhood diabetes, obesity, childhood cancer and many more. For mother, research shows that breastfeeding benefits their health. It will increase levels of oxytocin that stimulates postpartum uterine contractions, minimizing blood loss and encouraging rapid uterine toning.

Most of the working mothers have insufficient time and that makes the breastfeeding becomes very hard to perform and mothers cannot maintain their milk supply to their infants. In consequence, the best solution to overcome this problem is by using the breast pump. There is also some common reason of why the mothers use a breast pump such as to stimulate their milk production when they are unable to nurse their infant after birth. A breast pump allows mother to store milk in bottles or storage bags for later, and then bottle-feed it to baby or mix a little cereal when he or she

reaches the solid food stage. Mothers can refrigerate breast milk safely for five to seven days, or freeze it for up to a year (Bregam et al., 2005).

The breast pump can be divided into two types which are the manual breast pump and the electric breast pump. The manual breast pump is great for mothers who stay at home or are able to their child for feedings during the work day while electric breast pump is a better choice for mothers who are frequently separated from the babies because of work or health problems. Usually, the breast pumps are designed to satisfy the needs, the health and the comfort ability of mothers. However, the electric breast pump is quite costly whereas the manual breast pump could give problems like musculoskeletal disorder (MSD).

The musculoskeletal disorders are among the most common type of human afflictions. They affect all age groups and frequently cause disability, impairments and handicaps. They consist of a variety of different diseases that cause pain or discomfort in the bones, joints, muscles or surrounding structures and they can be acute or chronic, focal or diffuse (Felson 2000). Thus, this project is to create and develop the manual breast pump in ergonomics way in order to decrease MSD problems.

The main focus for this project is to design a manual breast pump that considers the ergonomics criteria which are safety, the comfort when use, the handling method, productivity or performance of the product (International Ergonomics Association, 2008). In addition, this study will also considered about the development of the manual breast pump by using method that has been chosen which is simulating the design using finite element analysis.

1.2 PROJECT OBJECTIVES

There are several objectives of this project:

- (i) To design a manual breast pump with ergonomics approach using Solidworks.

- (ii) To make a prototype of the designed manual breast pump using Rapid Prototyping machine.
- (iii) To validate the designed manual breast pump using simulation process.

1.3 PROJECT SCOPES

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

- (i) The developed manual breast pump is only a prototype and is not readily functional as a commercial product.
- (ii) The validation of the manual breast pump through simulation software is considered precise.

1.4 PROJECT BACKGROUND

This project is to prevent the musculoskeletal problems among mothers who expressed their breast milk using manual breast pump. Currently, there are few studies have been done for such a function. This project will design and simulate a manual breast pump that will be done by adapting the ergonomics criteria. In doing this, some of the problems associated with the musculoskeletal disorders will be tackled. Others problem are not tackled in the duration of this project.

1.5 THESIS ORGANIZATION

This thesis will be divided into five chapters. The first chapter briefing the project's idea and some acknowledgement about the breast pump. It is also includes the major concern of the project which is ergonomics that will be applied in the design process of the breast pump. There will also include the problem statement, scopes of the project and objectives included in this chapter.

Chapter two discusses the literatures generally on the manual breast pump and the previous studies about ergonomics. In addition, this chapter also contained briefs the

main idea of the simulation process. Some common information about the validation is also stated in this chapter.

Third chapter lays out the methodology used throughout this project. There are several numbers of steps need to be completed before achieving the goals. This project utilized Solidwork in the design process and Rapid Prototyping machine to make the prototype of the breast pump. The software used during the simulation process in this project is also briefly explained.

Then, the fourth chapter explains the analysis of the processes, results and discussion. For this the chapter, the results will be shown and discussed. This will help others to understand more about the development of the design of this manual breast pump.

Last chapter concludes the problems and the recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discussed the findings on several topics which are important to this project. The topics are divided into four subtopics which are: [1] information about manual breast pump; [2] ergonomics; [3] the simulation process; and [4] validation types. Then, the research is abridged according to the definition, the history, the previous findings and information. All the information and the reviews are taken from the books, journal and information from the websites.

2.2 MANUAL BREAST PUMP

This subchapter explained the study of currently manual breast pump. Simply defined; a breast pump is a mechanical device that extracts milk from the breast of a lactating woman. A breast pump is used to trigger the milk-ejection response or let-down. This can be achieved by using suction to pull the nipple into the tunnel of the breast shield or flange then release, which counts as one cycle. There are many reasons of why women use breast pumps. Women use breast pump to express breast milk which is later bottle fed to their child by a caregiver. A breast pump may also be used to stimulate lactation for women with a low milk supply or for the women who have not just given birth. A breast pump may be used to reduce inflammation, a painful condition whereby the breasts are overfull, possibly preventing a proper latch by the infant. Manual breast pumps are operated by squeezing or pulling a handle in a recurring way,

allowing the mother to directly control the pressure and frequency of milk extraction. Despite the fact that the manual breast pumps are small and inexpensive, they can require significant effort and can be tiring because the mother provides all the power. This style is recommended for occasional usage such as a working mother and also when a mother is away from her baby for a single feeding.

Based on the previous project, there are several types of manual breast pump that exist relying on different mechanisms to generate suction. The types of the manual breast pump are shown in Table 2.1.

Table 2.1: Types of the Manual Breast Pump


Types	Description
Rubber bulb models 	<ul style="list-style-type: none"> • Squeezing and releasing a rubber bulb generates a vacuum. • Rubber bulb is attached directly to the collection container. • Some manufacturers separated the bulb from the collection container by modifying the angle at which it is attached so the pump or by adding a length of tubing. These modifications were thought to reduce the high potential for bacterial contamination of the bulb caused by the easy backflow of milk. • Vacuum control on these pumps is extremely difficult. It will increase the nipple pain and damage. • Pressure – type bulb –vacuum control is left to chance. • Inexpensive, collect only about one half ounce of milk, must be emptied frequently. • Mothers complain of nipple pain during pumping and low milk yields.

Table 2.1: Continued

Cylinder Pumps Models

- The outer cylinder generates vacuum as it is pulled away from the body.
- The inner cylinder with the flange is placed against the breast; a gasket at the other end helps form a seal with the edge of the outer cylinder. Gasket may need to be replaced occasionally if they dry out, or lose their ability to form a seal.
- Can harbor bacteria and must be removed during cleaning, contrary to some user instructions.
- When placing the gasket back on the cylinder, roll it back and forth over the cylinder to help restore the shape.
- Small plastic or silicone inserts can be placed in the inner opening to custom fit the pump to the breast.
- Silicon liners; designed to collapse against the breast during the suction phase to provide external posture.
- This type is lightweight, not too expensive, easily cleaned.

Squeeze Handle Models

- Typically used for occasional pumping and is a type that can be used when no electricity is available.
- Easily cleaned but their operation may present difficulties for women with hand or arm problems, such as arthritis.
- The hand and wrist can tire easily with repeated use.

In summary, the manual breast pumps are naturally used in the short-term. They also suit one of the ergonomics criteria which they are extremely lightweight and portable. However, some of them which are not designed according to suitable criteria had given some of disadvantages that will lead to diseases or MSD.

2.3 ERGONOMICS APPROACH

This subchapter explained about ergonomics; by discussing the criteria that should be applied in designing the tools, the principles and the example of previous findings on ergonomics.

2.3.1 Definition of Ergonomics

Ergonomics can be defined as the science of designing the work, equipment and workplace to fit the worker. The apposite ergonomics design is required to avoid repetitive strain injuries, which can develop overtime and can lead to long-term disability. It is the scientific discipline concerned with the understanding of interactions among humans and other element of a system, and the job that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance (International Ergonomics Association, 2008).

Ergonomist consider the job being done and the demands on the user, the equipment which include its size, shape and how appropriate it is and the information used to assess the fit between a person and the used technology. Ergonomics illustrate on many disciplines in its study of humans and their environment including mechanical engineering, industrial engineering, industrial design, kinesiology, biomechanics, physiology, psychology and others. Currently, the focus of ergonomics is to minimize work stressors, both physical and environmental to reduce the potential for bodily harm.

2.3.2 Domains of Ergonomics

Through the review, ergonomics can be divided into three domains. This field is summarizing in Table 2.2.

Table 2.2: Domains of Ergonomics

Domain	Explanation
Physical Ergonomics	<ul style="list-style-type: none"> • Concerned with human anatomical, and some of the anthropometric, physiological and biomechanical characteristics. • Important in the medical field, particularly to those diagnosed with physiological ailments or disorders. • Relevant topics include working postures, materials handling, repetitive movements, lifting, work related musculoskeletal disorders, workplace layout, safety and health.
Cognitive Ergonomics	<ul style="list-style-type: none"> • Concerned with mental processes. • For example, perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. • Relevant topics include mental workload, human-computer interaction, human reliability, work stress and training as these may relate to human-system.
Organizational ergonomics	<ul style="list-style-type: none"> • Concerned with the optimization of socio technical systems, including their organizational structures, policies and processes.

Therefore, from this ergonomics approach study, the suitable method to solve the problems of MSD at the hand, the wrist, the elbow and the backrest while using the common manual breast pump is physical ergonomics since it concerned with human anatomical, and some of the anthropometric, physiological and biomechanical characteristics.

2.4 PRELIMINARY DESIGN

This subchapter discussed the design sketches based on the previous project. The information and explanations for each figure is also included.

2.4.1 Design

Based on the previous project, the preliminary design is totally depended on the crucial parts. The crucial parts are the funnel, the manual pump, the bottle, the valve and the valve cap. This is shown in Figure 2.1 and the description for each part is explained in Table 2.3.

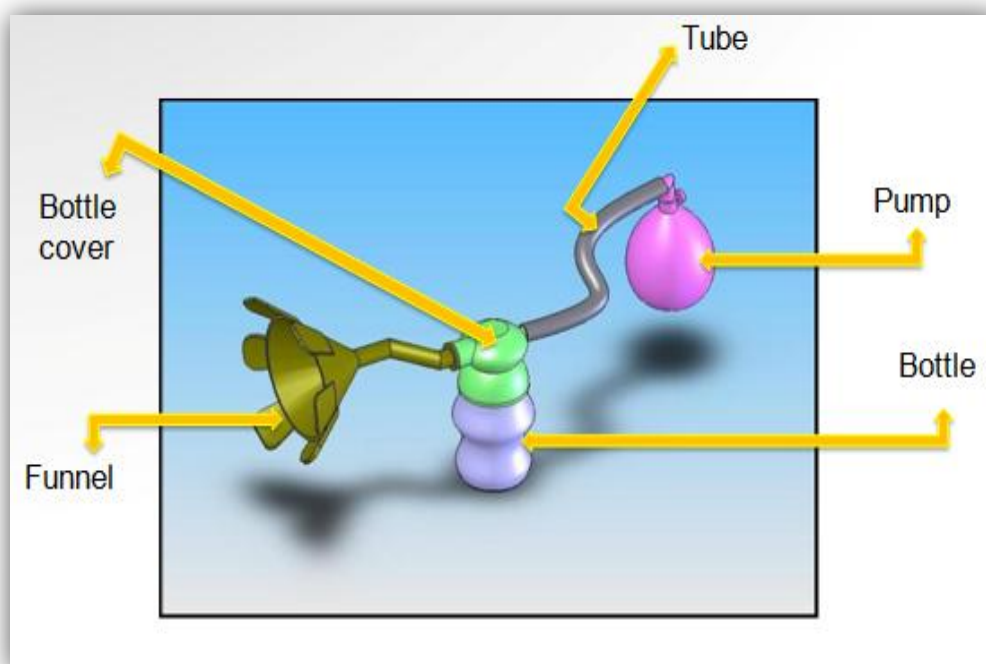


Figure 2.1: Preliminary Design of the Manual Breast Pump
According to the Previous Project