UNIVERSITI TEKNIKAL MALAYSIA MELAKA

REDESIGN OF PERFORATOR THROUGH INTEGRATION OF ERGONOMICS APPROACH AND QUALITY FUNCTION DEPLOYMENT (QFD)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Penebuk lubang kertas digunakan secara meluas untuk menebuk lubang pada kertas. Tetapi, terdapat masalah pada penebuk lubang kertas sedia ada iaitu saiznya yang besar dan ia juga agak berat. Saiznya yang agak besar menyukarkan penyimpanan penebuk lubang kertas di dalam bekas pensil. Selain itu, penebuk lubang kertas yang agak berat menyukarkan untuk dibawa ke mana-mana sahaja. Maka, penebuk lubang kertas yang saiznya lebih kecil dan ringan perlu direka untuk menyelesaikan permasalahan tersebut. Maklumat daripada pengguna dan penilaian ergonomik iaitu ukuran saiz tapak tangan dan jari dikumpulkan melalui satu soal selidik dan pengukuran antropometri. Keperluan pengguna terhadap penebuk kertas yang baru telah dianalisa menggunakan kaedah Quality Function Deployment (QFD). Satu prototaip telah dibangunkan mengikut keperluan pengguna yang terpenting berdasarkan analisis pada QFD. Penebuk lubang kertas yang baru dinilai melalui soal selidik dan perbandingan diantara penebuk yang lama dan baru dianalisa menggunakan kaedah statistik. Hasil kajian soal selidik menunjukkan kriteria "ringan", "mudah dipegang", "mesra alam", "saiz yang kecil", dan "serbaguna" penting pada penebuk lubang kertas yang baru. Penebuk lubang kertas yang baru berjaya memenuhi keperluan pengguna berdasarkan penilaian yang dilakukan. Kesimpulannya, intergrasi ergonomik dan QFD telah terbukti sebagai kaedah yang sesuai untuk merekabentuk penebuk lubang kertas yang baru.

ABSTRACT

Perforator is widely used to punch hole on papers. However, there are problems with the existing perforator corresponding to its size and weight. Size of the existing perforator is quite large which leads to setback to store it in the pencil case. Furthermore, the weight of existing perforator is quite substantial and inconvenience to carry it everywhere. To solve the issues, a new perforator which is lightweight and appropriate size was designed and fabricated. Information from users and anthropometry of palm and fingers were determined through a questionnaire survey and ergonomics assessment respectively. The users' requirements were analyzed using Quality Function Deployment (QFD) and a prototype of redesigned perforator was fabricated based on the essential users' requirement. Redesigned perforator was evaluated through a questionnaire survey and statistical analysis between existing perforator and redesigned perforator. The findings of this study show that "lightweight", "easy to hold", "safe to environment", "appropriate size" and "multipurpose" were the most essential features in the redesigned perforator. Evaluation of the redesigned perforator proved that it was successfully accommodated users' requirement. As a conclusion, integration of ergonomics approach and QFD was proved to be an appropriate and scientific tool to redesign the perforator.

DEDICATION

Alhamdulillah, I am most grateful to Almighty Allah S.W.T for blessing me with good health and ideas in completing this research successfully.

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LIST OF ABBREVIATION

CAD	-	Computer Aided Design
HoQ	-	House of Quality
ISO	-	International Organization of Standardization
mm	-	Milimiters
n.d	-	No Date
QFD	-	Quality Function Deployment

CHAPTER 1
INTRODUCTION

This chapter provides information regarding to background of the study, problem statements, and objectives of the study. This chapter also explains the scope of the study. The outline of how the study will be conducted also presented in this chapter.

1.1 Project Background

Perforator is a tool for making or cutting holes on sheets of paper. Perforator can be categorized as office tool or stationary. There are two common types of perforator which are single hole punch and two hole punch. Single hole punch normally used to punch a ticket or card while two holes punch normally used to punch paper sheets for filing purpose.

The filing holes dimensions and the location of the two holes punch must follow International Standard which is ISO 838 and the holes are located symmetrically in relation to the axis of the sheet. ISO 838 stated that the two holes must follow the diameter of 6±0.5 mm and the center of these holes are 80±0.5 mm apart with a distance of 12±1 mm to the nearest edge of the paper.

This study will focus on the two holes punchers that are normally used by students or office workers. Normally, for the sizes of the perforator that has in the market is around 120 mm (long) x 120 mm (width) x 62 mm (height). There are problems

regarding the existing perforator which is it's hard to be stored in the pencil case due to its large size. Furthermore, the weight of existing perforator is quite substantial and inconvenience to carry it everywhere. To solve the issues, a new perforator which is lightweight and appropriate size need to be designed and fabricated.

This study determines the information from the users regarding the existing perforator. The users' requirements are then translated into the engineering characteristics using Quality Function Deployment (QFD). In addition, ergonomics approach such as anthropometric measurements were incorporated in the redesigned perforator. Prototype of the redesigned perforator was fabricated based on the users' requirements obtained through questionnaire survey. The redesigned perforator is evaluated through a survey to ensure it can accommodate the requirements and satisfaction of users.

1.2 Problem Statements

Perforator had been widely used as an office tool and stationery to make holes on paper. However, previous studies have recognized several problems regarding existing perforator are summarized as follows:-

(a) The common two holes punch has a large size which makes it hard to carry everywhere because it takes spaces to store and hardly to fit in pencil case. The existing perforator is usually quite large and bulky and it was inconvenient to be stored and carried in small bookcases or briefcase (August F. Manz, 1988).

(b) The existing perforator is not convenient to carry in outside office, school or home due to heavy and bulky (Wayne Schwartzman, 1994).

1.3 Objectives

Specifically, this study applied the integration of ergonomic approach and QFD in order to achieve the following objectives:-

(a) To determine information from the users regarding existing design of perforator.

Information including background of the users such as age, profession and hand dominant will be surveyed. In addition, the difficulty level of using and storing the perforator, the pinching and gripping forces of users, the anthropometry of users' palm and fingers, and users' preference regarding perforator design are studied as well.

(b) To develop the specification of perforator design and fabricate its prototype by considering the users' information.

The specification of perforator will be developed through transformation of users' information into engineering specifications. Based on the specifications, prototype of perforator will be fabricated.

(c) To evaluate the effectiveness of developed perforator design.

The evaluations will be carried out in terms of mass and size of the perforator, the material used, and the pinching effort of users when using the perforator.

1.4 Scope

This study focuses on developing a new perforator design. In order to redesign the perforator, the information regarding existing perforator such as users' requirements and anthropometrics measurements are obtained. The users are randomly selected at the Faculty of Manufacturing Engineering (FKP) at Universiti Teknikal Malaysia Melaka (UTeM). They include both male and female students, lecturers and staff. The users are healthy and having no physical disabilities.

The requirements obtained from the users are analyzed using QFD to identify the essential requirements to be incorporated in the redesigned perforator. Only essential requirements obtained from the House of Quality (HoQ) will be considered in the redesigned perforator. There was limitation of the design which is it design to punch a small quantity of papers compared to the existing perforator. For the selection of the material of the perforator and their properties are not discussed thoroughly in this study. Furthermore, the redesigned perforator requires further analysis and improvement to make it commercially available.

1.5 Study Outlines

This study started from identification and introduction of existing perforator which widely used as stationery and office tools to punch a hole on papers. However, there are problems with the existing perforator, so improvements are required to redesign the perforator to accommodate users' requirements. Chapter one provides an introduction, problem statements, objectives, and scopes of the study. The main and essential objective is to design and improve the perforator based on the users' requirements. The scope explains the range and limitation of the study. In chapter two, literature review is provided to support data, methodology and discussion of the study. Literature review was performed through online databases such as journal, conference, books, and other writing sources related to ergonomics approach, QFD, manufacturing process, and the evaluation of redesigned perforator. Chapter three discusses the method used. It starts from determining the users' requirements, translation of users' requirements into engineering characteristics using HoQ, the design and manufacturing process and evaluation of the redesigned perforator. Chapter four presents the results obtained from the questionnaire survey and anthropometry measurements. Besides, this chapter discusses the findings with supporting of journals. Chapter five concludes this study and provides recommendation for future works.

CHAPTER 2
LITERATURE REVIEW

This chapter presents the information regarding the literature review which related to the study. The information that related to the study that had been discussed in this chapter will be used in the methodology and discussion of the study in order to assist the author to achieve the feasible results that needed based on the objectives of this study.

2.1 Determination of Information from the Users regarding Existing Perforator Design

2.1.1 Questionnaire Survey and Anthropometry Measurement

Survey is a tool to collect data by which it is used to gather information about individual correspondent's response. This survey will be focusing on the factual information about individual response, or it might aim to collect the opinions of the survey takers (Kendra Cherry, 2011). Robert Ferber et al., 1980 agreed that in the same ways by defining survey as a method of gathering information from a number of individuals, a "sample," in order to learn something about the larger population from which the sample has been drawn.

The advantages of using the survey method; large amount of data in a relatively can be collected in a short period time; compared to other techniques, the survey method is less expensive; this method also can be created quickly and administered easily;

the information on a wide range of things, including personal facts, attitudes, past behaviors and opinion. Meanwhile, the disadvantage of using the survey method; poor survey construction and administration can undermine otherwise well-designed studies; the answer choices provided in a survey may not be an accurate reflection of how the participants truly feel; the selected participants, response rates can bias the results of a survey; there are several types of survey where it can be conducted. It is a good chance if we have participated in a number of different market research surveys in the past. The most common ways to administer survey include mail, telephone, online and home interview.

There were two sessions of a questionnaire survey conducted for this study. First survey was to determine the feedbacks from users regarding existing perforator design and anthropometrics measurements. The feedbacks from users about the difficulty level of using and storing the existing perforator design in term of size, mass and the hand grip were gathered as users' requirements for redesigned perforator. This part of questionnaire is used to fulfill the Quality Function Deployment (QFD) in customer voice phase which is to refine the customer requirements. Likerts items and scale which can measure broader attitudes and values (Rob Jones, 2010) was used to rate the existing perforator. There are five scales which is the first scale is strongly disagree, second scale is disagree followed by neither agree nor disagree, agree and lastly which is scale five is strongly agree.

2.1.2 Ergonomics Approach

Ergonomics is important for all products and designs because using ergonomics; it can give human comfortable feelings when using it. Furthermore, ergonomics helps to prevent human body from getting injured. Based on R.S. Bridger (2003), ergonomics is the study of the interaction between people and machines and the factors that affect the interaction and ergonomics is the application of scientific principles, methods and data drawn from variety of disciplines to the development of engineering systems in which people play a significant role (Karl Kroemer et al.,

2000). The basic disciplines are psychology, cognitive science, physiology, biomechanics, applied physical anthropometry, and industrial systems engineering.

The purpose of the ergonomics is to eliminate design or system that uncomfortable for people to use and improve the performance of the system or design by improving human interactions. It is because ergonomics helps to generate tolerable system conditions that do not pose known dangers to human life or health. The term 'ergon' is from Greek words which mean work and 'nomos' which means law.

For this study, quantitative ergonomics was used when collected the anthropometry measurements of perforator's user. The data needed are age, gender, right-handed or left-handed users and experiences of using the perforator. It is because anthropometrics considerations in connection with age and gender, right-handed and left-handed users, experience and technique have a great incidence on the design of hand tools (Michel Aptel and Laurent Claudon, 2002). Anthropometry measurements required to design a proper ergonomics design of products in the design stages. The users' expectation of the products also needs to be identified in the first stage of a survey to determine the users' requirements for the design stages usages (L. Claudon et. al, 2006). The users' pinch and grip strength were collected to identify whether there is a significant difference in strength between male and female. Pinch strength was used to identify the minimum force required to perform the redesign perforator. Table 2.1 is a summarization of proceedings papers and journals regarding anthropometry of palm and fingers, pinch and grip strength.

Table 2.1: Summary of previous studied regarding anthropometry of palm and fingers, pinch and grip strength

Author	Description
Patrick G. Dempsey M.M. Ayoub, 1996	Pinch strength data were collected with independent variables of gender, wrist position, grasp type and pinch width to investigate. All main effects were significance at $\alpha = 0.05$ level. The results shows that the values of the variables investigate have a significance difference for male and female.
Yunis A.A. Mohammad, 2005	Hand anthropometric data can help in the proper designing of the hand tools for better efficiency and less human fatigue. Researcher collected both dimensions of left-handed and right-handed on Jordanian subjects. Results show that there is a significance difference between dimension of hand for both female and male.
Taha Z. Nazaruddin, 2005	Obtained grip strength data and develop models to predict of grip strength of Malaysian industrial workers. Use t-Test which is P value > 0.05 as no significance difference with alpha value of 0.05. it was found that the neutral network predicts human grip strength accurately based on hand dimension, age, wrist circumference and weight. Results show that male grip strength are 50% higher than female grip strength.
Christopher W. Nicolay Anna L. Walker, 2005	Examined grip strength and endurance in three experiments to assesses the relationship between anthropometric variation and grip performance for 51 individuals, aged 18-33 years. Results show in contrast to strength, anthropometric variation was completely unassociated with relative grip endurance. Results also show larger male produced greater average grip force than females

2.2 Development of perforator specification and prototype fabrication

2.2.1 House of Quality (HoQ)

Quality Function Deployment (QFD) originated in Japan in 1972. QFD is used to transform customers' requirements into technical specifications at the design stage. H.-T Liu, 2011 stated that QFD is a successful tool to assist the product design and development team systematically in translating market research and customers' requirements into the technical specification. In QFD development, there are four phases of matrices which are customer requirement planning matrix, product characteristic deployment matrix, process and quality control matrix and operative instruction matrix (Bottani et al., 2006). In this study, the first matrix which is customer requirements matrix that consist House of Quality (HoQ) were been focused. HoQ is the primary tool in the QFD to investigate customer needs and transform it to technical specifications for developments of the products.

In HoQ, the first step is to identify the customer requirements (CRs). Customer requirements normally obtain through market research. From the customers' requirements, it will be transformed into engineering characteristics (ECs) which is a measurable specification such as width, mass or number of functions. Engineering characteristics are an engineer language for developments of the products. Those engineering characteristics are likely to affect one or more of the customer requirements (Hauser and Causing, 1988). For example the customers' requirement of an "appropriate size" would be transformed into width, length and height of the product for engineering characteristics.

In the relationship matrix, it is the relations between customer requirements and engineering characteristics. For relationship matrix, it will indicate the extent to which each engineering characteristics affect customers' requirements. Symbols or indicators used to indicate the rank of the relationship. The indicators used are the scores of 9, 3, or 1 that represent by a symbol depending whether they were strong, medium, or weak relationship (a solid circle represent strong relationship, a circle represent moderate relationship and triangle represent weak relationship). In the QFD