IMPROVING DESIGN OF CHAIR WITH FLIP TABLE (ANALYSIS AND ERGONOMICS)

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ABSTRACT

In designing such a product or thing for human use, the 'human factor' is the important element that must put in consideration. One of the things that regularly used by human being to sit is chair. Ergonomic or human factor in the design is a must because the sitting posture has been applied by human whether during learning, eating, in the transport or even in the workstation. The suitability of each chair is depending on the circumstances or situation needed by its user. Research had shown that human product that can be adjustable following to the situation, is a product that consider more about the ergonomics terms. According to the development, the chair design can withstand load of 90 kg and the hanger part at the chair can withstand 15 kg load, after being analyzed by computer software. The development during the project is to fulfill the learning objective that to produce the frame of chair with adjustable flip table, with using low cost according to the human factor terms. The variety of applications from the project can be use to produce a product based on human factor.

ABSTRAK

Dalam merekabentuk sesebuah produk atau barangan untuk kegunaan manusia, 'faktor manusia' merupakan elemen penting yang harus dititikberatkan. Salah satu barangan yang lazim digunakan oleh manusia untuk duduk adalah kerusi. Ergonomik atau faktor manusia dalam rekabentuknya adalah perlu kerana manusia telah mengaplikasikan postur duduk samada untuk belajar, makan, di dalam kenderaan atau di stesen kerja. Kesesuaian setiap kerusi adalah bergantung kepada keadaan yang diperlukan oleh penggunanya. Kajian telah menunjukkan bahawa produk manusia yang boleh disesuaikan mengikut keadaan adalah merupakan produk yang mengambil kira faktor manusia atau ergonomik. Berdasarkan hasil pembangunan, rekabentuk kerusi yang dihasilkan dapat menampung daya seberat 90 kg dan bahagian penyangkut yang terdapat pada kerusi mampu menampung daya seberat 15 kg, setelah dianalisis dengan perisian komputer. Pembangunan yang dijalankan semasa kajian ini adalah untuk memenuhi objektif pengajian untuk menghasilkan rekabentuk bingkai kerusi dengan meja lipat yang boleh diubahsuai menggunakan kos yang rendah berdasarkan terma-terma faktor manusia. Kepelbagaian aplikasi daripada kajian ini boleh digunakan untuk menghasilkan produk berdasarkan faktor manusia.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Many of engineering design can be improved due to the development of the engineering technology. The improvement of design not only can reduce the problem that have been unsettled before, but also more considering about the user and the environment.

Chair is one of the invention created by human for them to sit. Nowadays, chair can be obtained in many kind of material, such as steel, wood and plastic.

1.2 Problem Statement

The design process enable us to follow a systematic approach to design. The most important step of the design process is identifying the customer need. For example, we are required to design a chair that can be used by a child. Clearly, all of us know how to sit on a chair, so in that perspective, we know how a chair works. A chair is used for sitting. Unfortunately, the description doesn't state how the chair is made. What material is used? Is the chair flexible or rigid? Does the chair rotate or fixed? What does it mean that the chair is to be used by a child? Is safety a biggest concern? The cost of the chair ? and so on.

The set of specifications for improved chair are :

1.2.1 The device should meet all guidelines for such devices established by appropriate federal authorities & organizations representing the physically challenged.

1.2.2 The device should be capable of being easily located and used by people; especially student

1.2.3 The device should be safe to use by people, and safety should be considered when choosing materials, finishes and the shielding of possible moving components.

Before the improved design of chair with flip table, nowadays plastic chair that provided in lecture hall are not capable to :

i. Locate student goods, such as bag
ii. Adjust the flip table according to user's body

1.3 Project Objectives

i. To improve the design of chair with flip table (function)
ii. Conduct an analysis due to the design
iii. Fabricate the frame prototype

1.4 Project Scopes

i. To study the process of engineering design in making a product
ii. Improvement of the designed chair; especially for students' need and its function
iii. Fabricate the frame of the chair with flip table
iv. Conduct an analysis of the design; by using Algor or Cosmos software
v. Considering the ergonomic of the design
vi. Come up with the idea of safety in the design and human factor

1.5 Project Background

Early human history shows that the design of artifacts was determined by human needs. For example, the knife was invented to protect humans from dangerous surroundings and Egyptians invented the wheel to travel and transportation.

The improved design of chair with flip table is used to provide student a better space to locate their goods during learning, lecture time and less area used in the lecture hall. The main focus of improved design is the function ability of the chair.

The renewed design also consider the human factor (ergonomic) and perhaps less cost is used in developing the improved design.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to explain about the design process required for making a product .Chapter Two also discusses about the ergonomic concept especially in working posture, which can be understand through ergonomic studies and the previous researches. In addition, there is also an information about human-body study related to engineering design or human factor design consideration.

2.2 Ergonomics of Design

"Human factors" is an umbrella term for several areas of research that include human performance, technology, design, and human-computer interaction. It is a profession that focuses on how people interact with products, tools, procedures, and any processes likely to be encountered in the modern world. The term 'human factors' is used mainly in the United States. Variants include "human factors engineering", an extension of an earlier phrase, "human engineering". In Europe and the rest of the world, the term "ergonomics" is more prevalent. Cognitive ergonomics is another term used. Human factors practitioners can come from a variety of backgrounds; though predominantly they are Psychologists (Cognitive, Perceptual, and Experimental) and Engineers. Designers (Industrial, Interaction, and Graphic), Anthropologists, Technical communication Scholars and Computer Scientists also contribute. Whereas ergonomics tends to focus on the anthropometrics for optimal human-machine interaction, human factors is more focused on the cognitive and perceptual factors.

Areas of interest for human factors practitioners may include the following: workload, fatigue, situational awareness, usability, user interface, learn ability, attention, vigilance, human performance, human reliability, human-computer interaction, control and display design, stress, visualization of data, individual differences, aging, accessibility , safety, shift work, work in extreme environments including virtual environments, human error, and decision making. Simply put, human factors involves working to make the environment function in a way that seems natural to people. Although the terms "human factors" and "ergonomics" have only been widely known in recent times, the field's origin is in the design and use of aircraft during World War II to improve aviation safety.

2.3 Design, Materials Selection and Marketing of Successful Products

There are many things that make products successful in the market place. This paper is a comprehensive tool for understanding how to develop products with special respect to integrated product development. Materials selection, marketing and design analysis in the form of a design manual are presented as a tool for the product developer. Many different methods for materials selection and design have been presented over the last couple of decades. However, most methods have been limited to the material as a physical entity to give shape for a product. The new integrated product materials selection (IPMS) model presented incorporates factors such as fashion, market trends, cultural aspects, aesthetics and recycling, as well as the target group. Interesting examples of successful product contra failures are presented, as well as examples of materials selection for different products. Different methods for materials selection are discussed and analyzed with respect to the IPMS method presented.

Every design requires the selection of a suitable material and a decision regarding the methods of manufacturing to be used in producing the element. The two factors are closely related, and the choice will affect the shape, appearance, cost and marketing. It may also determine the different between a commercial success and a commercial failure.

As the design becomes more complex and involves more elements, the selection of suitable materials and methods of production becomes more difficult. The design engineer must be sufficiently familiar with the characteristics and properties of the materials and the way in which they can be shaped to ensure that his/her decisions are well made.

From the experience in using chair, there are many types of materials involved in producing a chair. Wood , metals, and polymers or plastics are the most common materials used to fabricate a chair. Manufacturers can build up a chair with only one material, like plastic chair and can also develop a chair using two or more materials, as used in the office. The best way to produce the new improved design is to put more ergonomics in design.

2.4 The Design Process

Creating solutions to problems involves the process of designing. Design is a broad term that is often associated with artistic expression, but it is best thought of as a thinking process involving planning with intention and purpose. We design everything from the look of a room to the vacation that we hope we will soon take. More important, design describes the process of developing solutions to problems.

With the understanding that designing is not a linear process; that is, when you design and make something, you do not think and act in separate, sequential steps. The creative process of designing is more like switching back and forth between a thinking-questioning-evaluating mode and an acting-doing mode. These modes have been called the active and reflective phases of design, and you are constantly moving between the two.

What this process of moving back and forth between the active and reflective phases means is that you will probably need to jump around a bit during your designing. For example, if you get to the point of choosing a solution and it occurs to you that you need a bit more background, you will need to revisit the step ' investigation and research'. Or , if you are building the chosen solution and find a fatal flaw that will not allow you to complete that solution, you will have to go back to the step where you looked at 'generation of alternative solutions' and pick another solution. There is nothing wrong with doing this. The design loop should provide you with a framework for your design and problem solving work, and help you keep on track.

2.5 Introduction of Product

Definition of chair according to Wikipedia, the famous encyclopedia website is, a chair is considered a movable seat for one person which has a back, usually four legs and sometimes two arms.

2.5.1 Type of Chairs related to Ergonomics

1. Seat height adjustability

   This allows the user to adjust the chair so that his/her feet are on the floor, or the work surface or keyboard is at an appropriate height, or preferably both. Pneumatic adjustability is easier to work than mechanical adjustability.

2. Seat depth adjustability

Achieved either by backrest in-out adjustability or a sliding seat pan, this changes the front-to-back depth of the seat. A shorter seat pan is necessary to allow small people to use the chair's backrest, while a deeper one feels more stable to taller individuals.

3. Backrest angle adjustability

This refers to changing the angle of the backrest relative to the angle of the seat. Although this often is done with an adjustment mechanism, it can also be achieved through the use of flexing materials or springs in the chair shell.

Backrest angle adjustability allows the chair to support different degrees of recline, which in turn transfers some upper-body weight to the chair backrest and lightens the load on the lower back's intervertebral discs. Backrest angle adjustability also increases the angle between the torso and the thighs, which causes the lower back to curve inward. This inward curve, called "lordosis," results in less pressure on the discs than a flat spinal shape.

4. Chair recline or tilt

This changes the angle of the entire seat relative to the floor. As with backrest angle adjustability, a reclined chair transfers some upper-body weight to the backrest of the chair. There are two main tilt geometries. One is column tilt, in which the chair pivots at the top of the base post and lifts the knees slightly while the back descends. The other is knee tilt, in which the pivot point is forward of the post, nearer the knees. In a knee tilt chair, the knee lift is negligible, but the back (and head) descend more than in a column tilt chair.

5. Seat pan angle adjustability

This generally refers to changing the forward-back angle of the seat. It consists of a choice of fixed angle, rather than a free-floating recline (above). Often, this feature provides forward tilt, in which the thighs slope downward. The main purpose of forward tilt is to open the angle between the trunk and thighs, inducing lordosis and reducing disc pressure.

6. Armrests

These support the arms, reducing the work of the shoulders and possibly the upper arms. Armrests can, however, be used inappropriately by inhibiting free motion of the arms during activities such as typing.

7. Height-adjustable armrests

These help avoid the problems of too-high armrests, which result in elevated shoulders and pressure on the undersides of the elbows and forearms, and too-low armrests, which require the worker to slump or lean to one side to use them. Height-adjustable armrests also can keep armrests out of the way during typing or other activities requiring free motion.

8. Width-adjustable armrests

This kind of adjustability changes the distance between armrests. Armrests that are close to the body can help avoid splayed elbows, which in turn cause the wrists to bend to the side during activities such as keying. A maintenance-adjustable mechanism requires leaving room for the hips and therefore does not permit the close positions that at-will adjustment allows.

9. Backrest height adjustability

This refers to a change in height of the lumbar support area of the chair backrest, although this feature is often interpreted to mean a change in height of the entire backrest. This feature accommodates preferences by different workers regarding where and how the lumbar support curve contacts the back. (Ergonomic Chairs.htm)

2.6 Anthropometry

Anthropometry is the study of the physical and dimensional measurement of humans. Although it has a long history as a sub discipline of physical anthropology, its use as an applied science is more recent and dates to the mid-20^{th} (e.g., Dempster 1955). Currently, a distinction is made between applied anthropometry (sometimes called engineering anthropometry) and the more academic anthropometry that is used in research in conjunction with other areas of human biology (Meredith 1953, Jensen and Nassas 1988, NCHS 1996).

In addition, a further distinction is made within applied anthropometry,based on the techniques used to gather the raw data. In the first section, the focus is on anthropometric data collected using traditional techniques and using traditional instruments, such as the anthropometer, calipers, and measuring tape. Traditional anthropometric instruments provide measurements of the body or its parts in one dimension, such as the length of the forearm. They can also provide measurements of a two-dimensional body feature along a plane, such as in head circumference. The second section is devoted to the use of various three-dimensional systems, which can be used to generate surface representations of the body shape. They can also provide measures of surface area or volume, which are generally difficult to obtain with traditional instruments.

2.7 Traditional Anthropometry

In applied anthropometry, the dimensions are used for various design tasks. The type of dimension that should be used depends very much on the specific design task. For example, when designing a standard doorway or an emergency door in an aircraft, one-dimensional data are appropriate. Complex designs, such as aircraft cockpits, often require the use of many one-dimensional measurements simultaneously. When designing a soft and flexible cap for the head, the two-dimensional head circumference is appropriate. However, when designing a hardshell helmet for the same head, a three-dimensional representation that takes into account curvatures and shapes would be more appropriate.

With respect to the posture of working positions, usually the simultaneous use of one-dimensional measurements is appropriate, because they can be directly related to the workspace in question. For example, to establish the level of a work surface for a simple standing assembly position, the key dimension would be elbow (or waist) height. If the maximum depth of the work surface is critical, then additional dimensions would be forward arm reach and possibly abdominal depth (because the abdomen contacting the work surface can effectively shorten forward arm reach). However, design for more complex working positions, such as assembly operations in a small enclosed space (as when building components of jet aircraft, for example), or repair operations involving leaning into the work space (in automobile engine repair, for example) usually requires the use of many dimensions and may best be accomplished with digital human models.

Posture and anthropometry are completely linked. The posture of the subject directly influences anthropometric values when data are collected. The reverse is also true - the anthropometric dimensions of an individual directly affect his or her posture. For example, a male who is 200 cm tall and a female who is 150 cm tall have a very different posture when sitting in an identical chair. The tall man's feet will touch the floor and he may sit well back into the chair. The short female's feet may not touch the floor, and she will likely sit forward in the chair to increase the comfort at the knees. Ideally, workspaces would be sufficiently adjustable so that all workers could adopt a posture that minimizes likelihood of injury and fatigue, but to date that goal has not been achieved.

Despite the obvious relationship, however, anthropometry does not always define a precise seated posture in a given space. Specifically, Reed (1998)showed that anthropometry is a good predictor of preferred seat fore-aft location for a driving task, but was a poor predictor of the preferred angle of the torso (with less than 20% of variance explained). Further, there is a considerable variability in posture, even given similar anthropometry. This variability is due to fatigue, the specific workload, and the specific work environment.

2.8 Sitting Posture on Chair

Sitting has a number of advantages over standing as a working position. The main one is that static, low level activity of the soleus and tibialis anterior muscles is required in standing and these muscles can, eventually , fatigue. Because drainage of the lower limbs may occur if a person stands still for long periods. Venous return depends on the pumping action which occurs only during rhythmic contraction of the leg muscles, which occurs when people move or during postural sway. Venous pooling in the lower limbs causes swelling at the ankles. In extreme circumstances, the reduced flow of blood back to the heart may cause a drop in blood pressure and the person may faint. The hydrostatic head which has to be overcome to return blood to the heart from the lower limbs is less in sitting than in standing if the seat is correctly designed.

However, the sitting posture has its own problems. In a study at the Eastman Kodak Company in New York, 35 percent of sedentary workers visited the medical department with complaints of low back pain over a ten year period. People with existing low back problems often cannot tolerate the sitting position for more than a few hours over the workday.

Keegan (1953) was one of the first authors to discuss the anatomy of the sitting position in relation to the problem of low back pain in sedentary work. In the standing position, the iliopsoas muscle is lengthened. In this position it stabilizes the pelvis in an interiorly tilted position and the lumbar spine in lodorsis. Loss of the lumbar lordosis occurs reflexively, as a way of compensating for the rearward tilting of the pelvis which occurs in the sitting position. As the pelvis tilts rearward when a person sits down, the lumbar spine flexes to keep the trunk and head erect.

2.8.1 Posture in Data Collection

The importance of posture in anthropometric data collection has been rec-organized since the mid-19th century. European anthropologists, frustrated over an inability to duplicate each other's skull measurements, realized that measurements to the top of the head could be anywhere on that curved surface . They resolved that problem by standardizing the position of the skull-so that the lower margin of the orbit and the top of the external auditory meatus (bony space for the ear) were aligned horizontally, and named the orientation the Frankfurt plane, after the city in which the conference was held (Garson 1885, Martin 1914, Hrdlicka 1920). Although this plane ties head orientation to the relative positions of the eyes and ears and is arbitrary, it nevertheless standardized the position so that measurements could be repeated by other observers. The Frankfurt plane is used today as the orientation for the measurement of stature, sitting height, and other measurements taken to or on the head.

The early recognition of the importance of body position, or posture, is reflected in the techniques and procedures for nearly all the dimensions measured by professional anthropologists. Good dimensional definitions will always describe the posture of the subject (e.g., Clauser et al. 1988). For example, the subject's posture in sitting height is shown in Figure 2.1 and .described as follows (Clauser *et al.* 1988).

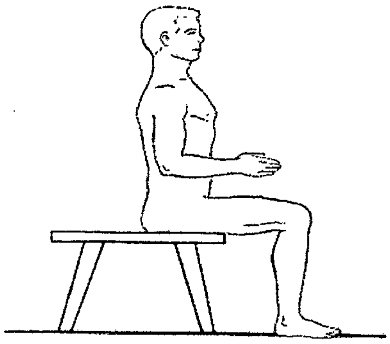

Figure 2.1 : Posture for measuring sitting height (Clauser *et al.* 1998)

This is not to suggest that the posture in the example is necessarilythe best posture in which to measure all seated dimensions, but it does serve to illustrate a well-defined posture, that the effect of the downward inclination of the thighs is to maintain the user body and afford a stabile posture when sitting on the chair with

(a) (b)

Figure 2.2 : "Rocking" over the ischial tuberosities (a) Erect sitting posture with lumbar lordosis. (b)Erect"slumped" posture with posterior pelvic tilt and lumbar flattening.

an equilibrium position of the pelvic musculature that is similar to that found in standing, with some of the lumbar lordosis retained. The effect of the sloping seat is to cause the pelvis to "rock" forward on the ischial tuberosities, resulting in a reduction in lumbar flexion. About 20 years earlier, Branton (1969) carried out a field study of the sitting postures of train passengers and observed how they tended