KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

REVERSE ENGINEERING OF AN ERGONOMIC OFFICE CHAIR

Thesis submitted in accordance with the requirements of the Kolej Universiti Teknikal Kebangsaan Malaysia for the Degree of Bachelor of Manufacturing Engineering (Honours) Manufacturing Process

By

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DECLARATION

I hereby, declare this thesis entitled "Reverse Engineering of an Ergonomic Office Chair" is the results of my own research except as cited in the reference.

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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process). The members of the supervisory committee are as follows:

Signature	:	....
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DEDICATION

For my family; Abdullah Hashim bin Omar,
Mrs. Nor Hayati binti Mahmood,
Mr. Hasnul Anis bin Abdullah Hashim,
Mr. Hasnul Afifi bin Abdullah Hashim,
Mr. Hamdi Wafi bin Abdullah Hashim,
Miss Nuryuha binti Abdullah Hashim,
Fauziah binti Abdul Ghani,
For my friends; Mr. Azrul bin Aziz,
Mr. Mohd Fadli bin Jusoh,
Mr. Nor Maliadie bin Yusof,
Mr. Taufiq bin haron,
Mr. Dzuhairy bin Hussain,
Mr. Mohd Hafiz bin Yusoff,
Mr. Mohd Syahrir bin Ibrahim,
Mr. Irwan bin Taib,
Mr. Irwan bin Mohamad Halim.

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ABSTRACT

The title for this PSM project is 'Reverse Engineering of an Ergonomic Office Chair', where it all about design of ergonomic office chair that can prevent of users from any injury or accident and give more comfortable for them or a long period when they sit at it. The usual office chair at market now only care about the attracting shape and cheaper cost. They did not realize the important of ergonomic characteristics that they have to apply at the chair to give comfortable to users and prevent any injury, even if some of them care but they did not do detail research about office chair with ergonomic characteristics, because it will increase the production cost and can not compete with others usual office at market. So, this PSM give explanations of how dangerous office chair without ergonomic characteristics will effect to users for a long term and also give detail explanations on how to design office chair with ergonomic characteristics and how it can solve the problems uncomfortable and also prevent injuries to users. The method that used in this PSM is reverse engineering method that applies to find out awesome design of ergonomic office chair with successfully. For more information you can find out in this PSM.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background.

What is ergonomics? According to the.Kroemer K.H.E (2001) et all Ergonomics is the application of scientific principles, methods and data drawn from a variety of disciplines to the development of engineering systems in which people play a significant role. Among the basic disciplines are psychology, cognitive science, physiology, biomechanics, applied physical anthropometry, and industrial systems engineering. The engineering systems to be developed range from the use of a simple tool by a consumer to a multiperson and sociotechnical system.

Design begins with an understanding of the user's role in overall system performance and that systems exist to serve their users, whether they are consumers, system operators, production workers, or maintenance crews. The resultant designs incorporate features that take advantage of unique human capabilities as well as build in safeguards to avoid or reduce the impact of unpredictable human error. Success is measured by improved productivity, efficiency, safety, acceptance of the resultant system design and last but truly not least improved quality of human life.

There is hierarchy of goals in ergonomics. The fundamental task is to generate "tolerable" working conditions that do not pose known dangers to human life or health. When this basic requirement is assured, the next goal is to generate "acceptable" conditions upon which the people involved can voluntarily agree according to current scientific knowledge and under given sociological, technological and organizational circumstances. Of course the final goal is to generate "optimal" conditions which are so well adapted to human characteristics, capabilities and desires that physical, mental and social well-being is achieved.

To be more specific, we may define ergonomics as the study of "human characteristics for the appropriate design of the living and work environment". Its fundamental aim is that all human-made tools, devices, equipment, machines and work environments should advance, directly or indirectly, the safety, well-being and performance of human beings. Thus ergonomics has two distinct aspects:

i. Study, research and experimentation in which determine specific human traits and characteristics that we need to know for engineering design.
ii. Application and engineering in which design tools, machines, shelter, environments, work task and job procedures to fit and accommodate the human. This aspect includes the observation of the actual performance of human and equipment in the environment to asses the suitability of the designed human-machine system and to determine possible improvements.

Ergonomics adapts the human-made world to the people involved because it focuses on the human as the most important component of our technological system. Thus, the utmost goal of ergonomics is the "humanization" of work. This goal may be symbolized by the "E&E" of ease and efficiency for which all the technological systems and their elements should be designed. Such design requires knowledge of the characteristics of the people involved, particularly of their dimensions their capabilities and their limitations. Ergonomics is neutral and it takes no side neither employers nor employees. It is not for or against progress. It is not a philosophy but a scientific discipline and technology.

1.2 Problem Statements.

Ergonomic today is growing and changing. The discipline's development stems from increasing and improving knowledge about the human and is driven by new applications and new technological developments.

As mentioned, several classic science provide fundamental about human beings. The anthropological basis is such knowledge consists of anatomy describing the build of the human body, orthopedics, concern with the skeletal system, physiology dealing with the functions and activities of the living body including the physical and chemical processes involved medicine, concern with illnesses their prevention and healing psychology, the science of mind and behavior and sociology concerned with the development, structure, interaction and behavior of individuals or groups.

To design things to "fit" the human body, we must know the dimensions of people. The development of the human race has led to much variability in body build among humans. Body sizes of some populations have been measured, but have only been estimated for most people on earth. (Kroemer K.H.E, 2001).

Long hours of sitting could cause health problems and occupational diseases and disorders, especially disorders of the musculoskeletal system (Landrigan & Backer, 1991). Chair design has been revolutionized and ergonomic chairs have been developed to prevent injuries disorders. Ergonomic chairs are designed in different sizes and shapes with adjustable features and contours such as seat height, seat depth, backrest tilt, sliding seat, lumbar support and chair tilt to maintain comfort and to reduce stress (Syarto, 200) In 1777, Ramazzini described hazards of constrained sitting amongwriters:

> *"Now this certain that constant sitting produces Obstructions of the Viscera, especially of the Liver and Spleen, Crudities of the Stomach, a Torper of the Leggs, a languid Motion of the refluent Blood and Cacbexies. In a word, Writers*

are depriv'd of all the Advantages arising from moderate and salutary Exercise."

More recently, a report by the National Institute of Occupational Safety and Health (NIOSH, 1997) summarized research demonstrating a relationship between awkward and constrained postures and musculoskeletal disorders. Furthermore, constrained postures increase discomfort and health risk (Aaras et al, 1997). Vidaman et al. (1990) found both sedentary work and heavy physical work were associated with abnormalities of the spine, but the relationship was particularly strong for sedentary work such as in the office.

Static seating postures can cause discomfort. Workers who sit in fixed postured experience more discomfort and chronic disorders (Graf et al, 1993, 1995). Movement reduces these risk (Aaras et al, 1997; Kilborn, 1987). It is difficult for us to tolerate unsupported and static seated postures for ore than a short while (Reinecke et al, 1985). When allowed to move freely, people are usually in constant motion (Branton, 1967, 1969; j Jurgens 1980). Sitters tend to cycle through postures over the day (Bhatnager et al, 1985; Branton and Grayson, 1967; Fleisher et al, 1987). People tend to develop unique patterns of seated movements (Fleisher et al, 1987; Jurgen, 1980; Ortiz et al, 1997).

We have long known that sitting in one place for a long time makes us uncomfortable. Static postures contribute to a broad range of chronic disorders (Hunting et al, 1981) that include joint impairments such as arthritis, inflamed tendons and tendon sheaths, chronic joint generation (arthroses), muscle pain (Grandjean, 1987), impaired circulation and tissue damage (Kilborn, 1986). Static and constrained postures interrupt blood flow in direct proportion to the muscle loads (Grandjean, 1987). Muscle oxygenation reduces with fairly low loads (McGill and Hughson, 200). At sixty percent of maximum force (such as while working with arms raised), blood flow is virtually occluded (Grandjean, 1987).

Static postures are reduce our effectiveness causing us to move more often (Bhatnager et al, 1985; Fenety et al, 2000; Jurgen. 1980) and to move into postures (Bhatgager et al, 1985) that we know to be harmful (Andersson, 1980). Some researchers maintain that such damaging effects are more related to a "lack of physical variation" than inactivity (Bendix 1994; Winkel and Oxenburgh, 1980). That is the actual of lack of variety of postures is more hazardous than the sedentary nature of the work.

More than seventy percent of people older than 40 experience intermittent back pain. Our sitting habits affect our risk of back pain (Bendix 1994; Kelsey 1975b). Kelsey (1975b) found that sitting more than half the time at work was associated with herniated dics in those older than 35.

Figure 1.1 The herniated lumbar spine, from two directions (Slavin and Raja 2001)

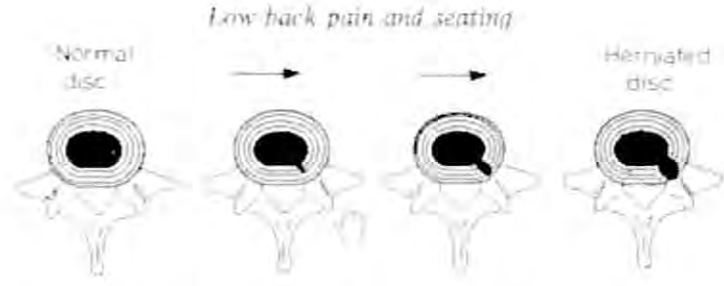

Figure 1.2 Progression of disc herniation (Bendix, 1994)

People often assume that back pain is caused by short-term (acute) events such as accidents. Yet though slips and falls certainly injure, research suggests long-term (low-level) chronic stressors are at least as important. That is, fixed postures are likely to lend to disabling back pain as heavy manual work such as construction.

Constrained postures can cause chronic degenerative alterations of the cervical, thoracic and lumbosacral areas of the spine (Graf et al, 1995). According to Wood and McLeich (1974) insurance and bank employees, who commonly sit in static positions for long periods are likely to develop very high levels of intervertebral disk immobility.

One reason that it is so important to move is that after the age of ten, our spine loses its ability to actively feed itself (or, rather, feed the inter-vertebral disc of the spine) and eliminate waste products (Adams and Hutton, 1983; Grandjean, 1987; Maroudas et al, 1975; Schoberth, 1978). After this age, the spine receives nutrients and eliminates wastes through passive changes in osmosis resulting from movement.

The overall forces acting on the spine are less important than the concentration of forces acting on the disc, ligaments and related spinal structures (Dolan and Adams, 2001) and the susceptibility of these structures to damage. The associated risk also varies considerably between people. Compressive loads and displacement of force are affected by our age and the degeneration of the spine (Pollintine et al, 2004).

Dolan and Adams (2001) add, "tissue stress probably plays a major role in determining if a given tissue is painful, it is tissue stress rather than overall loading which influences the metabolism of connective tissue cell". We know that repetitive movements can be hazardous (NIOSH, 1997). Repeated cycles of movements resemble the effects of static postures (Kumar, 2004).

1.3 General Research.

Conducting research was important to generate deeper understanding of human biomechanics and to find ways to improve sitting comfort. Technology has changed the behavior of workers and types of jobs. Now, people work and sit for many hours a day. Many jobs are performed with static pressure and repetitive motion and require less time standing and moving. Examining chair design on the human body is critical to providing recommendations, preventing injuries, creating safe environments and justifying advantages and cost (Martocchio & Berkson, 2000).

This study examined the notion that ergonomic chairs produce minimal discomfort and postural complaints. This study was also designed to provide useful information about the effects of factors such as type of chair, duration of sitting and type of activity that could increase human body discomfort. Four dynamic factors would affect the work environment; safety, health, productivity and legal issue. Unsafe environments could have a cascading effect by causing injuries. Injuries have an effect on decreasing worker's productivity and increasing worker's compensation issue, which could create economical and social impact on both workers and employers (Martocchio et al, 2000).

Therefore creating a safe environment would be an important element in protecting workers from injuries, increasing worker's productivity and reducing worker's compensation lawsuits (Martocchio et al, 2000). Understanding the design philosophy of chairs and the effects of chair design on discomfort is important because chairs are essential part of the work environment (Carter & Banister, 1994). Although, Carter and Banister stated that due to different body dimensions, work habits and preferences, it is hard to appoint an optimal chair, current and feature chair studies might assist in narrowing the selections to good quality chairs.

1.4 Scope of Project.

For this project I only mention about office chair type even there are many types of chairs like rest chair and so on. So, the data that I have provided in this research only use for design an ergonomic office chair and the other types maybe can use also for certain part only not all of them.

There are several parameters involved in this design but I have to mention here for the small component that I think not influence the result I just ignore them. Scope of the project is start from the prototype until I finished with new design of an ergonomic office chair. These include collected data from other peoples who already did research on this topic and take their data that I thought relevant with this topic.

Most importantly I have to design new product with prototypes that already exist that why they called it reverse engineering process where I have to redesign from finish product to make it more comfortable and ergonomic than before. Because the project to design an ergonomic office chair so we must knew the users of this chair that are people who aged range from 18 years to 60 years.

1.5 Objectives of this Research

There are several objectives that I have to achieve during doing topic that is Reverse Engineering of an Ergonomic Office Chair. That is:

i. Define and understand the reverse engineering process involved.
ii. Define and understand of properties ergonomic office chair.
iii. The problems and effects to peoples who have used usual office chair.
iv. Make a research about this topic and collected data from the peoples who already did on this topic.
v. Provide design guidelines for an ergonomic chair "feature" that can be used.

CHAPTER 2

LITERATURE REVIEW

2.1 Sitting and Chair Positioning.

Most of us would rather sit than stand. Sitting has been found to require less muscle work than standing (Andersson et al, 1974b). It is easier to work while sitting and it stabilizes postures. Sitting may increase intradiscal pressure relative to standing (Andersson, 1980), but research is not consist (Althoff et al, 1992; Rohlmann et al, 2001; Wilke et al, 1999).

Many of us spend most of our day (at work, at hime, driving and out) sitting. However, continuous sitting has disadvantages and potential long-term consequences. Sitting flattens the lumbar spine. As we sit, our hamstring muscles stretch, rotating our pelvis back (Rani Luerder, 2004). About 2/3 of this shift towards sitting is by flattening the lumbar spine with the rest from tilting of the pelvis. (Bendix and Biering Sorensen 1983)

Standing **Sitting Erect** **Sitting Relaxed**

Figure 2.1 Relaxed sitting flattens (flexes) our lumbar spine.

Research indicates that lumbar supports can reduces load on the spine (Andersson et al, 1974b; 1975). It is also tilts the angle of the individual vertebra so that pressures at the front of the discs increase (Adams et al, 1996; Bendix et al. 1996; Corlett, 1999).

Although Andersson's research demonstrates that lumbar supports can reduce intradiscal loads on the lumbar spine, the benefits of backrest lumbar supports are not consistent (Corlett, 1999). Bendix et al (1996) reported that lumbar supports on backrests helped to reinstate lumbar curves compared to straight backrests while performing tasks, but not during passive sitting and reading".

Characteristics of the lumbar support vary between users and may vary over time for the same individual. Reinecke et al (1992) developed a pneumatic device that induces continuous passive motion in the lumbar spine in order to reverse the detrimental impact of constrained sitting.

Additionally, lumbar supports only benefit users if they are properly designed, correctly adjusted for the user, and the user sits in the chair in a manner that takes advantage of the feature.

That is not to say that lumbar supports cannot benefit users. They reduce intradiscal pressure, often stabilize postures, reduce muscle loads and help promote comfort. Yet lumbar supports only benefit users if they are properly designed, adjusted for the user and the user sits in the chair in a way that enables them to benefit (Rani Leuder, 2004).

Some suggest that excessive lumbar curvature also substantially increases risk. Bendix (1987) notes that excessive lumbar curvature can adversely affect posterior portions of the lumbar vertebrae prolonged compression can contribute to pain. Poor postures aggravate those problems. Most injuries involve combinations of flexion, side bending and rotation (Evjenth and Hamberg, 1984). Neutral postures help reduce the impact of individual risk factors from combined movements'.

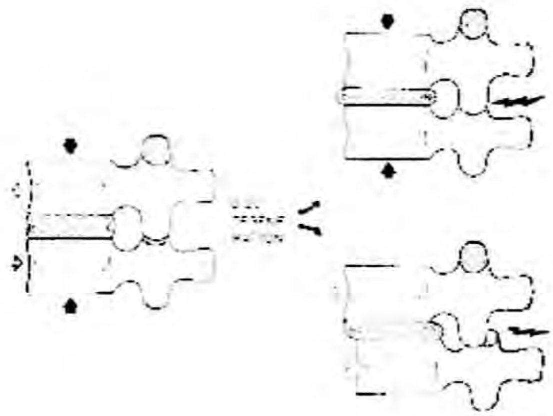

Figure 2.2 Facet joints forces are a significant source of injury (Bendix, 1994).

Seat angles also affect the curve of the lumbar spine. Nachemson (1981) concluded that that we need a minimum of 1100 thigh-torso angles to reinstate the natural curve of the lumbar spine". The hip/pelvic angle affects the lumbar spine as well (Makhsous et al, 2003; Wu et al., 1998).

Although lumbar supports can clearly benefit users, they may also introduce new problems when the lumbar back support does not adjust high enough for the user.
Sitters may also position their lumbar support improperly (sometimes to lock in their hips to reduce the amount of muscle work) but in the process, they may reverse the natural curve of their lumbar spine.

Consequently, lumbar supports are important but they are affected by the specific conditions. The spine and the lumbar spine functions best in a dynamic environment.