APPLICATION OF INTEGRATED ANALYTIC HIERARCHY PROCESS (AHP) AND TECHNIQUE OF ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS) IN CONCEPTUAL DESIGN SELECTION OF HOSPITAL BEDS

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

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the Degree of Manufacturing Engineering (Manufacturing Design) (Hons.). The member of the supervisory committee is as follow:

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ABSTRAK

Projek ini adalah mengenai aplikasi AHP dan TOPSIS dalam proses pemilihan konsep reka bentuk katil hospital. Penjanaan idea dalam menghasilkan katil hospital adalah penting kerana ia memerlukan pertimbangan yang tepat berdasarkan kriteria yang penting. Reka bentuk katil hospital telah meningkat sepanjang tahun berdasarkan kepada jenis kondisi pesakit dan untuk memberikan produk mesra pengguna untuk penjaga dan kejururawatan kakitangan. Pemilihan reka bentuk konsep katil hospital akan memberi tumpuan kepada jenis elektronik katil perubatan yang digunakan di wad standard. Objektif utama projek ini adalah untuk menentukan konsep reka bentuk yang terbaik dengan menggunakan kaedah bersepadu AHP-TOPSIS dengan mengenal pasti kriteria penting untuk mereka bentuk katil hospital. Reka bentuk konseptual adalah berdasarkan kepada konsep yang dicadangkan yang akan dijana berdasarkan keperluan pelanggan. Terdapat lima reka bentuk konsep katil hospital yang berbeza dan akan dijadikan sebagai alternatif di dalam pemilihan reka bentuk konsep ini. AHP adalah digunakan untuk menentukan kewajaran pemilihan kriteria. Di ikuti dengan TOPSIS yang digunakan untuk melaksanakan kedudukan alternatif yang merupakan konsep yang dicadangkan. Integrasi kaedah AHP dan TOPSIS telah terbukti sebagai salah satu kaedah yang berjaya dalam pelbagai aspek untuk proses membuat keputusan kerana penilaian yang sistematik antara kriteria dan alternatif yang disulkan. Daripada lima konsep reka bentuk katil hospital, konsep rekabentuk 3 telah menjadi alternatif yang terbaik berdasarkan prestasinya dan memenuhi kehendak pelanggan. Ranking TOPSIS menunjukkan sama selepas analisis AHP dalam perisian Expert Choice. Oleh itu, objektif utama dan khusus untuk projek ini telah dicapai. Kesimpulannya konsep rekabentuk 3 adalah reka bentuk konsep yang terbaik dari konsep yang lain dan mempunyai yang paling tinggi nilai peratus keutamaan berbanding dengan alternatif lain iaitu sebanyak 30% menggunakan pendekatan AHP-TOPSIS bersepadu.

ABSTRACT

This project is about the application of AHP and TOPSIS in the conceptual design selection process of hospital beds. Generation of ideas in producing a hospital beds are crucial since it need a precise consideration based on its important criteria. The design of hospital beds has improved over the years based on patient type of illness and to gives a user friendly product to the caregiver and nursing staffs. The conceptual design selection of hospital beds was focused on electronic types of medical beds used in a standard ward. The main objective of this project was determine the best conceptual design using integrated AHP-TOPSIS method by identified the important criteria in order to design a hospital beds. The conceptual design is based on proposed concept that has been generated based on customer requirement. There are five different conceptual designs of existing hospital beds was developed as alternatives of this conceptual design selection. AHP is used to determine the weight of the selection criteria. Follows with TOPSIS that is used to perform the ranking of alternatives which is the proposed concept. The integration of AHP and TOPSIS method was proven as one of the successful method in multi-criteria decision making processes because of the systematic evaluation between criteria and alternatives. Based on the result from the five different conceptual design of hospital bed, Design Concept 3 was selected as the best alternatives based on its performance to the requirement. The ranking of TOPSIS shows the same after the analysis of AHP in the Expert Choice software. The main and specific objectives for of the project were achieved. As a conclusion Design concept 3 is the best conceptual design of hospital bed and has the highest percentage priority value compared to other alternatives which is 30% using integrated AHP-TOPSIS approach.

DEDICATION

Dedicated to my beloved father, Hasan Bin Mohammad,
my appreciated mother, Azizah Binti Sidek
and my adored sisters and brother, Amalina and Mohd Anuar Fariz
for giving me moral support, cooperation, encouragement and also
understandings.

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LIST OF ABBREVIATIONS

3RPL	-	Third-Party Reverse Logistics Providers
A^-	-	Negative Ideal Solution
A^+	-	Ideal Solution
AHP	-	Analytical Hierarchy Process
A_m	-	Potential Alternatives
C_n	-	Criterion
CR	-	Consistency Ratio
FEMA	-	Federal Emergency Management Agency
ICU	-	Intensive Care Unit
		Ideal Solution
Kg	-	Kilogram
Max.	-	Maximum
NIS	-	Negative Ideal Solution
Obj.	-	Objective
PDS	-	Product Design Specification
PIS	-	Positive Ideal Solution
TOPSIS	-	Technique for Order preference by Similarity to an
VIKOR	-	VIseKriterijumska Optimizacija I Kompromisno Resenje

CHAPTER 1
INTRODUCTION

1.1 Background

A hospital bed also known as cot's hospital is a bed that has been produced by manufacturer in health industry to help patients who seek for treatment or in a form of health care. According to Rij, (2001), these types of beds have its own system and function both to make sure patients contentment and also give advantages and benefit to nurse and doctors. This product has its own system and function including changeable height of every part of body of the bed such as head, feet, back rest and side rails. Hospital beds and other similar form of beds are not only used in hospitals, but it is also used for other health care facilities and settings, such as for nursing homes, assisted living facilities, and in home health care. Beds in hospitals and other medical settings have a special relation to health. They are the main tools to organise and treat health to recovery. People or families are having a difficult when it comes to medication or give a treatment to their family because they do not have specific household for nursing environment especially for their bed. Bed is one of the important hospital device used to treat a patient who almost spend their day on the bed.

According to Oetiker (2011), history of hospital beds started on 1815 to 1825 as the side rails part has adjustable function as the main features which produced in England. As time passed, Health industry need a bed with more function and modern. The beds today are given credit to an invention by Dr. Willis Gatch, the chair of the Department of Surgery at the University of Indiana School of Medicine. He has invented the first modern with manual adjustable bed features, known as the 'Gatch Bed' in 1909. It was more basic hospital beds compared to today's adjustable bases, but it has the same fundamental that is with the ability to move freely from the others.

Nowadays manufacturers started to get involved with this since there is a lot of demand for this type of utilization. There is a lot of type for hospital beds that are consists of Nursing bed, Intensive Care Unit (ICU) and surgical bed. They are a lot of design produce by manufacturer to fulfil the Hospital requirement. In this case, they need to have the best design of Hospital bed, to give an advantage to all party especially for the person who are operated their patient. Designer has produce and brainstorming a lot of conceptual design for this type of bed. Some of the conceptual design appears almost the same important and make it hard to make decision.

Analysis Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is one of a method of multi-criteria decision analysis (MCDA). MCDA methods have made a success in developing a unique and systematic decision for decision maker. MCDA approaches to provide systematic and techniques for finding an accommodate solution. Decision maker has its own characteristic as they were subjected as the centre of the MCDA process. The method is required a process so that there are no same solution for different decision maker, in fact the process is required consolidate data and information. Decision maker are provided with the consolidate data also known as subjective data which it will produce accommodate solution and result.

AHP is a method which criteria that has been compared and uses a fundamental scale of absolute numbers that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences and judgement with respect to quantitative and qualitative attributes just as well or better than other scales based on Ishizaka & Nemery (2013) and according to Dweiri *et.al*. (2006). AHP was developed by Saaty in the 1970s (1980) has proven the efficiency of this application in decision making process and has been widely used in manufacturing and production systems, business planning, economic planning, conflict resolution, logistics and capital budgeting.

In addition, TOPSIS is one of the problem solving method of MCDA that was developed by Hwang and Yoon in 1981. This method requires only an essential number of inputs from the user and its output is simple and clear to understand. Its fundamental is about the first-

rate solution is the solution that is very close distance to positive ideal solution and the furthest distance are the negative ideal solution. It contains steps from gathering all the data of alternatives on the different types of criteria to ranking all the observe data of ideal solution. It is proven that TOPSIS is very useful in making decision for conceptual design since because this process it gives rapid and easy decision and the ranking output of similarities and differences between alternative gives better understanding.

In this project, integration of AHP and TOPSIS are used in the conceptual design selection process of hospital beds under its specific important criteria and of five different propose alternatives. Therefore, a more effective way in evaluating decision and determine weight for each criterion was achieved by combining both methods since the alternatives is dealing practical and theoretical problem.

1.2 Problem Statement

Design process consist of different stages which is from customer requirement to detail design. Conceptual Design is one of the crucial steps in the design process since it gives the idea about the product appearance. The worst cases that has been experienced by designer are there is no systematic approach or inaccurate decision causes redesign of the product and it may cause waste in a lot of factors. To make a design concept of hospital's bed there is a lot of factors needs to be considered from technology to the environment to make sure designers able to design and produce a selected product that gave benefits to all level of workers in the organization. At this stage, designers, faces many challenges by having difficulties in order to make decisions for the best and affective concept from all concept design and to fulfil customer requirement at the same time.

Design concepts consist of more than one design before continue to the preliminary design stages and detail design. This stages, designer must come out with different concept of hospital bed's so that customer or a person who will operate the bed's recognize its function clearly. After brainstorming the idea for design concepts, designers start to compare advantages among the designs. Result shows some significant same value for the different

designs. Based on Saaty (2008), Decision making involves numbers of criteria and sub criteria used to rank the decision. It also needs to create priorities for the alternatives with respect to the criteria or sub criteria in terms of which they need to be evaluated.

Therefore, methods of decision making are needed to achieve the best decision. Among the decision making method and tools, AHP and TOPSIS has been chosen as the most effective version of comparing and scoring method.

1.3 Objectives

The main objective for this project is to determine the best design of Hospital's beds using integrated decision making tools such as Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and analytic hierarchy process (AHP). There are three (3) specific objectives as follows:

a) To identify important criteria in conceptual design of hospital beds.
b) To suggest five different existing conceptual design of hospital beds based on market requirement.
c) To verify the results of integrated method using sensitivity analysis approach.

1.4 Scope of project

This project was focused on hospital bed that is used in the standard ward also known as surgical or medical hospital beds. Type of bed used is electrical medical hospital beds since it is the usual model used in nowadays hospital in around the world. The conceptual design selection of hospital's bed is based on existing design and for the propose concept design are using existing design in the current market. Patients for this type of beds consists of people who at low-risk condition and have limited interaction to surroundings and need some form of observation from doctors and nurse. The design of hospital's bed is focused on the main criteria of the function which to give the best design for the person who are handling and operating the bed. The suitable design candidate was selected based on some

of its important criteria such as performance, cost, service condition and ergonomics in order to achieve the main goals of this product. In the meantime, it also to produce friendly-user hospital's bed. AHP and TOPSIS is a powerful and affective decision making process as it helps decision makers set priorities to the alternatives as it gives weightage to each criteria and produce the ranking of all alternatives based on information and data collected. Therefore, this project was focused on the application of integrated AHP and TOPSIS methods in conceptual design selection of hospital's bed.

CHAPTER 2
LITERATURE REVIEW

2.0 Overview

This chapter explain preliminary review about the integration of AHP-TOPSIS method in conceptual design selection of hospital's bed design. Secondary sources such as books, journals and online researches are used to get related information regarding the project. Moreover, it provides understanding about existing design of hospital's bed used in medical industry and their related functionality and mechanism, as well as the method that is most appropriate for conceptual design stages.

2.1 Introduction to hospital's bed

Hospital beds are a special device design for a person who need special treatment or need to get service and medication. According to Gibson (2006), state that this hospitality type of utilization is different based on its construction, function and symbolic from other types of beds. It is a complex design that implement necessary services, medication and expertise are attached to this type of bed. He also states that hospital bed is one of the important device because once a patient is admitted to hospital they need a bed immediately to make sure the patient is located at the proper space when there are in emergency state. At the same time this bed is physically accessible in a health care facility means that each bed is maintained and that supporting services such as health care, assistance, food, laundry and housekeeping.

2.2 Existing hospital beds

There are a lot of type of hospital beds based on this project review and all those type have its own function and purpose. These type of beds are design for different cases in its area of healthcare environment. There are a lot of manufacturer of this nursing device around the world with their own unique and qualities to supply to their customer. According to Catalano *et.al*. (2006) the largest number of producing beds are in America with different states.

2.2.1 Types of hospital beds

Catalano *et.al*., (2006) also state that there are two major types of hospital beds that consist of medical or surgical hospital beds and intensive care units. This major types of hospitals are very important for nurse as their main device to give treatment. Both types have the common purpose which is to be patient-friendly and user friendly to accommodate the sick, and injured patients. Some of the most well-known manufacturer that produce this type of bed has been review as example of medical or surgical hospital beds and intensive care units

2.2.1.1 Medical and surgical hospital beds

This is the common types of bed found in every hospital or nursing home. Catalano *et.al*. (2006) state that, this beds are design for comfortability of the patience and the person who rely on acceptable medical practicability. Consist of two different type which is manually operated and electrical operated for its mechanism. Medical beds are also designed for patients who is in the stable state of medical condition and are made for those who has less needed in terms of convenience of the medical and nursing staff. Figures 2.1 shows common basic manually operated surgical beds that is used in hospital over the world. The manual type is simple and easy to handle since it needs less care from the nurse.

Figure 2.1: Manual surgical/medical bed of hospital beds Anony, (n.d)

In other hand, technology of this device has improved time to time. It gives a positive impact to the patient and especially to the nurse or staff because it helps to make their task easier and use less energy to perform the work in order to assist and reduce their risk of injury. The automatic component which is derived by electrical helps the manufacturing industry of this product gives opportunity to the other type of engineering get involves such as electrical and mechatronic engineering as they need to implement their expertise to the bed. This type of bed designed by more Figure 2.2 shows and example electrical type of Surgical/Medical Bed of Hospital beds from well-known manufacturer in America.

Figure 2.2: Electrical surgical/medical bed of hospital beds. Hill Rom (2017)