Faculty of Engineering

APPLICATION OF AXIOMATIC DESIGN CONCEPT TO IMPROVE THE PORTABLE CRANE DESIGN

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This report is submitted to Faculty of Engineering University Malaysia Sarawak (UNIMAS) as to fulfil the requirements of Bachelor Degree Program Mechanical Engineering and Manufacturing System

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This project report attached here to, entitle "Application of Axiomatic Design Concept to Improve the Portable Crane Design" prepared and submitted by DAYANG NUR RAFIZA BINTI AWANG YUSUF-8134 as a partial fulfilment of the requirement for the Degree of Bachelor of Engineering with Honours in Mechanical and Manufacturing System is hereby read and approve by:

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Supervisor

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ABSTRACT

A portable crane is designed for a whole range shop floor lifting job. It is transportable and requires no external power. The application of portable crane is widely used in the Mechanical Engineering field. This device is assisting any lifting job and considered as one of the material handling system device. The axiomatic design approach is applied to the design of the portable crane. An existing design is analyzed based on the Independence Axiom, but the existing design is discovered to violate this axiom. A new design is proposed to satisfy Independence Axiom. The design also examined to determine whether any corollaries were followed. Investigation also done whether the design contradicted any of the axioms or corollaries; this was done by comparing the axiomatic evaluation of the design alternative with an intuitive one.

ABSTRAK

Kren mudah alih dicipta khas untuk melakukan semua kerja yang berkaitan dengan mengangkut barang. Ia mudah diangkut dan tidak memerlukan kuasa dari luar untuk menggerakkannya. Penggunaan kren mudah alih diguna dengan luasnya dalam lapangan Kejuruteraan Mekanikal. Alat ini membantu dan memudahkan semua kerja mengangkut dan juga dikategorikan sebagai salah satu daripada alat dalam sistem mengendalikan bahan. Kaedah "Axiomatic Design" diaplikasikan untuk merekabentuk kren mudah alih yang baru. Reka bentuk yang lama dianalisa berdasarkan "Independence Axiom" didapati bercanggahan dengan "Axiom". Reka bentuk baru dicadangkan untuk mematuhi "Independence Axiom". Rekabentuk diuji untuk memastikan penggunaan "corollaries". Penyelidikan juga dilakukan untuk memastikan rekabentuk tidak bercanggahan dengan "axiom" atau "corollary". Penyelidikan dilakukan dengan menilai perbezaan di antara rekabetuk baru dan lama.

CHAPTER 1

INTRODUCTION

1.1 Background

Human have been designing mechanical objects for a long term. Each of the objects is the end result of a long and often difficult design process. There are certain techniques that can be used during the design process to help ensure successful results. In the design process there are divided into two stages of design. The first stage is conceptual stage and the second stage is embodiment stage. During the conceptual design stage, there are several tools can be applied to enhance the creativity and provide framework so the process will be more organize.

Design involves a continuous interplay between what we want to achieve and how we want to achieve it. The objective of design is always stated in the functional domain, whereas the physical solution is always generated in the physical domain. The design procedure involves interlinking these two domains at every hierarchical

level of the design process. These two domains are inherently independently of each other.

Design may be formally defined as the creation of synthesized solution in the form of products, processes or system that satisfy perceived needs through the mapping between the functional domain and the physical domain, through the proper selection of design parameters that satisfy functional requirements. The design axiom provides the principles that the mapping techniques must satisfy to produce a good design, and offer a basis for comparing and selecting designs. The design axioms apply to all synthesis processes: the design of manufacturing process, machines, products, and even organizations. Since we are surrounded by products, it easy to pick one of the products and analyzed its design from the axiomatic point of view.

1.2 Introduction of Portable Crane

The portable crane is a product selected into the application of design axiom for this project. Portable crane is a small crane that can be broken down into several parts for easy transportation. It must be assembled and bolted into place to be used effectively. Portable crane designed for a whole range of floor lifting job. They are transportable and require no external power. They can be used where no overhead lift is available and relatively short lift required. It also increase efficiency and productivity while decreasing operator bending and risk of back injury. The portable crane is widely used in the Mechanical engineering field for assist any heavy duty job. There are various types of a portable crane that available in the market with a various function and features.

1.2.1 Problem statement

Based on the Mechanical Engineering Laboratory's (UNIMAS) environment, there arise several limitations for existing portable crane that available the laboratory. The limitations were classified in term of functionality and ergonomically.

In term of functionality, the existing portable crane is difficult to steer because of the roller used to move the crane. Besides, the roller also limit the mobility of crane when require to go up the steps and it is difficult to cross the crane over the drain.

The problem also encounter at in term of it is ergonomically. The application of ergonomics should be result in products that are safer or easier to use. For existing portable crane in the mechanical laboratory, the location of manual hydraulic hand pump that used to raised and lowered the boom are not suitable for the average height of the user in mechanical laboratory. So it cause of the uncomfortable during the adjusting the boom.

The existing portable crane is a heavy-duty steel construction. It is makes the portable crane heavy and causes the limitation of crane's mobility. A part from that, bas the load is increases, the more difficult it is to steer.

Figure 1.2 shown the existing portable crane in Mechanical Laboratory of UNIMAS and the causes of limitations of existing portable crane as discussed above is designated in the yellow circle

Figure 1.2 The Existing Portable Crane

1.3 Aim and Objectives

The aim of this project is to improve the performance of the system which does not necessarily mean improve the performance of each component. The capability of creating a new design becomes more important than ever before because of the engineering environment is rapidly changing. Accordingly, a change to one portion of the design can negatively impact other portions unintentionally, because no framework was used to trace the impact of the design choices between the task decisions. It is generally no feasible to restart the design process from scratch, so new modified functional requirements (FRs) and constraints (Cs) must be incorporated into the existing design as the change occur.

The objectives of this project are:

i. To apply Axiomatic Design methodology for improving existing design of portable crane for the purpose of Mechanical Engineering Laboratory (UNIMAS).
ii. To overcome the problem that encounter at existing portable crane.
iii. To develop prototype of an improved portable crane.

The important of this project is that the design axioms facilitate the evaluation of existing designs and enable quick identification of poor designs. Once the problem is identified based on the axioms, better designs can be developed.

CHAPTER 2

LITERATURE REVIEW

2.1 Axiomatic Design

Axiomatic Design is engineering theory that has been developed at Massachusetts Institute of Technology (MIT). The basic idea for axiomatic design was advanced in the mid 1970's and it was later published in a book in 1990 [Suh, 1990]. Nam Suh's development of axiomatic design over the past 25 years or so, has been reported in a series of theoretical papers, a research monograph, detailed solutions to practical engineering designs, development of computational tools for rational designers and most recently this text intended for graduate students and professional engineers. The aim of this theory is to improve design activities by providing the designer with theoretical foundation based on logical and rational through process and tool. A system design technique based on Axiomatic Design theory is discussed as a tool that can be used to improve communication between costumer and design engineer. Axiomatic design defines as the creation of synthesized solution in the form of product, processes or system that satisfy perceived needs through mapping between functional requirements (FRs) and design parameters (DPs) [Almstrom, 1998]. Axiomatic design

is about how to think and used fundamental principles during synthesis or mapping between the domains of the

design world [Suh, 1995]. Axiomatic design is conceptual because it is an abstraction of the design process; it provides design tools because that is what theories do; and it has been used successfully by many in industry and academia because the basic intent if axiomatic design is to help current designers and future practitioners [Suh, 1995].

Whether the design solution is a tangible product, service, software, process or something else, designers typically follow these steps [13]:

1. understand their customers' needs
2. define the problem they must solve to satisfy these needs
3. create and select a solution
4. analyze an optimize the proposed solution
5. check the resulting design against the customers' needs

The Axiomatic Design process guides designers through these same steps. They can use all of their existing design tools and software and efficiently arrive at a successful new design, or diagnose and correct an existing design. The main concepts of Axiomatic Design are [Hinterstiener, 2000]:

1. Domains, which separate the functional and physical parts of the design.
2. Hierarchies, which categorized the progress of a design in the functional and physical domains from the systemic level to more detail levels.
3. Zigzagging, which indicates that decisions made at one level of the hierarchy affect the problem statements at lower levels; and
4. Design axioms, which dictate that the independence of the functional requirements must be maintained, where FRs are defined as the minimum set of independent requirements that characterized the design goals and the information content (i.e., cost, complexity, ect.) must be minimized in order to generate high quality designs.

Solution alternatives are created by mapping the requirements specified in one domain to a set of characteristic parameters in an adjacent domain. The mapping between the customer and functional domains is defined as concept design; the mapping between functional and physical domains is product design; the mapping between the physical and process domains corresponds to process design.

2.1.1 Domain

The world of design is made up of four domains; the customer domain, the functional domain, the physical domain and the process domain.

Customer domain is characterized by needs that the customer is looking for in the product or process or systems or materials.

In functional domain, the customer needs are specified in term of functional requirements (FRs) and constraints domain (Cs).

To satisfy the specified FRs, design parameters (DPs) were conceived in the physical domain.

Finally, to produce the product specified in term of DPs, a process that is characterized was developed by process variables (PVs) in the process domain.

The domain on the left relative to the domain on the right represents “what we want to achieve,” whereas the domain on the right represents deign solution of “how we propose to satisfy the requirements specified in the left domain.” To ho from “what” to “how” requires mapping. During this mapping process, the Independence Axiom must be satisfied.

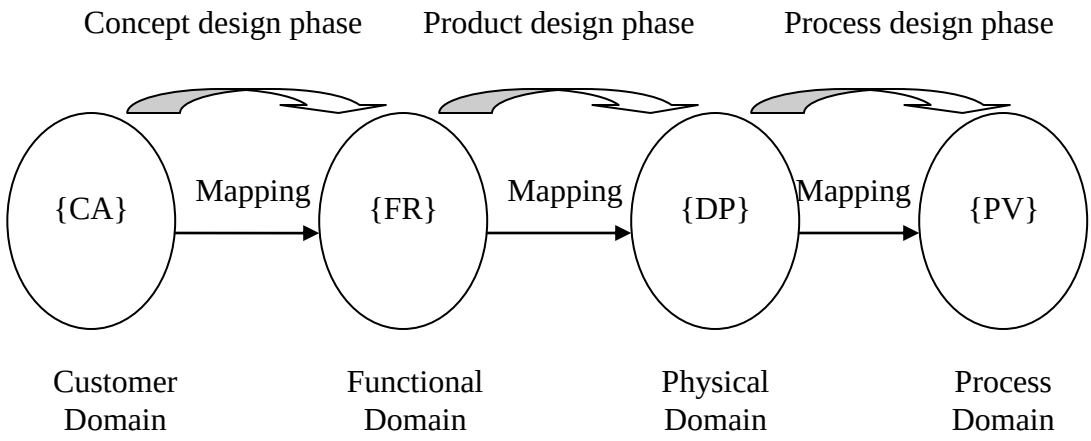

Figure 2.1 The Fundamental Concept of Axiomatic Design [16]

2.1.2 Hierarchies

According to Axiomatic principle, the essence of the design process lies in hierarchies. The designers begin the design from comprehensive functional requirements and a design can decompose functional requirements into many hierarchies [Shin, et al, 2002].

2.1.3 Zigzagging

The zigzagging between functional requirements and design parameters is necessary because the two sets of each level are connected and mutually dependent [Shin, et al, 2002].