UNIVERITI TEKNIKAL MALAYSIA MELAKA

IMPLEMENTATION OF DESIGN FOR MANUFACTURE AND ASSEMBLY (DFMA) AND ANALYTICAL HIERARCHY PROCESS (AHP) IN OPTIMIZING CONCEPTUAL DESIGN OF HAND TOOL TROLLEY

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

by

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2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Implementation of Design for Manufacture and Assembly (DFMA) and Analytical Hierarchy Process (AHP) in Optimizing Conceptual Design of Hand Tool Trolley**

SESI PENGAJIAN: **2014/2015 Semester 2**

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

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ABSTRACT

Nowadays, in the era of competitive manufacturing demands organizations around the world are facing a great challenge in producing a high-quality product at the economical market price in the shortest time to be manufactured and sell to the customers. Due to that issue, researcher and innovators have to amplify their focus to simplify and increase efficiency of the operation in manufacturing and assembly process and cost. The main objectives of this project is to optimize the conceptual design of hand tool trolley by using the DFMA and AHP approach. The original design of hand tool trolley was analyzed by using DFMA software to obtain the suggestion for redesign parts. Next, three new conceptual designs were proposed by eliminating, modified or redesign parts in the original design hand tool trolley. Then, the best conceptual design is selected based on the criteria in AHP analysis. The DFMA method have proved that the original hand tool trolley has been improved by 63% of design efficiency which is reducing the total number of parts from 127 parts to 22 parts in the new design of hand tool trolley. The weight of the new design of hand tool trolley is 20.12g which is less than 225N or 22.5kg have achieved the problem statement of this project. The assembly time reduce form 1410.43s to 838.85s for the new design. Finally, the cost of the product is reduced by 69.43% which is from RM357.02 for the old design to RM109.13.

ABSTRAK

Dalam era industri pembuatan yang kompetitif pada masa kini ia menuntut organisasi di seluruh dunia untuk menghasilkan produk berkualiti tinggi dengan harga pasaran yang rendah tetapi produk dapat dihasilkan dan sampai kepada pelanggan pada masa yang singkat. Oleh hal yang demikian, para penyelidik perlu menfokustkan tumpuan mereka untuk memudahkan dan meningkatkan kecekapan operasi dalam pembuatan dan segi proses pemasangan serta kos sesuatu produk. Objektif utama projek ini adalah untuk mengoptimumkan reka bentuk troli alatan tangan dengan menggunakan pendekatan DFMA (rekabentuk untuk pembuatan dan pemasangan) dan AHP (proses analitikal secara hierarki). Reka bentuk asal troli alatan tangan dianalisis dengan menggunakan perisian DFMA untuk mendapatkan idea tentang bahagian-bahagian yang perlu direka bentuk semula. Seterusnya, tiga reka bentuk konsep baru dibuat dengan mengurangkan, mengubah suai atau mereka bentuk semula bahagian tertentu dari reka bentuk asal troli alatan tangan. Kemudian, reka bentuk konsep yang terbaik dipilih berdasarkan kriteria dalam analisis AHP. Kaedah DFMA telah membuktikan bahawa rekabentuk asal troli alatn tangan troli telah meningkat sebanyak 63% daripada kecekapan reka bentuk dengan mengurangkan jumlah komponen daripada 127 bahagian ke 21 bahagian dalam reka bentuk baru troli alatan tangan. Berat baru troli alatan tangan adalah 20.12kg iaitu kurang daripada 225N atau 22.5kg dan telah mencapai pernyataan masalah projek ini. Masa pemasangan produk dapat dikurangkan daripada 1410.43s ke 838.85s bagi reka bentuk baru. Akhir sekali, kos produk dikurangkan sebanyak 69,43% iaitu daripada RM357.02 bagi reka bentuk yang lama kepada RM109.13.

DEDICATION

Especially for my beloved family, thanks for the continuous moral support. To respective lecturer and supervisor, thanks for the guidance and knowledge. Finally, to all my friends and every participated person, I really appreciate your support.

ACKNOWLEDGEMENT

Thanks God for the strength throughout this journey.

Firstly, I would like to express my deepest gratitude to my supervisor, Prof Madya Dr. Hambali bin Arep @ Ariff for constant guidance, constructive comment and invaluable idea throughout this project. In addition to that, I also would like to thanks lecturers and technicians for ideas and cooperation while completing this project. Deepest thanks and appreciation to my family member for their continuous moral support and encouragement throughout this journey. Not forgotten, my friends especially my classmates for the ideas, suggestion and guidance in the project and report preparation. Last but not least, I would like to thanks everyone that have involved directly or indirectly in making this project succeed.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

DFMA	-	Design for manufacture and Assembly
AHP	-	Analytical Hierarchy Process
Inc.	-	Incorporation
N	-	Newton
CAD	-	Computer Aided Design
CTQ	-	Critical To Quality
CAE	-	Computer Aided Engineering
US	-	United State
DFA	-	Design for Assembly
DFM	-	Design for Manufacture
Co.	-	Company
E_m	-	Design efficiency for manual assembly
N_m	-	Theoretical number of parts
t_m	-	Total assembly time
VFM	-	Value for Money Vector

CHAPTER 1
INTRODUCTION

This chapter describes briefly on the background of this project. The project focuses on the implementation of integrated DFMA and AHP in optimizing conceptual design of hand tool trolley. The overall content of this chapter includes background, problem statement, objectives, scope and summary of the project.

1.1 Background

Nowadays, in the era of competitive manufacturing demands, organizations around the world are facing a great challenge in producing a high-quality product at the economical market price in the shortest time to be manufactured and sell to the customers. Due to that issue, researcher and innovators have to amplify their focus to simplify and increase efficiency of the operation in manufacturing and assembly process and cost. Some common engineering effort that has been recognized as the key strategy for survival and growth is by integrating the design in manufacturing and assembly activities with other concurrent engineering approach (Venkatachalam et al., 1993).

The hand tool trolley is a device that is used by mechanics in the garage to place and transport their tools such as various sizes of spanner, pliers, hammers, and screw driver. With the aid of hand tool trolley, mechanics can retrieve their tools easily, without working in awkward positions, for example bending or twisting their body. This project focuses on the implementation of Design for Manufacture and Assembly (DFMA) and

Analytical Hierarchy Process (AHP) in optimizing conceptual design of the hand tool trolley. In order to optimize the early stage of design which is also known as conceptual design, for a hand tool trolley, DFMA method is used to generate a few conceptual designs of the hand tool trolley follow by AHP analysis, a decision making method that is used to select the best conceptual design.

Design for manufacturing and assembly (DFMA) is a set of guidelines that foster the simultaneous involvement of product design and process design with the aim to efficiently manufacture and assembled products with minimum labor effort, assemble time and cost. DFMA mainly used in three main activities which are 1) as a fundamental principles for concurrent engineering studies to provide the guidance to the design team to simplifying the products structure in order to reduce manufacturing and assembly costs, and to quantify the improvements, 2) as the benchmarking tools to study the competitors' product and quantify manufacturing and assemblies difficulties, and 3) as a should-cost tool to help control costs and help to negotiate suppliers contracts (Boothroyd, 1994).

DFMA implementation process can be classified into two stages. At the initial stage, the designer develops a simple conceptual design by focusing on an assembly that requires a minimum number of parts to perform during installation. In the second stage, the designer redesigns existing assemblies in order to optimize the design for ease manufacturing and installation (Herrera, 1997). According to Huang (2001), ease of manufacturing and assembly is a crucial process as it can affect cost, quality and productivity of the product.

Analytical hierarchy process (AHP) is one available method for forming a systematic approach for a single decision maker or a group decision and has been introduced to determine the best selection among few options. Based on Ho (2008), AHP consists of three main operations, which are according to the following, firstly hierarchy construction, secondly priority analysis, and finally consistency verification. The process starts with the breakdown of complex multiple criteria decision problems into its component parts of which every possible attributes are arranged into multiple hierarchical levels. Next, each

cluster in the same pairwise is compared, which can based on decision maker experience and knowledge.

1.2 Problem Statement

Most manufacturing organizations today was not utilizing the optimum product development process for the introduction of new product in design activities due to lack awareness about optimization in design which can contribute much positive effect to the overall manufacturing cost. In addition to that, many of these companies are still using the traditional 'design first and then throw it across the wall to manufacturing' approach (Boothroyd, 1994). Many existing products are not optimally designed, thus provide an opportunity for designers to dramatically improve the product (Mann, 1991).

Both well-defined problem specifications and high level design solutions are developed during the early stage of design and become significant as design complexity increases. New customer demands and increased legislation drive business-oriented companies into new business models focusing on the entire product life cycle. Dewhurst, (2011) and Wu and O'rady (1999) stated that in the general manufacturing, 70% of the production cost is determined during at the design phase, as shown in Figure 1. Thus, there was a need to carefully consider the manufacture and assembly activities at the preliminary stage of design. Traditionally, attempts to save costs have been done through job cuts or improving operational efficiency. Yet, continual efforts have to be employed to understand, control, and reduce costs from the early stages of product development (Dewhurst, 2010).

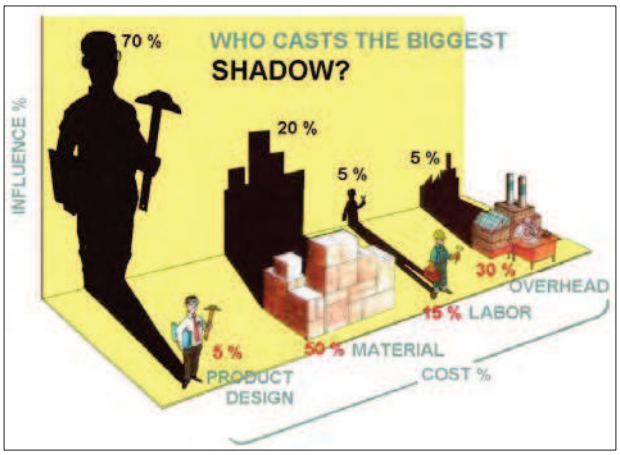

Figure 1: Who cast the biggest shadow? (Anonymous)

A hand tool trolley is also known as the tool storage carts, mobile tool cabinets or the tool displays stands on wheel. In the garage, pushing and pulling the trolley are among the most common work activities which can contribute to fewer injuries and ergonomic related problem. However, there are no compressive injury statistics as the injuries resulting from these activities are not always recorded very specific and the injuries fall into different categories making it difficult to analyze. Some common injuries related to hand tool trolley are overexertion (e.g. back strain), injuries due to slip and fall while pulling or pushing the trolley and injuries to fingers and hands due to being caught in, on or between objects (e.g. between a cart and the wall) . Pushing or pulling objects that are hard to move or to stop (for example a trolley), make a demand to reduce its weight. Besides that, according to Reinhold, (1986), the force required to move equipment on wheels or casters is 225N whereby the condition is standing and involved the whole body. Thus the weight of trolley must be less than 225N in order to minimize the handling force and consequently minimize the injuries.

By implementing the right approach during the conceptual design, manufacturer can get a lot of advantages during the product development process. This project is presents on the implementation of Design for Manufacture and Assembly (DFMA) and Analytical Hierarchy Process (AHP) for one selected product. The methods apply are based on new techniques of merging the similar characteristics and connecting the complementary feature of both methods, which were then applied to the conceptual design of a hand tool trolley for better purpose.

1.3 Objective

The main objective of this project is to implement the integration of DFMA and AHP in optimizing conceptual hand tool trolley. The specific objectives for this project are listed as follows:

I. To compare product performance between the existing design and redesign hand tool trolley using DFMA method.

II. To decide the best conceptual design using the AHP approach.

1.4 Scope

This project emphasized on the optimization of conceptual design by implementing two method, DFMA and AHP, a concurrent engineering approach and using a hand tool trolley as a case study. Only Boothroyd-Dewhurst DFMA methodology is applied for product evaluation. Lucas Hull DFMA method and Hitachi Assembly Evaluation Method are not discussed in this project. Boothroyd-Dewhurst DFMA methodology is used to identify design problems and generate new design solutions. Next, AHP approach is apply in order to enhance selection of conceptual design of the redesign product. The tools used along this project are the DFMA software, for product evaluation. Expert Choice software for product selection and Solidworks CAD software for 3D drawing of product design.

1.5 Significant of study

The prediction of future manufacture and assembly issues early in the design process actually ensures a potential result of eliminating waste before the product actually reaches the production line (Dewhurst, 2011). According to Jingyan Zuo (2004), up to 85% of the life-cycle cost was determined during the initial stages of design, which also referred as the conceptual design phase, whereby the actual life-cycle cost spent is only about 5% at that stage. This proved that an improvement made at the conceptual design stage

compare to at the detailed design stage can significantly reduce the time-to-market of high quality products and total costs. It is may be impossible to overcome a poor, hasty decision made during the conceptual design phase, at the detailed design phase that follow. Therefore it is becoming increasingly significant to carefully and thoroughly consider important trade-offs at the conceptual design phase.

As the conceptual design tends to be highly unpredictable as it is evolving process in which both the understanding of the problem and design concept are iteratively refined, thus a good design tool is needed in order to optimize the design concept development and selection. That why the stage conceptual design is important to get the optimization design before produce the product at market.

The research findings should be important in improving existing products design in terms of cost, minimizing the number of parts and ease in handling. Capability of Boothroyd-Dewhurst DFMA methodology should help designers design products to improve the efficiency of the product design. Analytical Hierarchy Problem (AHP) is a useful strategy that will enhance the decision making of choosing the best conceptual design after the DFMA approach.

CHAPTER 2

LITERATURE REVIEW

This chapter provides the description on overview of substantive understanding on report title and related to the scope of the study. Throughout this chapter, all the keywords related to the project such as research patent (hand tool trolley), conceptual design, optimization, Design for Manufacture and Assembly (DFMA), Analytical Hierarchy Process (AHP) will be discussed. All the theoretical information is collected based on the available research obtain from scholarly text including journals, research patent, books and conference papers.

2.1 Conceptual Design

Conceptual design is study phase in which ideas and alternatives are evaluated and to be considered in product development process. According to Saw (2011) conceptual design stage is the most crucial and difficult task in an engineering design. At this stage, the new and innovative design is implemented through which it needs the intervention from expertise in making decision regarding the incomplete and imprecise knowledge of the design requirements and constraints. Due to the significant decision making during the conceptual design, thus there are many tools have been developed to support the conceptual design development.