CRITICAL COMPONENTS IDENTIFICATION USING ANALYTIC HIERARCHY PROCESS – A CASE STUDY TOWARDS PRODUCT DESIGN IMPROVEMENT

by

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TABLE OF CONTENTS

CHAPTER 3 METHODOLOGY

CHAPTER 4 RESULT AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

Mengenalpasti Komponen yang Kritikal Menggunakan Proses Hirarki Analisis – Kajian untuk Penambahbaik Rekabentuk Produk

ABSTRAK

Kegagalan produk semasa operasi boleh menyebabkan ketidakberpuasan pelanggan. Untuk mengekalkan nilai produk yang tinggi, tindakan yang tepat seperti langkah penyelenggaraan dan ketahanan produk adalah salah satu bahagian penting semasa fasa penambahbaik rekabentuk produk. Dalam fasa ini, pengenalpastian komponen kritikal yang perlu diberi keutamaan untuk penambahbaik rekabentuk produk mestilah dikenalpasti dengan jelas. Namun begitu, amalan penambahbaik rekabentuk produk sedia ada, tidak memberi perhatian terhadap pengenalpastian komponen yang kritikal yang perlu diutamankan dalam penambahbaik rekabentuk produk. Oleh itu, untuk membuat proses penambahbaik ini lebih berkesan dan cekap, kajian ini menyarankan model pengenalpastian komponen yang kritikal. Objektif utama model yang dicadangkan ini adalah untuk mengenalpasti komponen yang kritikal untuk penambahbaik rekabentuk produk. Metodologi kajian ini bermula dengan aplikasi Komponen Klasifikasi Analisis (KKA) di mana komponen utama dan komponen sokongan dikenalpasti. Seterusnya, hasil daripada KKA digunakan sebagai input untuk Proses Hierarki Analisis (PHA). Dalam langkah ini, input dibandingkan dengan menggunakan perbandingan pasangan berdasarkan kriteria yang telah dipilih iaitu tersumbat, rosak dan longgar. Satu kajian terhadap dua jenis senjata ruji yang berbeza digunakan untuk mengesahkan model yang telah dibina. Hasil daripada kajian ini menunjukkan terdapat lima komponen yang kritikal iaitu spring kompress, badan senjata ruji, spring outlet, tukul dan rivet dalam senjata ruji perlu diberi keutamaan untuk penambahbaik rekabentuk produk. Dengan memiliki maklumat ini, ia dapat membantu pasukan rekabentuk untuk memberi perhatian kepada komponen tertentu semasa penambahbaik rekabentuk produk.

Critical Components Identification using Analytic Hierarchy Process – A Case Study towards Product Design Improvement

ABSTRACT

Failure of product during its operation may result unsatisfied customer. In order to maintain the high value of product, proper action such as maintainability measure and reliability is one of crucial part during product design improvement phase. In this phase, the identification of critical component that should be prioritized for product design improvement must be clearly identified. However, in current practices of product design improvement, the attention on identifying critical component has been neglected. Therefore, to make this improvement process more effective and efficient, a decision model of critical component identification is proposed. The main objective of this proposed model is to identify the critical components towards product design improvement. The methodology of this study starts with the application of Component Classification Analysis (CCA) where the main components and support components is identified. Next, the result from the CCA is used as the input for Analytic Hierarchy Process (AHP). In this step, the input is compared by using pairwise comparison based on the criteria that has been chosen which are clogged, breakdown and loose. A case study of two different types of staple guns is used to validate the developed decision model. Results from this research shows that there are five critical components which are compress spring, body, outlet spring, hammer and rivet in the staple gun should be prioritized for product design improvement. By having this information, it will help the design team to focus on that particular component during product design improvement.

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter presents overview of research study which involve of research background, problem statements which drives to the objective and scope of this project. Research background section gives overview on research content while problem statements discusses about the problem that happened in identify critical component in the past literature. Next, the objectives of this research is proposed, followed by the scope and limitation.

1.2 Research Background

Customer satisfaction determines the success of product and only product at high value meet requirements of customers who expect them to perform efficiently through their whole life cycle (Li, Liu, & Li, 2014). In order to fulfill these requirements the minimum parameters should be assured within the product development processes. From an elementary part to compound parts, they must be designed and manufactured on high quality level, reliable and safe to be used. Reliability is one of the critical attribute that determine the effectiveness of product where it measures the ability of product to avoid

failure. A reliability deficiency will lead to lost product performance, safety issues and also require restorative actions for examples repair, diagnosis, spare replenishment and maintenance (Pecht & Rafanelli, 2009).

Various type of machines have distinct of reliability requirement, failure rate and safety level (Groenevelt, Pintelon, & Seidmann, 1992). The proper maintainability measure should be defined for different type of machines in early stage of design development phase. This will maintain the reliability and availability of production facility in the acceptable level.

1.3 Problem Statements

Component failure or operating condition change causes degradation of product performance (Payman Dehghanian, Fotuhi, Ali, & Kazemi, 2011). Demands for maintaining the reliability of product and pressure to optimize maintainability measure has led to severe companies' pressure. In general, the product reliability has become one of the key factors for the product to be successfully marketable (Yadav, Singh, Babu, & Goel, 2003). The ability of product to be built reliably in competitive environment nowadays, not only depend on how effective the company can manage the product design improvement but also how they do so at the earliest stages of product design improvement. In order to enhance the value of product, identification of critical component to be prioritized for product design improvement is very essential.

There are few research about identification of critical components during operation phase such as (Bertling, Allan, & Eriksson, 2005) which proposed a method on identification of critical component in power distribution system. Thus, this research attempts to fill gap in the literature by proposing a methodology of analytic hierarchy process which focused on the critical component identification for design product improvement.

1.4 Research questions

For this study, there are two research questions have been constructed. The questions are as the follows:

- How does the identification of critical component can add value in the process product design improvement?
- How does the process of critical component identification can be carried out systematically and effectively?

1.5 Objectives of the study

The main research objective for this study is to develop the critical component identification decision model for product design improvement. The model will assist designer to identify the critical components towards product design improvement. The specific objectives of this study are highlight as the following:

i. To propose the critical component identification decision model by using Analytic Hierarchy Process (AHP).

ii. To validate the critical component decision model by using case study of different type of staple gun.

1.6 Scope

This research is focusing on identification of critical component for improving product design. The experiment has been done on two different validation model of staple gun in order to seek the functional failure in each component while performing normal operation. Then, the component classification analysis (CCA) is conducted in order to analyze the section involved and also component that probably related in enhancing functional failure. Later, the information gained from the component classification analysis (CCA) is used as input for analytic hierarchy process (AHP) for further analysis on critical component identification.

1.7 Significant of the Study

In this study, the identification of critical component decision model is developed. The main significant of applying Component Classification Analysis (CCA) and Analytic Hierarchy Process (AHP) in developing this decision model is to help the design team to identify which components that they should consider more during product design

improvement. This identification not only improves the right component at the early of product design improvement process but also can fulfill the customer desired in the end.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature of past researches. The first section discussed about the product lifecycle. There are three areas in product lifecycle that have been further reviewed which are product development phase, product operation phase and product improvement phase. Second section is about product reliability and maintainability. Then, critical component identification process is review and lastly, the final section presents the literature reviews finding.

2.2 Product lifecycle

In this study, three phase of product lifecycle has been reviewed which are product development phase, product operation phase and product improvement phase. Detail review of these phases is discussed in next section.

2.2.1 Product development phase

Product development processes (PDPs) are the methods and procedures that companies apply to form new products and make it marketable. There are some reasons that cause companies to form or develop new product frequently. Many companies employ various types of distinct product development processes (PDPs) to design new products. Well-designed PDPs are very essential to shorten process time, manage risks, and design better products. Moreover, (R. Roy, Colmer, & Griggs, 2005) reported that due to the high competitive, customers regularly wants new products with high quality and functionality without price increment. However, the rate of success for new product to be commercialized still did not show much increment in term of profit (Barczak, Griffin, & Kahn, 2009). Besides that, they also claimed that the percent of sales and profit gained by new products showed decrement trend with less than one third of sale and profit by new product. This situation caused the companies' continuing to find the best way to improve their new product development in term of efficiency (such as cost reduction, shortest time to market) and effectiveness (such as high quality of new product and high marketability). The process of development product should not only focus on product specifications and its physical configuration, but also include the product offering such as product support and after-sale supplies (Krishnan & Ulrich, 2001). Previous studies have primarily concentrated on the field of Product Development Process (PDP), because it can give advantage in term of competitiveness among company. The performance of a product is located in its development process (Dekker & Smidt, 2003) and for that reason, to enhance this parameters, appropriate process in the PDP is necessary.

Research by (Erat & Kavadias, 2008) compared older product prototyping processes for their product development process. However, they found that the finding is insufficient and gave complex architectures. While, (Ho & Lin, 2009) presented product development process based on concurrent function deployment and concurrent engineering. In another research, found that product development in manufacturing system was involved of mass production and mass customization (Gu, Hashemian, & Nee, 2004). Multi demand from customers and market competition required production development to meet the quality, productivity and also cost based on the customer demand. An open-architecture product (OAP) is one of the methods that can deal with the contradiction between mass production and product customization (Koren, Hu, Gu, & Shpitalni, 2013)

2.2.2 Product operation phase

The performance of product purchased is not only the requirement that can fulfill customer desired, but total value gained, quality of purchase product and also the experience of service life throughout purchase product (Ghodrati, Benjevic, & Jardine, 2012). Thus, many products for examples, industrial products require support throughout their operating lifetime. As alternatives, manufacturers attempt to offer their customers in gaining high value of profit from the purchased product which known as product support. Typical types of support that manufacturers should offer for their new product for example; installation, training, service for maintenance and repair, documentation, availability in term of spare part, upgrades (to enhanced functionality), customer consultation and schemes of warranty (Goffin, 2000).

In other research, (Wang, 2011) found that the instability of operating conditions might produce undesired final output. It may be helpful if customer can predict the quality of product during operation phase, thus the adjustments of process condition can be made. This research focused on the real-time prediction of quality for final product during operation phase. An approach of data-driven modeling has been introduced. This approach used information of available process up to the current points to obtain their time-varying relationships with the quality of final product during operation phase. Thus, the prognosis of final quality product can be gained in real time.

2.2.3 Product improvement phase

The interaction of customer that used the product and manufacturer plays important role in improving any product. Effective communication between customer and manufacturer will give good input in improving products. The input that gained through actual use and customer-manufacturer communication will help manufacturer in redesign and yet improve the product (Habermeier, 1990). This is supported by (Zhang, Peng, & Gu, 2015) in their research which reveal that the involvement of customer during product design can fulfill the requirement of functional needs of products. Besides that, (Brockhoff, 2003) also agree that customers' perspective can give positive feedback for future improvement product. Usually, the characteristic of product such as reliability and maintainability are discovered if the product has been used, sometimes for long period of time (Habermeier, 1990).