



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**APPLYING A CRISP AND FUZZY ANALYTIC HIERARCHY  
PROCESS METHOD FOR SPATIAL MULTI-CRITERIA DECISION  
ANALYSIS  
[CASE STUDY: SPECTACLES PRODUCT DESIGN]**

**This report submitted in accordance with requirement of the University Teknikal  
Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering  
(Manufacturing Management) with Honours.**

by

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## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

### BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

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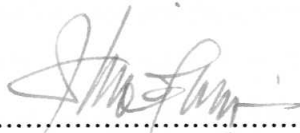
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I hereby declare that this report entitled “Applying a Crisp and Fuzzy Analytic Hierarchy Process Method for Spatial Multi-Criteria Decision Analysis” is the result of my own research except as cited in the references.

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Date : 3 June 2013

## **APPROVAL**

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



.....  
**Hasoloan Haery Ian Pieter**  
**(PSM Supervisor)**

## ABSTRAK

Kajian ini adalah mengenai ciri-ciri reka bentuk produk berdasarkan keperluan pelanggan menggunakan kaedah Proses Hierarki Analisis 'Crips' dan 'Fuzzy' (AHP dan FAHP). Dalam kajian ini, responden yang terlibat terdiri daripada pelajar-pelajar pengajian tinggi di Melaka. Kajian dijalankan terhadap 1000 responden dengan soal selidik yang dibangunkan menggunakan 3 ciri-ciri reka bentuk yang dicadangkan, yang mengandungi 6 jenis reka bentuk masing-masing digunakan dalam skala 1 hingga 7 berdasarkan perbezaan semantik daripada perkataan Kansei. Objektif kajian ini adalah untuk mengenal pasti, menganalisis, membenarkan, dan menilai ciri-ciri dan keperluan reka bentuk produk di samping untuk menghasilkan keputusan mencari keutamaan atau prioriti produk. Kajian ini telah dijalankan ke arah reka bentuk cermin mata. Kaji selidik Ujian Post diperlukan untuk mengesahkan keputusan, di samping menganalisis korelasi. Berdasarkan data keputusan, semua perkataan Kansei digunakan dalam kajian ini adalah sah kerana semua nilai-nilai alpha Cronbach lebih daripada 0.7. Perkataan Kansei dikenal pasti melalui 30 responden, sebagai penyebutan ciri-ciri reka bentuk produk adalah 'Bosan – Menarik' (B / A), 'Biasa – Unik' (C / U), 'Tidak Hebat – Mengagumkan' (L / C), 'Klasik – Moden' (C / M), dan 'Tidak Kuat – Teguh' (F / R). Rim Penuh adalah ciri-ciri reka bentuk yang paling diberi keutamaan yang berkaitan dengan reka bentuk yang dicadangkan. Berdasarkan perkataan Kansei, keutamaan yang paling dipilih adalah perkataan 'Tidak Hebat – Mengagumkan' (L / C) di mana nilai purata tertinggi terletak di Bingkai penuh jenis-6. Penemuan ini adalah sama dan terbukti melalui kajian Ujian Post dijalankan. Berdasarkan latar belakang responden, 'Kuasa Optik' cermin mata mempunyai perkaitan yang signifikan ( $p < 0.01$ ) kepada 'Bosan-Menarik' dalam perkataan Kansei.



## ABSTRACT

This study is about product design features based on customer requirements using a crisp and fuzzy analytical hierarchy process (AHP and FAHP) method. In this study, the respondents involved were the higher education students in Melaka. The survey conducted towards 1000 respondents with the questionnaires developed using the 3 proposed design characteristics, that were containing of 6 design types respectively applied in the scaled 1 to 7 of semantic differential to Kansei words. The objective of this study is to identify, analyze, justify, and evaluate the features and design requirements of the product, beside to generate the decision making in order to find the preference or priority of the products. As a case study, this study was conducted towards the spectacles design. The Post Test survey is required in order to validate the results, beside the correlation analysis. Based on the results data, all of the Kansei words used in this study were valid, since all of the Cronbach alpha values were more than 0.7. The Kansei words identified through 30 respondents, as the articulation of the product design characteristics are 'Boring – Attractive' (B/A), 'Common – Unique' (C/U), 'Lame – Cool' (L/C), 'Classic – Modern' (C/M), and 'Fragile – Robust' (F/R). While the most preference design characteristics related to the proposed design, is Full Rim characteristic. To the Kansei words, the most preference was on "Lame- Cool" (L/C) word, where the highest value was occurred on the type-6. This finding is similar and proven through the Post Test survey conducted. Towards the respondents' background, the 'Optical Power' is having significant correlation ( $p < 0.01$ ) to 'Boring-Attractive' of Kansei word. Based on this reason, the decision made to customer requirements should be carefully determined by the comparison analysis, especially to each criterion using Kansei Words as an articulation of customer quality feelings.

## **DEDICATION**

***For my beloved parents who are always supported me:***

*Abdul Latiff Bin Abdul Rahman*

*Merduwati Binti Mustafa*

***And***

***For My Supervisor,***

*Mr Hasoloan Haery Ian Pieter*

***For my families and friends***

***Thanks for their loves and caring.***

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## LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
FAHP	-	Fuzzy AHP
FEAHP	-	Fuzzy Extended AHP
MCDM	-	Multi Criteria Decision Making
CS	-	Customer Satisfaction
KE	-	Kansei Engineering
KES	-	Kansei Engineering System
HEI	-	High Education Institution
MMU	-	Multimedia University
PMM	-	Politeknik Merlimau Melaka
UTeM	-	Universiti Teknikal Malaysia Melaka
KW	-	Kansei Word
SDF	-	Style Description Framework
GRA	-	Grey Relational Analysis
CI	-	Consistency Index
CR	-	Consistency Ratio
TOPSIS	-	Technique for Order Preference by Similarity to Ideal Solution
PROMETHEE	-	Preference Ranking Organization Method for Enrichment of Evaluations
FL	-	Fuzzy Logic
AI	-	Artificial Intelligence
TFN	-	Triangular Function Number
FIS	-	Fuzzy Inferences System
B/A	-	Boring – Attractive
C/U	-	Common – Unique
L/C	-	Lame – Cool
C/M	-	Classic – Modern
F/R	-	Fragile – Robust



# CHAPTER 1

## INTRODUCTION

### 1.1. Background of Study

In today's global and dynamic competitive environment, the competition among market players becomes more severe. In business globalization, according to Lin and Luh (2009:191), consumers' requirements become more complex and the high technology development led to vigorous business competition and market uncertainty. In facts, the rising of customers' expectations are largely influencing the companies' experiences to a boundless commercial world. In order to continuously maintain customer satisfaction for long-run profitability, according to (Heffernan & LaVelle, 2006:1), the trend of business to globalization competitors have been moving from national to regional and, thus, international market. Due to this reason, the competition among industries related becoming increasingly intense. They are not only compete on how to provide products with high quality (Shen *et al.*,2000:91). Matzler and Hinterhuber (1998:25) defined this competition as a focal point of how to capture market share through the attraction of new customers as an offensive strategy, where the delivery of innovative products to the

marketplace is, thus, considered as a key element for a company to confront competitive challenges (Shen *et al.*, 2000:91).

Viewing on this condition, to achieve or sustain a competitive advantage, Bettis and Hitt (1995:7) argued that the rapidly development of product and process innovations are, therefore, becoming important task in global industries. Beside on how the companies deliver the product innovation that should be more relevant to markets (according to Alegre *et al.*, 2006:333 is as result of three major trends such as intense international competition, fragmented and demanding markets, and diverse and rapidly changing technologies), the ways of companies to meet these challenges also depends on the nature of their business, the dynamic forces of the market in which they operate, and the resources and skills that can be applied to ensure their business objectives are met (Shepherd & Ahmed, 2000:100). Voelpel *et al.*, (2005: 37) stated that to counter direct competitive challenges, the companies have to continuously learn new ways of improving their efficiency and performance. This is due to a successful product launched to the market will soon be followed by its competitors with others value added products offered.

On the efforts for implementing the innovations (that was initially interacting with the normative evaluation as multi-level and are espoused “common sense” or “normalized knowledge”), according to McAdam (2005:384), the conformity based on the evaluation elements of the innovation should be as the comparison toward the existing norms. Govindarajan and Trimble (2006:1) said "*today's business importance task is about how to find the* νεξτ αδσσανταγε due το επερσ στρατεγησ στανρσ το δεχαμ σινχε τηε δαμ ιτ ισ χρεατεδ.∇ Τηισ μεανσ, ωηερε χονσυμερισμ ισ ρυννινη ηιγηερ ανδ τηε προδυτ λιφε σπαν ισ γεττι νγ σηορτερ, ιτ ισ ονε οφ τηε χηαλλενγεσ φορ τηε μαρκετινγ ανδ δεσιγν δεπαρτμεντσ ιν ε ντερπρισεσ το κνω ηωω το γετ α τηορουγη γρασπ οφ τηε χονσυμερ'σ preference and potential target user group.

Based on this reason, Hizon *et al.*, (2006) commented that the company must to be master with new competencies and utilize the most appropriate forms of technology in each phase of their business life cycle. This means that the companies, are consequently, requiring the product development competencies, which is not only lie on more effectively than they have in the past. They also should have as follows:

- A key adjustments identified and implemented to support the new "solutions" focused business model (Shepherd & Ahmed, 2000:100). This is due to a company's survival in rapidly changing condition and highly competitive circumstances depend on the timely design and the development and marketing of new products or services with creative and innovative features (Shen *et al.*, 2000:91).
- To guard themselves from obsolescence or ossification by offering processes, systems, products, or services not previously observed in a market. This means that to drive their business sustainability, they must be better integrate and align the way they treat customers with their go-to-market strategy and branding at each touch point of the relationship (Heffernan & LaVelle, 2006:1). For instance, companies turn their strategy to a "solutions" focused business model in order to counter the effects of decreasing technology and product life-cycles, tightening margins, and increasing commoditization of product components (Shepherd & Ahmed, 2000:100).
- The strategic intent against the competitors that are not only enough to capture higher market shares, but to also on how to gain sustainable competitive advantages within certain market segments, where the core competences of the firm can be exploited, and to create a high level of customer satisfaction and loyalty (Matzler & Hinterhuber, 1998:25). This is due to the achievement of quality attributes does not always improve overall customer satisfaction, and not all service attributes are viewed as equally important to customers (Lin *et al.*, 2010:255).
- The target values determination of the engineering characteristics. Since they are complex problems with multiple variables and objectives that needs to be trade



off all kinds of conflicts and constraints (according to Zhaoling *et al.*, (2008:1165) are the conflicts among the engineering characteristics and the contradiction between the customer needs and design budget), then the exploration of customer satisfaction model should be taken through a comprehensive perspective (Lin, 2007:110).

Hence, what the companies do their business should have against the product development related that must consider not only the technological satisfaction of consumers, but their affective needs as well. First, this is due to, according to Kim *et al.*, (2010:527) the affective need is greatly influenced by the appearance and performance functions of the products. Whether consumers choose a product, it depends largely on their emotional feelings of the product image (Lin *et al.*, 2004; 2005). Especially, due to the product image plays an important role in consumers' preference and choice of a product (Chuang *et al.*, 2001). On this reason, emotions mainly are conveyed through the semantics of an object. They follow a complex process including how the visual stimulus answers to customers' values, but also attributes and design elements (Kongprasert *et al.*, 2009:1)

Second, according to Oztekin *et al.*, (2011:1), to better serve the customer and create superior customer value, thus it is most helpful to know who the customer is and what the

χυστομερ ωαντσ. Τη θυεστιον οφ ωηο της χυστομερ ισ ρελατεσ το μαρκετ σεγμεντατιον ανδ ταργετ μαρκετινγ, ανδ της θυεστιον οφ ωηατ της χυστομερ ωαντσ δεπενδσ ον ιδεν τιφψινγ προδυχτ αττριβυτεσ ανδ τηειρ ρελατιβε ιμπορτανχε το της χυστομερ ορ μαρκετ σεγμεντ βεινγ ταργετεδ. Ωηιλε το βεστ μεετ χονσυμερσ' νεεδ οφ α προδυχτ φορμ α δεσιγν περσπεχτιβε, της πηψισιχαλ ελεμεντσ οφ της προδυχτ ρεθυιρε σηουλδ βε λινκεδ το της χονσυμερσ' περχεπτιον οφ της προδυχτ (Λιν *ετ αλ.*, 2004:898). Ον της ποιντ οφ ωιεω, της ρεδυχινγ οφ γαπ βετωεεν χυστομερσ ανδ προδυχτ ισ αν ιμπορταντ ιν προδυχτ δεσιγν (Κονγπρασερετ *ετ αλ.*, 2009:1). Ηοωεωερ, σινχε της προχεσσ οφ προδυχτ φορμ δεσιγν ορ της περχεπτιον οφ της χονσυμερσ ισ α οφτεν βλακκ βοξ ανδ involving uncertain information, according to Heffernaan and LaVelle (2006:1), the key to achieving

emotive success is how to understand the customers' needs and expectations. Here, Shen *et al.*, (2000:92) underlined that a deep understanding of customer satisfaction is a prerequisite to achieving customer satisfaction. For example, Dröge *et al.*, (1997:18) proposed the consumer satisfaction/dissatisfaction (CS/D) models pertinent to the consumer choice as a given and specify satisfaction to be a function of antecedents relative to the alternative already chosen. Whiles, Vahidnia *et al.*, (2008:593) suggested about some spatial planning or spatial problems that can be considered as a multiple criteria decision making or multiple MCDM problems involve a set of alternatives that are evaluated on the basis of conflicting and incommensurate criteria.

Third, Ayağ and Özdemir (2009:180) said human assessment on qualitative attributes is always subjective and thus imprecise. Due to in the real situations are, in facts, the information incomplete or imprecise to deal with problems (such as how to explore issues, how to describe a shared scenario, and how to realize the scenario for testing from design disciplines that can be useful to improve “vision” thinking for product design innovations), and also the linguistic assessment of human's feelings and judgments are vague and difficult to represent as crisp numbers, then the judgment should be taken carefully. Here, Chou *et al.*, (2007) commented about the using of interval judgments or fuzzy evaluations as an alternative solution. Rather on fixed value, they stated that fuzzy approach seems resulting with more confident. By considering this reason, according to Singh (2009:1), the fuzzy numbers or linguistic values characterized by fuzzy numbers used to convey the assessments of human's feelings and judgments are therefore required. Especially, in setting the priorities so that it will make the best decision when the both qualitative aspects of a decision need to be considered. An example, the synthetic extent analysis method of fuzziness-based analytic hierarchy process (AHP) approach so-called as fuzzy extended AHP (FEAHP). This approach is to address the complex decision problems, according to Meixner (2005), where there is a large number of decision makers (group decision in multi-criteria decision making or MCDM) and when there is a need to follow human behavior. This is due to fuzziness comes closer to reality compared to classical evaluation processes using crisp data. By



using fuzzy approaches for decision making, according to Chow and Luk (2005:280), it will enable the decision-makers to make choices among a number of alternatives and criteria based on the formulating priorities and a series of tradeoffs.

## 1.2. Problem Statements

Today's business world is very competitive markets where a successful product on the market will soon be followed by the competitors. In terms of business strategy, it is, therefore necessary for the company to improve their marketing strategy to survive in the current market. Especially, to the condition of markets where many players offers the products that consumer sees it as an alternative uniformity to the products in the market and as a choice of the desired product. In this condition, the customers tend to choose other products due to the number of product standardization in the market becoming abundant. However, the products that have its owned distinction, it will be able to attract the attention of consumers and help consumers to make decisions compared to products with similar functions in the market. Based on this reason, the difference of the products should be, therefore, achieved by a company through delivers the customer with the good product quality. This is due to the different products on the market if it is not coupled with a good quality, it will not be enjoyed by consumers.

Considering on this reason; where the customer satisfaction (CS) is a central issue of today's business and its imperative task in organizational performance to survive in hypercompetitive market, the overall customer satisfaction should be therefore determined as an indicator of a more fundamental relationship to the performance of the firm as a result of the behavior of the economy and benefit the firm (Anderson *et al.*, 1994). Various studies found that the level of higher customer satisfaction leads to greater customer loyalty (Anderson & Sullivan, 1993; Bearden & Teel, 1983; Bolton & Drew, 1991; Boulding *et al.*, 2009). Via loyalty is increasing, it is argued, customer satisfaction help for future earnings, (Fornell 1992; Rust *et al.*, 1994.1995), reduce the