CONTRIBUTION TO THE MAPPING OF CUSTOMER'S REQUIREMENTS AND PROCESS PARAMETERS

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ABSTRACT

This study proposed a decision method to help designers and engineers select manufacturing process that ensured to meet customer's requirements. It has intended to make a decision on manufacturing parameters such as quality, time, cost and environmental impact. The decision method was structured by a matrix. It was used to evaluate the relationship matrix between the manufacturing process of each product attributes and all the manufacturing parameters. The method was in 2 steps. The first was to create the matrix. The second was to support how to use the matrix to make a decision and select manufacturing process. Results from the matrix can be used to guide for selecting manufacturing process that is corresponding to customer's requirements.

Keywords: *customer's requirements, manufacturing process, environmental impact, leather goods*

1. INTRODUCTION

The idea of successful marketing has intended to see products from the customer's point of view. Good design and good quality are not enough to meet customer's requirements. Designers need to deal carefully with possible interaction problem between customers and

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product interfaces. Moreover, designers are challenged with questions of what environmental issues are most relevant and how to consider them in relation to the products that they are developing. In particular, it is quite relevant to understand how design changes can affect the environmental performance of product concepts early in design process [1].

Presently, the leather goods industry in Thailand is facing a severe competition in the global market. It was due to the quality that products do not meet customer's requirements. The image of products is not recognized by customers. Product visual form does not express their identity. Especially, the European market is interested in products that do not make an effect on the environment. On the other hand, manufacturers in Thailand still produce products by using a traditional manufacturing process that is not friendly with the environment. Thus, the European market does not accept products from Thailand. To compete in the global market, it is necessary to adopt design and manufacturing strategy coping with higher quality, reduced production costs, express their identity, meeting customer's requirements and friendly with the environment.

This purpose of this study is to propose a decision method to help designers and engineers select manufacturing process that ensures to meet customer's requirements. It means making a decision on manufacturing parameters (i.e. quality, time, cost and environmental impacts). The decision method is structured by a matrix. It leans on quality function deployment (QFD) concept to evaluate the relationship matrix between manufacturing process of each product attributes and manufacturing parameters. This paper is organized as follows: Section 2 presents the literature review. Section 3 describes a new decision method. Conclusion is drawn in Section 4.

2. LITERATURE REVIEW

2.1. Quality Function Deployment

Quality function deployment (QFD) is an important product development method. It is most commonly used in the early design phase of the design process [2]. QFD originated in the late 1960s and early 1970s in Japan from the work of Akao [3]. QFD is a systematic method for translating the voice of customers into a final product through various product planning, engineering and manufacturing stages in order to achieve higher customer satisfaction [4]. QFD is typically viewed as a four-stage process to design products that optimally meet customer needs. The first phase is to collect customer needs for the product (or customer requirements, customer attributes) called WHATs and then to transform these needs into technical measures (or technical requirements, product design specifications, engineering characteristics, performance measures, substitute quality characteristics) called HOWs. The second phase transforms the prioritized technical measures in the first phase into part characteristics, called Part Deployment. Key part characteristics are transformed in the third phase, called Process Planning, into process parameters or operations that are finally transformed in the fourth phase called Production Planning into production requirements or operations [5].

2.2. Sustainable Design

Sustainable product design, also known as Design for Sustainability (D4S), is one globally recognized way companies work to improve efficiencies, product quality and market opportunities while simultaneously improving environmental performance. The design for sustainability approach is based on taking a life cycle view of a product. The product life cycle starts with the extraction, processing and supply of the raw materials and energy needed for the product. It then covers the production of the product, its distribution, use (and possibly reuse and recycling), and its ultimate disposal. The environmental challenge for sustainable design is to design products that minimize environmental impacts during the entire of the product life cycle. Then, Sustainable design is a concept to help companies rethink how to design and produce products to improve profits and competitiveness and to reduce environment impacts at the same time [6].

There are various methods, qualitative and quantitative, for assessing the sustainability profile of product. Life-cycle assessment (LCA) is a methodology that attempts to quantify the overall environmental and economic impact from material extraction to eventual disposal at the end of life [7]. LCA can be used as decision support tools supplying information on the environmental effects of products [8]. The methodological framework for conducting LCA comprises four main phases: definition of goal and scope, inventory analysis, impact assessment and interpretation [9]. LCA was applied to many industrial sectors (e.g. food, leather, textile) to define environmental impacts. De Monte et al. [10] presented how to use of LCA methodology to evaluate environmental performances of alternative packaging systems for retail sales of coffee. Nazer et al. [8] proposed the method for reducing the environment impact of the unhairing-liming process in the leather tanning industry.

3. METHOD

This study followed the concept of the design system as shown in Figure 1. It was intended to help designers and engineers select manufacturing process that ensures to meet customer's requirements. The design system had 3 phases. First, brand value and customer perceptions were compared to explore brand identity. Second, the product attributes that express brand identity were used to create new products [11]. Third, the result from the second phase was used to contribute designers and engineers selecting manufacturing process.

This approach was structured by a matrix that mapped manufacturing process of each product attributes and manufacturing parameters. The structure of the matrix was composed of 3 parts: product attributes, manufacturing parameters and the relationship between product attributes and manufacturing parameters. This approach was in two steps. The first was to create the matrix that lean on QFD concept to evaluate the relationship matrix between manufacturing process of each product attribute and all the manufacturing parameters. The manufacturing parameters were quality, time, cost and environmental impacts. The second was to support how to use the matrix to make a decision and select manufacturing process. Results from the matrix will be used to guide designers and engineers selecting the manufacturing process of new leather bags.

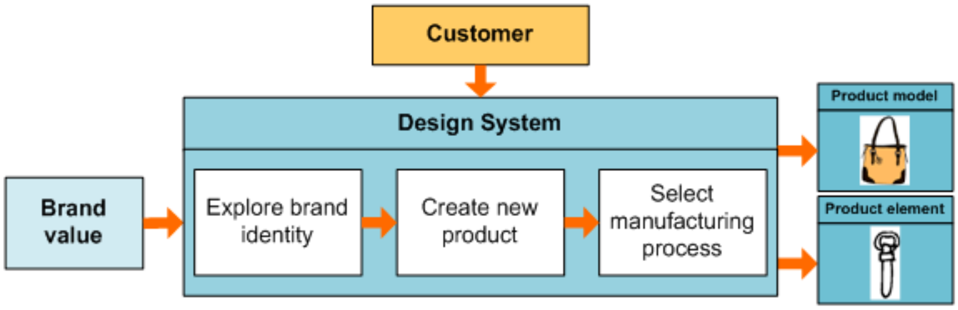

Figure 1: The concept of the design system

3.1. Product Attributes

The product attributes of leather bag can be defined in 2 groups: individual parts and assembly sets as shown in Figure 2. Each of the product attributes can produce from various manufacturing processes.

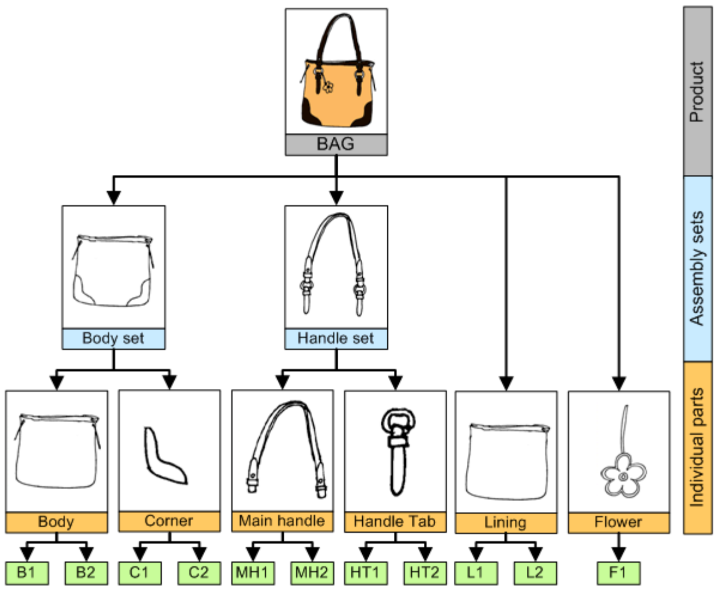

Figure 2: The product attributes of leather bag

3.2. Manufacturing Parameters

Manufacturing parameters can be defined by 4 parameters: quality, time, cost and environmental impact.

3.2.1. Quality

Classification of quality was based on basic functions and auxiliary function [12]. This study focused on basic functions that related to customer's feeling, such as soft, strong and straight [13]. "Soft", a soft feeling of leather gained value from tactile dimension. "Strong", a strong structure and proportional dimensions gained value from visual and tactile dimension. "Straight", smooth outside of the bags like a straight line that gained from visual dimension. They were quality characteristics that associated directly with manufacturing processes.

3.2.2. Time

This study focused on manufacturing times of each product attribute.

3.2.3. Cost

Normally, the production cost can be divided in 3 costs: material, labor and overhead. This study focused on material and labor costs.

3.2.4. Environment Impact

LCA is used to identify and assess the environmental impacts of leather goods industry. The impact matrix is used to impact assessment. The first step, designers and engineers selected the environment criteria, which were relevant to each stage of the product life cycle. The second step, designers and engineers filled in the impact matrix and highlighted the activities with relative high impact.

Environmental Criteria	Raw material	Manufacturing	Use	EOL
Water consumption	+++	0	0	0
Energy consumption	+	++	0	0
Toxic emission	+	+++	0	0
Recyclability	0	0	0	++

Figure 3: The result of impact matrix

The result of impact matrix is presented in Figure 3. Leather and cotton are usually raw material for making leather bags. Water is important to manufacturing process of leather and cotton due to they are chemical intensive industry. Thus, water consumption was selected in raw material stage.

Energy consumption was selected in manufacturing stage. Most of the electricity produced in Thailand is not based on renewable and clean technology (e.g. wind power, solar, tidal). It is based on thermal power plants because they have high efficiency and capacity and long service life [14].

Most toxic emission in leather goods industry produced from gluing process and painting process. The adhesive is used to assemble components through stitching (sewing) that most frequently used are solvent based. Lacquer and thinner are solvent based, which are mostly used in painting process. Disadvantage of solvent based conveys to some risks such as environment impact and harmful effects for the human body. Then, toxic emission was selected in manufacturing stage. Use stage had not environmental impact because leather bags don't need to use energy consumption.

We can extend End-of-Life (EOL) of leather goods by recondition, reuse, recycling and energy recovery. Recycling of post-consumer finished leather is not currently available [15]. Only accessories of leather goods can be reused and recycled due to their production from metal or plastic. Thus, EOL stage focused on recyclability of accessories. It can be defined in 2 directions: reuse and recycling. Reuse depended on the difficulty of disassembly. Recycling focused on the process to separate materials. It depended on the difficulty to separate, the existence of the recycling process and the difficulty to recover.

3.3. Relationship between Product Attributes and Manufacturing Parameters

This step was to evaluate the relationship values between product attributes and manufacturing parameters. This study used various methods to evaluate the relationship values.

3.3.1. Quality

Likert scale was used to evaluate the quality of product attributes. The scale value had 5 levels: 1 – strongly disagree, 2 – disagree, 3 – neither agree nor disagree, 4 – agree and 5 – strongly agree.

3.3.2. Time

Standard time of each process was used to calculate the manufacturing time. The unit of measure was minute.

3.3.3. Cost

Standard costs of each process were used to calculate the direct labor cost. This study assigned the average direct labor cost. It was 5 baht per minute. Quantity of material was used in each process. It was used to calculate material cost.

3.3.4. Environmental Impacts

- Water consumption focused on amount of water (litre) per material (1 kg) in manufacturing process.

Water consumption (litre) = material area (cm^2) x water consumption of each material (litre/cm^2)

- Energy consumption depended on machining time of each process.

Electricity consumption (kWh) = time (hour) x electric power (kW)

- Toxic emission focused on Volatile Organic Compounds (VOCs). VOCs are organic chemical compounds that may also be harmful or toxic. This study, VOCs emissions depended on gluing time and painting time. The VOCs values came from Material Safety Data Sheet (MSDS).

VOCs emissions (g) = weight of VOCs (g/litre) x manufacturing time (hour) x hourly usage (litre)

- Recyclability focused on reuse and recycling of accessories. Likert scale was used to evaluate the difficulty of disassembly (R_d), the difficulty of separate (R_s) and the difficulty of recover (R_r). The scale value had 5 levels: 1 – strongly difficult, 2 – difficult, 3 – neither difficult nor easy, 4 – easy and 5 – strongly easy. In case of existing recycling process (R_e), the value is 1, means to have been existing recycling process. The value is 0, means to have not been existing recycling process. The total parameters of recyclability were 4.

$$\text{Recyclability} = [(R_d/5) + (R_s/5) + (R_r/5) + (R_e)] / \text{Total parameters}$$

3.3.5. Results

The result matrix is shown in Figure 4. It summarizes the relationship values between product attributes and manufacturing parameters.

			Quality			Time (min.)	Cost (Baht)		Environmental Impacts			
									Raw Mat.	Manufacturing		EOL
			Soft	Strong	Straight		Material	Labor	water consumption (litre)	Energy consumption (kWh)	Toxic emission (g)	Recyclability
Individual part	Body	B1	5	3	2	32	252	160	19.53	0.2	26.66	0
		B2	3	3	4	25	280	125	16.926	0.1375	167.5	0
	Corner	C1	3	5	4	11	21	55	1.5345	0.1025	13.33	0
		C2	3	4	5	8	25	40	1.209	0.0975	154.2	0
	Main handle	MH1	3	4	3	46	100	230	6.51	0.325	26.66	0.65
		MH2	3	4	3	38	110	190	5.673	0.285	167.5	0.55
	Handle Tab	HT1	3	4	5	12.5	180	62.5	1.116	0.1063	13.33	0.6
		HT2	4	4	5	9.5	162	47.5	0.8184	0.0938	97.85	0.55
	Lining	L1	4	3	4	27	45	135	4.8825	0.0255	13.33	0
		L2	3	5	5	22	45	110	4.2315	0.0225	13.33	0
	Flower	F1	4	4	3	13.5	25	67.5	0.465	0.1875	97.86	0.25
Assembly	Body set (body + corner)	BS1	3	4	3	24	20	120		0.45	26.66	0.35
		BS2	3	4	3	21	30	105		0.385	83.01	0.4
	Handle Set (main handle + handle tab)	HS1	4	4	4	18	35	90		0.1875	13.33	0.4
		HS2	4	5	5	13	15	65		.0.1255	41.5	0
	Last Assembly	LA1	4	5	5	20	10	100		0.5625	26.66	0.65

Figure 4: The relationship values between all product attributes and manufacturing process

3.4. Use the Matrix to Make a Decision and Select Manufacturing Process

This section was to explain how to use the matrix to make a decision and select the manufacturing process. This section can be divided in three steps: define the technical conditions, generate solutions and make a decision to select manufacturing process as shown in Figure 5.

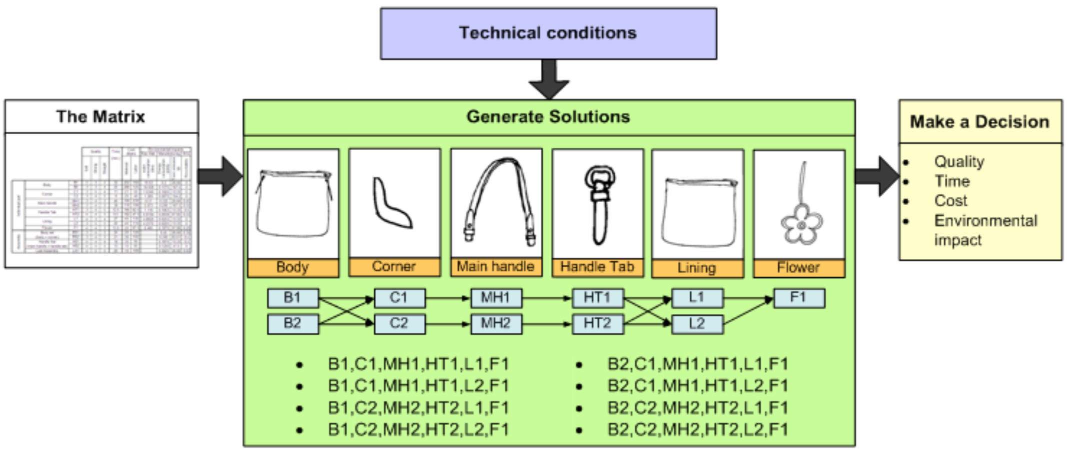

Figure 5: The framework of a new decision method

3.4.1. Define the Technical Conditions

This step defined the technical conditions to scope the limit of each manufacturing process. The technical conditions came from the experience of expert designers and expert engineers.

They were important to designers and engineers selecting the manufacturing process. If designers and engineers selected unsuitable techniques, the images or values of a leather bag will change. Then, designers and engineers have to understand the technical conditions of each technique.

The handle tabs were illustrated in Figure 6. They were produced from different techniques. The left handle tab (HT1) was the folding edge technique. The right handle tab (HT2) was the painting edge technique. The folding edge technique used more manufacturing time than the painting edge technique because it needed to fold the edge before stitching (sewing). The painting edge technique was used to make a low price bag due to it was an easiness to make. The manufacturing time was shorter than the folding edge technique as shown in Figure 4. Both techniques expressed the different images and values. HT1 expressed official. HT2 expressed casual and comfort. Thus, both techniques were not used in the same bag. Presently, the painting edge technique was used to make a luxury bag by changing color of the edge from same color to contrast color to increase attractiveness.

Figure 6: The example of assembly technique

3.4.2. Generate Solutions

Product attributes as shown in Figure 2, were combined to generate the manufacturing process solutions. This step was composed of two steps. First, the individual parts were selected to generate solutions. The assembly sets were not selected because their manufacturing processes usually follow the product individual parts. Then, the individual parts can be generated 32 solutions. Second, the solutions were reduced by using the technical conditions. The folding edge technique was used with C1, MH1 and HT1. The painting edge technique was used with C2, MH2 and HT2. Owing to the technical conditions, solutions were reduced from 32 to 8 solutions as shown in Figure 5.

3.4.3. Make a Decision to Select Manufacturing Process

This step was to make a decision selecting manufacturing process which depended on the manufacturing parameters (quality, time, cost and environmental impact).

		Quality			Time (min.)	Cost (Baht)		Environmental Impacts			
								Raw Mat.	Manufacturing		EOL
Solutions		Soft	Strong	Straight		Material	Labor	water consumption (litre)	Energy consumption (kWh)	Toxic emission (g)	Recyclability
1	B1+C1+MH1+HT1+L1+F1+BS1+HS1+LA1	3.67	4	3.67	204	688	1020	34.04	2.1468	257.8	0.32
2	B1+C1+MH1+HT1+L2+F1+BS1+HS1+LA1	3.56	4.22	3.78	199	688	1020	33.39	2.1438	257.8	0.32
3	B1+C2+MH2+HT2+L1+F1+BS2+HS2+LA1	3.78	4	3.89	182	674	910	32.58	1.8368	708.6	0.27
4	B1+C2+MH2+HT2+L2+F1+BS2+HS2+LA1	3.67	4.22	4	177	674	885	31.93	1.8338	708.6	0.27
5	B2+C1+MH1+HT1+L1+F1+BS1+HS1+LA1	3.44	4	3.89	197	716	985	31.43	2.0843	398.7	0.32
6	B2+C1+MH1+HT1+L2+F1+BS1+HS1+LA1	3.33	4.22	4	192	716	960	30.78	2.0813	398.7	0.32
7	B2+C2+MH2+HT2+L1+F1+BS2+HS2+LA1	3.56	4	4.11	175	702	875	29.97	1.7743	849.5	0.27
8	B2+C2+MH2+HT2+L2+F1+BS2+HS2+LA1	3.44	4.22	4.22	170	702	850	29.32	1.7713	849.5	0.27

Figure 7: The summary values of each solution

From the target customer of previous phase in the design system [11], it focuses on officers. They are between 25-35 years old. The salary is medium-high. Lifestyle is trendy. Thanks to the folding edge technique express to official value and the painting edge technique is related to trendy style when using contrast color, both techniques can be used to make bags for this target group. The new products can be classified in 2 collections: formal style (classic color + the folding edge technique) and casual style (contrast color + the painting edge technique)

In the manufacturing process point of view, solution 8 is the shortest time. However, it is not friendly with an environment because this solution releases toxics more than the other solutions. Solution 7, the manufacturing time is longer than solution 8 a bit, but production cost and toxic emission are much lower than solution 8. Results from the matrix are only used to guide designers and engineers select solution. Then, the suitable solution depends on decision of designers and engineers.

4. CONCLUSION

This study proposed a decision method to help designers and engineers selecting manufacturing process that ensured to meet customer's requirements. It intended to make a decision on manufacturing parameters such as quality, time, cost and environmental impact. The decision method was structured by a matrix that mapped product attributes and manufacturing parameters. The technical conditions were used to scope the limit of each manufacturing process. The manufacturing process solutions were reduced from 32 to 8 solutions. Results from the matrix will be used to guide designers and engineers selecting manufacturing process. The suitable solution depends on a decision of designers and engineers.

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