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An Innovative Design Approach for Charcoal Briquette Packaging Design to Meet Customer Requirements

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Abstract
To survive in the competitive challenges, the products have to be designed to meet the needs and requirements of customers, differ from the competitors, and be friendly with the environment. This research was to propose an innovative design approach for charcoal briquette packaging design to meet the customer requirements. The customer requirements were explored and translated to product characteristics by using quality function deployment. The customers' perceptions to product visual forms were explored through the emotional design approach. Customers' requirements and customer perceptions were integrated to create a new charcoal briquette packaging. A new packaging design and process during its life cycle was evaluated an impact on the environment through carbon footprint values. The result showed that the innovative design approach can be used to guide designer design the charcoal briquette packaging to meet the requirements and perceptions of customers, illustrate the product identity and be friendly with the environment.

Keywords
Customer requirement, Emotional design, Quality function deployment, Brand identity, Life cycle assessment.

Introduction

It is a known fact that design plays a very important role on effective and efficient marketing and customer satisfaction of any kind of products. The novelty for the 21st century is that they mainly ask for personalized products and services. New products have to be dramatically designed and manufactured: they are expected to meet the needs and requirements of customers, differ from the competitors, and be friendly with the environment. This trend leads to force design method to think a new partnership between designers and customers. Collaborative design based on customer expectations are some of main parameters which influence the final design of a product. To take advantage over the competitors, a designer needs to adapt the design and manufacturing strategy to respond to continuous change of customers. Thus, it is important to work closely with customers to make sure that the products will fulfil their needs and requirements (Kongprasert, 2012).

The Bio-Circular-Green Economy Model (BCG) is being touted by the government as a new model to bolster economic recovery. BCG model has been conceptualized to underpin Thailand 4.0 policy as a strategy to drive the economic and social development. BCG economy is placed on the national agenda to speed up development because the sectors can increase the value of products and services, and keep economy, society and the environment in balance. The four strategic areas for the BCG model are based on economic foundation and strengths namely, food and agriculture; medical and wellness; energy, material, and biochemicals; and tourism and creative economy. Science, technology and innovation will be employed to enhance the capacity and competitiveness of players in the value chain, both upstream and downstream, in all four segments, coupled with supportive policy, legal and financial measures. Thus, the BCG model is a global megatrend and it will be a new growth engine for the Thai economy in the future.

Thailand is an agricultural country in Southeast Asia having a large number of agricultural products. After harvesting, there will be a large amount of agricultural waste left which could be used as biomass

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energy. In Thailand, biomass can be produced from agricultural waste materials, such as cassava root, rice straw, leave and stem of sugar cane, bagasse fiber, coconut shell, and palm shell. Charcoal briquette is one of the biomass fuels that have a good potential of creating a new form of sustainable energy source. It is a block of compressed coal dust, charcoal dust, sawdust, wood chips, or biomass, which can be used as fuel in stoves. It can be produced in a simple process and having a high heat value. It can make from various types of agricultural waste: including coconut shell, sugarcane bagasse, cassava rhizomes, coconut husks, sawdust, rice husks, coffee husks, soda weed, rice bran, and Madan wood (Kongprasert et al., 2019). Thus, this study focuses on the charcoal briquette because of is widely used for cooking purposes and has the potential to increase the value of the product.

From these important challenges, it is important to develop a design methodology that supports the design activity to meet the needs or requirements of modern customers, increase the value of the product, and be friendly with the environment. It focuses on a conceptual design process. The new design approach can help skilled designers to respond to important challenges or problems by integrating the emotional design, quality functional deployment, product identity and environmental impacts in the design process.

Literature review

Emotion is crucial for everyday decision making (Norman, 2004). Emotion fundamentally involves physiological arousal, expressive behaviors, and conscious experience (Myers, 2004). Customer's satisfaction is an affective behavior of customer. It relies on desires more than needs which desires are mainly depending on aesthetic, semantic and symbolic aspects of cognitive response to design (Crilly et al., 2004). This means that the customer purchases a product based on more subjective terms such as manufacturer image, brand image, reputation, design, impression, etc., although the products seem to be equal. Emotional design is a technique as product design targeted to satisfy customer's needs or requirements. By controlling certain design factors, customer's emotions can be evaluated, designed, and satisfied (Choi & Jun, 2007). Emotional design is relationship between the emotional responses and design appearance that focused on the user's need and experience. It is used to translate the feeling of customers and emotions related to products into the product domain. It is not only communicated through the style of design, function, form and usability, but also built up experience for the user on their needs and demands. There are three levels of information processing according to the situation and response: visceral, behavioural, and reflective. Visceral design concerns itself with appearances. Behavioural design has to do with the pleasure and effectiveness of use. Reflective design considers the rationalization and intellectualization of a product. They are integrated through any design (Norman, 2004). Emotional design is a common research field involving both designers and human factors. It focuses on the evaluation and decision-making phase in the design process. It is used to identify correspondences and gaps between customer's perception and designer's intention as illustrated in Fig. 1. The correspondence is used to guide designers for creating the new product. The gap is removed or modified to be relevant to customer's perception. The advantage of the emotional design is that the product designed responds to the needs or requirements of customers (Kongprasert, 2015). Practically, emotional design is performed with the questionnaire that new product or concept is evaluated by the customers. Semantic differential and Likert scale are used to measure the perceptions or attitudes of customer. Emotional design has been successfully applied in various design domains, such as consumer products (Battarbee & Mattelmaki, 2003), glasses (Lu & Petiot, 2014), shoes (Bouchard et al., 2009; Shieh & Yeh, 2013), hammers (Vergara et al., 2011), chairs (Kongprasert, 2012), perfume bottles (Huang et al., 2012), pillow (Kongprasert, 2014), eyeglass frame (Lu & Petiot, 2014), razors (Razza & Paschoarelli, 2015) and fashion products (Kongprasert & Butdee, 2017).

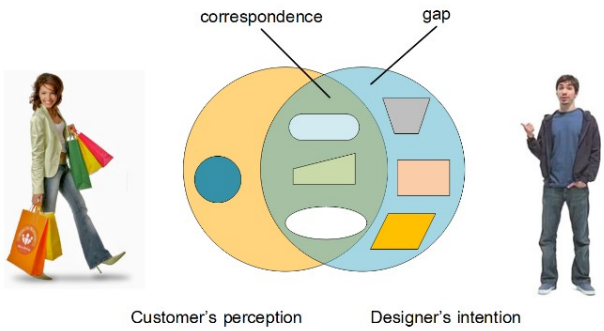


Fig. 1. Emotional design principle (Kongprasert, 2015)

Quality function deployment (QFD) is another customer-driven tool which 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 (Chen & Weng, 2006). QFD

is generally used in the early phase of new or improved products/services design process (Raharjo et al., 2008). QFD originated in the late 1960s and early 1970s in Japan from the work of Akao (1990). QFD has been used by many companies because of the following three basic reasons: saving design and development time, focusing on the satisfaction of customer and improving communication at all levels of the organization (Myint, 2003). 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 (Chan & Wu, 2002). QFD has been utilized extensively in the area of product design and manufacturing, such as computer mice (Lo et al., 2010), water cup (Mohamad & Yusoff, 2013), mobile phone (Wu & Ho, 2015), airplane tail (Ashtiany & Alipour, 2016), and offshore wind power (He et al., 2018). QFD can also be extended to service industries which include restaurant (Sularto et al., 2015) and hospital (Wood et al., 2016).

In business, a company that makes similar products in terms of products' performance on customer needs or requirements is a competitor. The difference from competitors leads to create their own identity which is personal or individual characteristics that are used to distinguish company's products and competitors. Identity expresses the values of the product with their form and features. It specifies the product's meaning, aim and self-image and fosters recognition. Thus, designer needs to focus on the identity of products. Warell et al. (2006) describe identity to the domain product design. First, they define identity as an attribute of a thing, which is shared with something else (i.e., 'similarity'); on the second, identity can be seen as a unique attribute of a thing (i.e., 'dissimilarity'). Identity expresses the brand's tangible and intangible characteristics and draws upon the brand's roots and heritage (Kapferer, 2008). Brand identity involves the key identity attributes of the company in a "condensed" form. It expresses the values of the brand with their form. The purpose of brand identity is to specify the brand's meaning, aim and self-image and is to foster recognition (Karjalainen, 2003). Brand identity is made of physique and personality. First, a brand has physical specificities and qualities – its 'physique'. It is made of a combination of either salient objective or emerging ones. Physique is both the brand's backbone and its tangible added value. The physical aspects of a products also comprise the brand's prototype and the flagship product that is representative of the brand's qualities. By communicating, any brand gradually builds up character with having specific personality. The way in which it speaks of its products or services shows what kind of person it would be if it were human. Then, brand identity illustrates the unique attribute that differs from the competitor and is to foster recognition while it is used to illustrate the unique attribute to share something, to transfer to next generation and to create the heritage (Kapferer, 2008). Various studies have followed a brand identity approach to analyze the brand, identity and visual form design of various products for creating new products or concepts, such as cars (Karjalainen, 2003; McCormack et al., 2004; Karjalainen & Warell, 2005; Karjalainen et al., 2006; Karjalainen, 2007; Warell, 2015), home appliances, fashion products (Kongprasert et al., 2008; Kongprasert & Butdee, 2017; Xu & Liu, 2019), furniture (Kongprasert, 2012) and pillow (Kongprasert, 2014).

Owing to environmental problems such as climate change, pollution, health, working circumstances and safety, the products that do not meet these concerns will be rejected by customers. Products that increase the environmental burden will also have no future. Thus, designer is challenged with new questions of what environmental issues are the most relevant for their business and how to consider them in relation to the products during product development. To understand how design changes affect the environmental performance of product concepts, designers need to focus on the environmental impacts that will occur in each stage of product life cycle. A life cycle approach is to assess the environmental impacts in conjunction with economic impacts under consideration of technical boundary conditions. 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 manufacture of the product, its distribution, use (and possibly reuse and recycling), and its ultimate disposal. Environmental impacts of all kinds occur in different phases of the product life cycle and should be taken into consideration for in an integrated way. The carbon footprint (CF) is one of the indicators of climate change, corresponding to a measure of the greenhouse gas (GHG)

emissions and removals associated with a product or process. The CF should be estimated based on the life cycle assessment (LCA) methodology, allowing for an effective quantification of the direct and indirect environmental impacts of a product or process during its life cycle, from material extraction, to production and final use (Mata et al., 2005; Morais et al., 2010). The LCA methodology makes it easier to identify the process' inputs and outputs responsible for the main environmental burdens and identify opportunities for improvement (Mata et al., 2003). Several studies are proposed LCA methodology for assessing the carbon footprint, as for example the PAS 2050 (2011) that establishes guidelines and specific requirements for assessing GHG emissions, based on the LCA methodology. Some of the more recent examples of LCA applications in corporate decision making, such as milk production (O'Brien et al., 2014), building materials' production (Giama & Papadopoulos, 2015), wind farm (Ji & Chena, 2016), beef production (Buratti et al., 2017), lithium-ion batteries (Lianga et al., 2017), and drink products (Cimini & Moresi, 2018).

Methodology

This study was to propose an innovative design approach for creating the new product for an effective marketing. It is conceptual design process. It integrated the functional needs and emotional needs of customers to design a new product and evaluate an environmental impacts at the same time. The customer's requirements were explored and translated to product characteristics by using quality function deployment. The customers' perceptions to product visual forms were explored through the emotional design approach. Customers' requirements and customer perceptions were integrated to create a new charcoal briquette packaging. A new packaging design and process during its life cycle was evaluated an impact on the environment through carbon footprint values. An innovative design approach has four phases as illustrated in Fig. 2. First, it was to explore the customer's requirements. Quality function deployment was used to translate the customer's requirement (functional needs) to part characteristics. Second, it was to explore the customer's perceptions to product visual form through emotional design approach. Third, it was to create the new product concept. Customer's requirements and perceptions were integrated to design a new product. Forth, it was to evaluate possible impact on the environment. Carbon footprint was used as an indicator for evaluating an environment impacts of a new product and process during its life cycle. This study focused on charcoal briquette packaging design to meet the customer requirements. This approach employed the following steps.

Phase 1: Explore the customer's requirements

This phase is to explore the customer requirements or needs and transform customer needs into part characteristics through QFD approach. It has two stages. First, QFD approach was formally employed at this stage for building voice of customer (VOC) into technical measures. Second, it was to transform technical measures into part characteristics. The technical characteristics are weighed and prioritized.

1) Explore the customer requirements and transform these needs into technical measures

This stage is called House of Quality (HOQ) building and the detailed process will be described in the following sections.

A: Customer Needs (WHATs)

The VOC represents customer requirements and expectations for charcoal briquette packaging. Data were collected from interview and weight by one thousand that based on questionnaire. Following questions were addressed during the survey conducted.

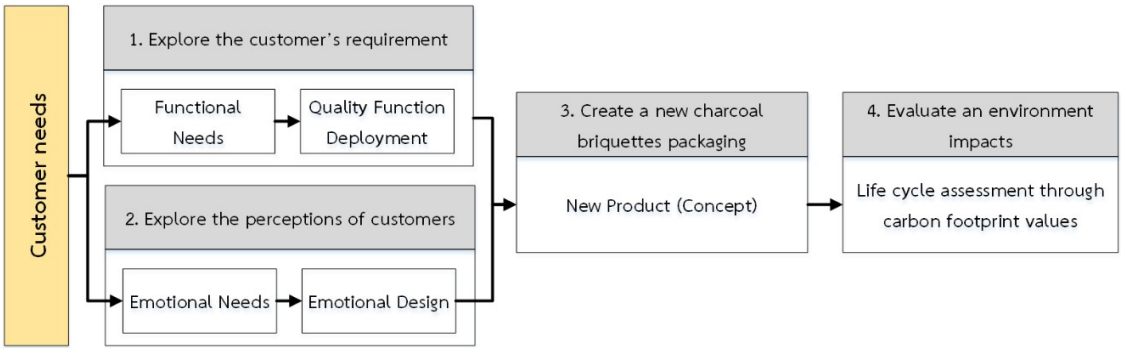


Fig. 2. An innovative design approach for new product design

B: Technical measures

This part listed and structured the technical measures (HOWs) identified by the product development team. The units and directions of goodness or improvement of these HOWs were also determined to facilitate further analysis and deployment. The list of customer requirements from section A were transformed into technical measures as shown in Fig. 3.

C: Relationship Matrix Between WHATs and HOWs

The Relationship Matrix of WHATs vs. HOWs is a systematic means for identifying the degree of relationship or linkage between each WHAT and each HOW. This study used 0, 1, 3, 9 scale to illustrate the relationship between customer requirements and technical measures. The detail of this section is depicted in Fig. 3.

D: Technical Correlation Matrix

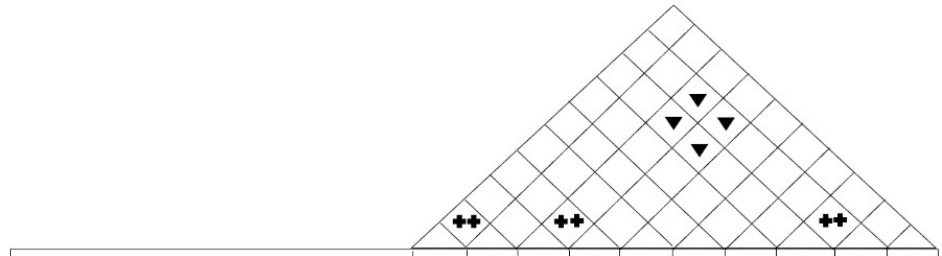
The Technical Correlation Matrix is the development team's assessments of which HOWs are interrelated and how strong these relationships are, which can be obtained through engineering analysis and experience. It can help designer to know the relationship and limitation of technical measures. This study, five types of technical correlations or impacts were identified in QFD: strong positive impact, moderate positive impact, no impact, moderate negative impact, and strong negative impact. A set of symbols are ++, +, (blank), −, −−. The detail of this section is shown in in Fig. 3.

E: Technical Matrix

The Technical Matrix contains more technical information that is linked to both customer needs and parts characteristics in QFD's second phase. It provides the initial rank ordering of the technical measures' relative importance based on the information in the previous parts. The result illustrated the final importance rating of each HOW that is a comprehensive measure for the HOW's priority (Fig. 3).

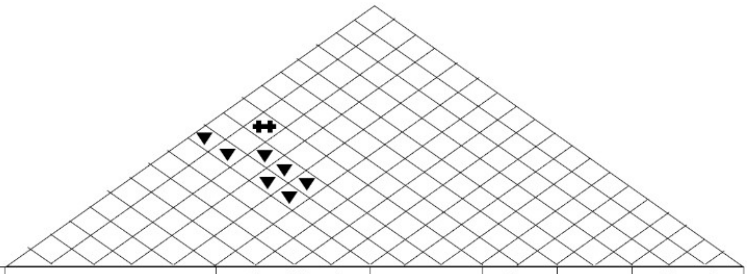
2) Transform technical measures into part characteristics

This phase was to transform technical measures into part characteristics through QFD approach. The technical characteristics are weighed and prioritized and serve as inputs for part deployment. Second, After the HOQ stage it comes up with the part deployment stage. At this stage the weighed of technical characteristics are linked with part characteristics of charcoal



Rows	Relative Weight	Relative Importance	Technical Measures / Customer Needs	1 Water proof material	2 Completely Close System	3 Strength Shape	4 Strength Material	5 Transparent Material	6 Open/Close System	7 Ignite Equipment	8 Compact size	9 Lightweight	10 Have handle
			Columns	1	2	3	4	5	6	7	8	9	10
			Direction	✖	✖	▲	▲	✖	✖	✖	▼	▼	✖
1	15.3	0.153	Can protect water and humidity from air	◎	◎		△						
2	15.6	0.156	Can keep the quality of charcoal briquettes	◎	◎		○						
3	14.5	0.145	Be stable and strength	○	△	◎	◎						
4	12.7	0.127	Can see through charcoal briquettes from outside					◎					
5	14.5	0.145	Be ready to open and close						◎		◎		
6	13.1	0.131	Have equipment for helping ignite							◎			
7	14.2	0.142	Be convenience for take away								◎	◎	◎
	100	1											
			Possibility	4	5	5	5	4	5	3	5	5	5
			Relative Importance	1286.4	1463	652.5	963	457.2	652.5	353.7	1291.5	639	639
			Relative Weight	15.32	17.42	7.77	11.47	5.44	7.77	4.21	15.38	7.61	7.61

Fig. 3. The HOQ of charcoal briquette packaging



Rows	Relative Weight	Relative Importance	Part Characteristics / Technical Measures	Material					Open/Closed System				Shape			See through		Ignite equipment		Type of Handle		
				Carton box with vanishing laminate	Craft paper with PP coating	Polypropylene (PP)	Plastic bag with graviera coating	Plastic bag with foil	Top cover system	Insert lock system	Zip locked system	Zip system	Cylindrical	Pyramid	Box	Window cut & Plastic	Window Cut	Alcohol Fuel	Torch	Rope Handle	Plastic Handle	Carton box handle
1	15.32	1286.4	Water proof material	◎	○	◎	○	◎														
2	17.42	1463	Completely Close System						◎	◎	○											
3	7.77	652.5	Strength Shape	◎	◎	◎	△	△					◎	○	◎							
4	11.47	963	Strength Material	◎	△	◎	○	△					○	○	○					△	○	○
5	5.44	457.2	Transparent Material													◎	◎					
6	7.77	652.5	Open/Close System						◎	○	△	○										
7	4.21	353.7	Ignite Equipment															◎	◎			
8	15.38	1291.5	Compact size										△	○	○							
9	7.61	639	Lightweight	○	◎	○	○	◎														
10	7.61	639	Have handle																	◎	◎	◎
			Difficulty	1	1	1	1	2	1	1	1	2	1	3	1	2	2	3	3	1	1	1
			Relative Importance	312.27	197.67	312.27	103.73	96.24	250.92	199.33	66.44	12.9	132.48	38.31	166.55	16.96	16.96	7.77	7.77	88.47	113.85	113.85
			Relative weight	13.8	8.7	13.8	4.60	4.27	11.1	8.84	2.9	0.6	5.9	1.7	7.4	0.7	0.7	0.3	0.3	3.9	5.0	5.0

Fig. 4. The part deployment of charcoal briquette packaging

briquette packaging. The detailed process is the same as HOQ. The part deployment of charcoal briquette packaging is shown in Fig. 4.

The part characteristics which have high relative weight values are used to design a new charcoal briquette packaging in next phase. They illustrated as follow:

- Material: carton box with vanishing laminate (13.8) and polypropylene (13.8).
- Open/Closed System: top cover system (11.1) and insert lock system (8.84).
- Shape: cylindrical (5.9) and box (7.4).
- Type of handle: plastic handle (5.0) and carton box handle (5.0).

Phase 2: Explore the perceptions of customers

This phase explored the correspondence and the gap between designer's intention and customers' perception and explore the product attributes that express the product personality. The customer's perception that corresponds to the designer intention is analyzed to explore the product personality. The product personality comes from product attribute. It is used to design a new product in the next phase.

This phase is followed the following steps:

1) Definition of sample charcoal briquette packaging

It focused on famous brands that were collected from website and internet. Ten charcoal briquette packaging images were selected to use in this study as shown in Fig. 5.

Fig. 5. Sample charcoal briquette packaging

2) Definition of semantic words

Semantics is often used in ordinary language to denote a problem of understanding that comes down to word connotation. It is used to describe the characteristics of the product from the customer's point of view. It is composed of two opposite semantic words and five

level scale. The semantic words were collected from magazines and websites. Five pairs of the opposite semantic words that are related to product personality were selected by experts and designers. They were Powerful-Eco friendly, Compact-Premium, Natural-Unique, Convenient-Safety and Simple-Strong. This selected list was brand-dependent and every charcoal briquette packaging visual of the brand will be tested against the same list of semantic words.

3) Definition of the questionnaire

The questionnaire is to provide designers with a fine understanding of customer's perceptions. It supports the exploration of the customer's perception of product visuals. It was created to help the designer to interview the targeted customers. It was used to interpret the customer's perception of product visual forms. It both measures semantics and examines the links between semantics and product. It is composed of charcoal briquette packaging image, semantic words and the Likert scale as shown in Fig. 6. The Likert scale is a psychometric scale commonly used in questionnaires. It is the most widely used scale in survey research, such that the term is often used interchangeably with rating scale even though the two are not synonymous. The scale used for evaluation was a five degree Likert scale (–2, –1, 0, 1, 2). The questionnaire was posted on website to interview the target group.

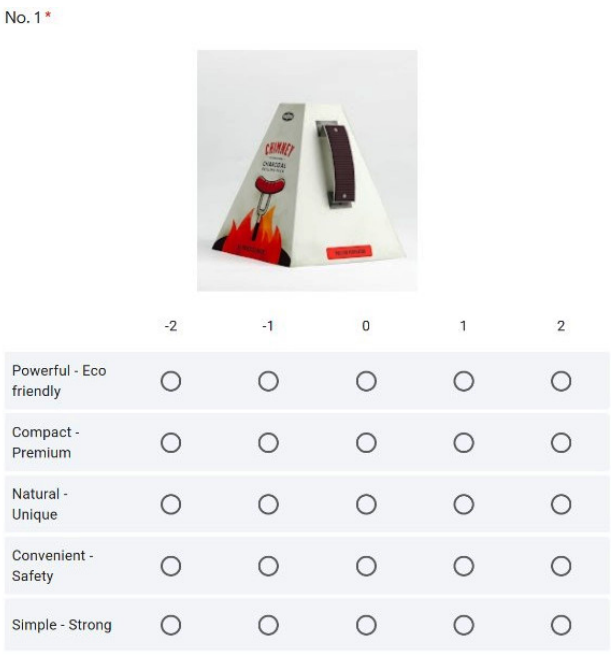


Fig. 6. Sample questionnaire

4) Interview target customers

This research focused on the perception of Thai peoples who live in Bangkok metropolitan and use as a cooking fuel for households. One thousand customers were interviewed.

5) Data analysis

This step consisted of the interpreting data from the questionnaire and data analysis by using STATBOX software. First, the data from the interviews were interpreted to explore the range and average semantic values of each packaging. The average semantic value of each packaging can be calculated as follows (Equation (1)).

$$S_{\text{packaging(aver)}} = \frac{\sum_{i=1}^{n} S_{\text{packing}(i)}}{n} \tag{1}$$

where: $S_{\text{packaging(aver)}}$ = the average semantic value of a packaging; $S_{\text{packing}(i)}$ = the semantic value of the packaging for customer i; n = number of data (number of customers' responses).

Table 1 only summaries the values of the semantics for all packaging. This data was created to prepare data before clustering the products.

Second, the clustering of visuals based on the experts' perceptions is done with the principal component analysis (PCA) technique. PCA is mostly used as a tool in exploratory data analysis and for making predictive models. Principal component analysis is concerned only with establishing which linear components exist within the data and how a particular variable might contribute to that component. STATBOX was employed as statistical tool that enables us to process a statistical analysis with PCA tools. The result from STATBOX enables to visualize through PCA mapping.

Table 1
The semantic value of each packaging.

Packaging No.	Powerful–ECO Friendly	Compact–Premium	Natural–Unique	Convenient–Safety	Simple–Strong
No. 1	–0.875	0.125	–0.325	0.275	–1.235
No. 2	0.712	0.465	–0.712	–0.135	–0.315
No. 3	–0.356	0.345	0.625	1.335	–0.625
...					

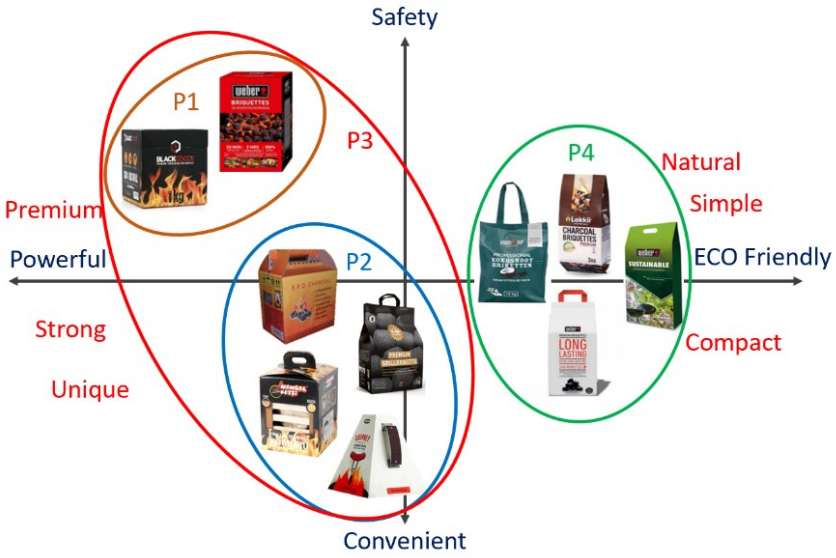


Fig. 7. Principal Component Analysis (PCA) mapping results

6) Results of PCA

The PCA mapping shown all packagings that were acted on with semantic words as shown in Fig. 7. It was clustered and interpreted from experts. The PCA mapping helps to explore the product's attributes that were relevant to semantic words. The results can be clustered in 4 groups.

P1: it is packaging group that expresses "Premium" and "Safety" value. "Premium" comes from black background (label) with white letter (detail). "Safety" comes from rigid box.

P2: it is packaging group that illustrates "Convenient" value. It comes from the handle of packaging.

P3: it is packaging group that expresses "Powerful" and "Strong" value. They come from the red and yellow colour of flame on packaging.

P4: it is packaging group that illustrates "Natural" and "Eco-friendly" value. They come from the colour of packaging that are earth tone (e.g. white, green, brown).

From the results, the authors can summarized in terms of the relationship between product attributes and product personality as follows:

- Designers should select black background (label) with white letter (detail) to illustrate "Premium" personality.
- Designers should select rigid box to express "Safety" personality.
- To get "Convenient" personality, designers should design packaging with handle.
- Designers have to select red and yellow flame to increase and add "Powerful" and "Strong" perception to charcoal briquettes.
- To be friendly with environment, designers should select white, green and brown colour of packaging to illustrate "Natural" and "Eco-friendly" personality.

Phase 3: Create a new charcoal briquette packaging

This phase was to create a new charcoal briquette packaging. The results from previous phases, customers' requirement and perceptions were integrated to design a new packaging. First, the part characteristics which have high relative weight values as shown in Fig. 4 were used to design a new charcoal briquette packaging that are related with customer needs. They were cylindrical (shape), box (shape), carbon box with vanishing laminate (material), polypropylene (material), top cover system (open/closed system), insert lock system (open/closed system), plastic (handle), and carton box (handle). The authors can generate 16 design concepts. All design concepts were reduced by focusing on standard packaging that widely sold in Thailand market. Thus, design concepts were reduced from 16 to 4 concepts as shown in Fig. 8.

Four concepts of packaging based on customers' requirements was illustrated in Fig. 9. In functional point of view, concept C and D can protect water and humidity from air because they made from polypropylene. All concepts can keep the quality of charcoal briquettes, be stable and strength, be ready to open and close and be convenience for take away. All concepts cannot see through the charcoal briquettes from outside and do not have equipment for helping ignite

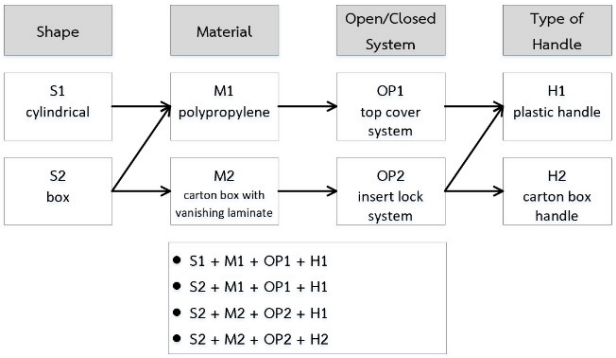


Fig. 8. Generate idea of new charcoal briquette packaging

which do not meet customer requirements and expectations as mentioned before.

Concept	Part Characteristics	Photo
A	**Shape:** Box (S2)	
	Material: Carton box with vanishing laminate (M2)	
	Open/Close System: Insert lock system (OP2)	
	Handle: Plastic handle (H1)	
B	**Shape:** Box (S2)	
	Material: Carton box with vanishing laminate (M2)	
	Open/Close System: Insert lock system (OP2)	
	Handle: Carton box handle (H2)	
C	**Shape:** Cylindrical (S1)	
	Material: Polypropylene (M1)	
	Open/Close System: Top cover system (OP1)	
	Handle: Plastic handle (H1)	
D	**Shape:** Box (S2)	
	Material: Polypropylene (M1)	
	Open/Close System: Top cover system (OP1)	
	Handle: Plastic handle (H1)	

Fig. 9. Concept of packaging based on customers' requirements

Second, the relationship between product attributes and product personality were used to generate idea (concept) of new charcoal briquette packaging that were related with customer perceptions (emotional needs). This study, the charcoal briquette manufacturer preferred new charcoal briquette packaging that focused on "Powerful" and "Premium" values. Red and yellow flame were used to illustrate "Powerful" value. Black background (label) and white letter (detail) was selected to illustrate "Premium" personality. The authors can create in 5 label concepts as shown in Fig. 10.

Five label concepts were proposed to the charcoal briquette manufacturer. Concept of label packaging (L3) was selected. Then, L3 was used to design a new charcoal briquette packaging. Four concepts of new

Fig. 10. Concept of label packaging based on emotional needs

charcoal briquette packaging were integrated with L3 labelling as illustrated in Fig. 11.

Fig. 11. A new charcoal briquette packaging

Phase 4: Evaluate environmental impact

This phase was to explore possible impact on the environment of each new packaging design and process during its life cycle through carbon footprint values. It focused on evaluating the carbon footprint value in raw material, manufacturing and disposal stage. Four concepts of new charcoal briquette packaging as shown in Fig. 11, they were analyzed to create the operation process chart of each concept. Concept CBP 1 and CBP used the offset printing and vanish coating technique for making the label on the box. Concept CBP 3 and CBP 4 used the offset printing technique for making the sticker label on the box. Fig. 12 illustrated the sample operation process chart of concept CBP 2. The weight and area of each packaging concept were used to calculate the carbon footprint value and packaging cost. The carbon footprint value based on calculation of emission factor value from Thailand Greenhouse Gas Management.

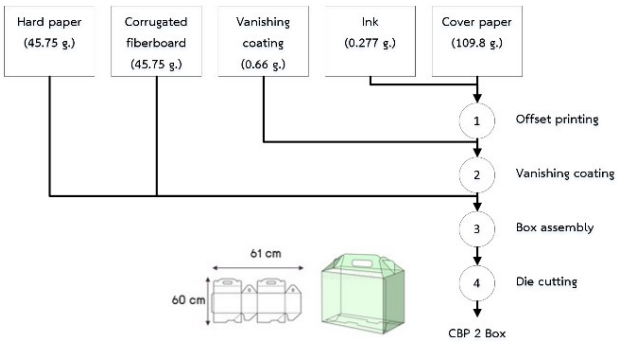


Fig. 12. The sample operation process chart of concept CBP 2

No.	Concept	Area (cm2)	Stage	Detail	Quantity	Emission factor per unit	Carbon Footprint	Total Carbon Footprint	Packaging Cost (Baht)
CBP 1		3050	Raw Material	Carton box	91.5 g	1.6149	0.1478	0.4692	20
				Corrugated fibreboard	38.125 g	1.6052	0.0612		
				Hard paper	38.125 g	1.851	0.0706		
				Ink	0.231 g	2.5	0.0006		
				Vanishing coating	5.55 g	1.8823	0.0104		
				HDPE Handle	12.15 g	1.617	0.0196		
			Manufacturing	Offset printing	114 w	0.6093	0.0695		
				Vanishing coating	114 w		0.0695		
				Box assembly	132 w		0.0804		
				Die Cutting	180 w		0.1097		
			Disposal	Paper Recycle	179.9 g	-1.88	-0.1505		
CBP 2		3660	Raw Material	Cover paper	109.8 g	1.6149	0.1773	0.5125	24
				Corrugated fibreboard	45.75 g	1.6052	0.0734		
				Hard paper	45.75 g	1.851	0.0847		
				Ink	0.277 g	2.5	0.0007		
				Vanishing coating	6.66 g	1.8823	0.0124		
			Manufacturing	Offset printing	114 w	0.6093	0.0695		
				Vanishing coating	114 w		0.0695		
				Box assembly	132 w		0.0804		
				Die Cutting	180 w		0.1097		
			Disposal	Paper Recycle	201.3 g	-0.82	-0.1651		
CBP 3		2292	Raw Material	Polypropylene (PP) Handle (PP)	129 g	1.3621	0.1757	0.1792	31.75
				Ink	0.2 g	2.5	0.0002		
				PVC sticker	9.16 g	1.8823	0.0047		
				Paper core	3.25 g	0.7243	0.0024		
			Manufacturing	Offset printing	114 w	0.6093	0.0695		
				Cut sticker	120 w		0.0731		
			Disposal	Plastic recycle	138.16 g	-1.06	-0.1464		
CBP 4		3050	Raw Material	Polypropylene (PP) Handle (PP)	144 g	1.3621	0.1961	0.1818	32.75
				Ink	0.2 g	2.5	0.0001		
				PVC sticker	7.8 g	0.51	0.0039		
			Manufacturing	Offset printing	114 w	0.6093	0.0695		
				Cut sticker	120 w		0.0731		
			Disposal	Plastic recycle	151.8 g	-1.06	-0.1609		

Fig. 13. The summarized value of each packaging

The results are illustrated in Fig. 13. Concept CBP 1 was the most suitable option when cost was considered as a priority. The packaging cost was lower than those of the other concepts. The carbon footprint of concept CBP 3 was lower than those of the others regarding impact on the environment which does not create any adverse impact. This concept releases carbon footprint (0.1792).

Discussion

From the customer requirements and expectations for charcoal briquette packaging in the first phase, it seems that customers would like to take all requirements into packaging. The authors can observe from the value of each requirement that has a value between 12-15%. Contrary, the results from QFD do not illustrate the important relative value of part characteristic which can see through the charcoal briquettes from outside and has equipment for helping ignite. It may occur from the experience of the designer during transform technical measures into part characteristics, weighted and prioritized.

The limitation of second phase, it needs to ask a statistical expert for the clustering and interpretation the relationship between product attributes and product personality from PCA results. It is important to have experience and understanding product attributes of charcoal briquette packaging.

Third phase, the authors found that a new packaging concept has to design based on standard packaging that widely sells in Thailand market. It is an important condition from the charcoal briquette manufacturer. Thus, design concepts are reduced from 16 to 4 concepts. The relationship between product attributes and product personality from the second phase can be used to guide designers by creating charcoal briquette packaging that is related to customers perception.

Fourth phase, the authors focused on the process of making the labelling on the box. They have offset

printing on the box and offset printing on a sticker. In fact, it still has many processes for making the labelling.

Conclusions

This study proposed an innovative design approach for helping designers design a new product. It focused on a charcoal briquette packaging design. Emotional design, product personality, and environmental impact assessment were integrated in the design process. Quality function deployment was used to translate the customer's requirement to part characteristics. The emotional design was used to explore the customer's perceptions to charcoal briquette packaging. The carbon footprint was used as an indicator for evaluating the environmental impacts of a new charcoal briquette packaging and process during its life cycle. an innovative design approach can be used to guide designers to respond to modern problems by creating charcoal briquette packaging that meets the customer's requirements, expresses product identity, and makes it environmentally friendly. The limitation of this research has to ask a statistical expert for clustering and interpretation of the PCA results who have experience and understanding the product attributes of charcoal briquette packaging.

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