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Application of Quality Function Deployment (QFD) method and kano model to redesign fresh fruit bunches sorting tool

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Abstract. The activity of lowering fresh fruit bunches (FFB) from truck to sorting floor is performed manually by workers using a sorting tool. Previously, the sorting tool used is a pointed iron bar with a T-shaped handle. Changes made to the sorting tool causes several complaints on worker and affect the time to lower the fruit. The purpose of this article is to obtain the design of an FFB sorting tool that suits the needs of these workers by applying the *Quality Function Deployment* (QFD) and Kano Model methods. Both of the two methods will be integrated to find the design that matches workers' image and psychological feeling. The main parameters are to obtain the customer requirements of the palm fruit loading workers, to find the most important technical characteristics and critical part affecting the quality of the FFB sorting tool. The customer requirements of the palm loading workers are the following : the color of the coating paint is gray, the bar material is made of stainless pipe, the main grip coating material is made of grip, the tip material is made of the spring steel, the additional grip is made of rubber and the handle is of triangular shape.

1. Introduction

Application of QFD in the development process can provide various information about the needs and desires of consumers, the needs of producers, as well as product needs. It can also help the company to evaluate the competition from both technical standpoint and consumer's point of view so that long-term orientation can be applied, communications processes can be formalized, and institutionalization of continuous improvement can be established.

Consumer products depend on the engineer as a determinant of product function and industrial designer role to increase the aesthetics on the design results. The design for the manufacturing process is an integrated practice involved in product development [1]. Application of QFD on development stage can give information regarding the needs and wants of consumers, producers needs, and product needs [2]. It can also help the company to evaluate competition from technical and consumer's point of view, so that formalize long-term orientation, formalize communication process, and Institutionalization of continuous improvement can be applied. QFD method can translate consumers wishes into product design [3,4]. The development of Kano-QFD models was successfully developed and successfully applied to product design and development [5]. The development of a conceptual model that proposes the quality of initiatives as alternatives using the QFD-Kano method [6]. This study develops the integration model by considering cost limitation and the different effects each attribute has through Kano concept in QFD framework. Understanding the level of importance of the technical characteristics of a product can reduce the costs incurred to produce products in accordance

with the wishes of consumers [7-9]. The Kano and QFD models could be applied to identify customer needs and can be calculated in customer satisfaction [10]. Integration of the Kano model with HOQ can meet the wants and needs of consumers [11]. The Kano model also can be used for the development of product design based on user needs by evaluating product effectiveness [12]. Increased ability of the company to be able to quickly respond to customer demand by taking into account the relationship between the company's matrix and service quality. Increases sales, products become healthy, comfortable and customer satisfaction increases customer loyalty [13].

The author has done a preliminary study of applying her design of FFB sorting tools on palm fruit workers. Based on the study, the faults of the previous design are the tip of the sorting tool is too spherical and slippery, a diameter of the bar is a bit too big which makes it heavy, the border between the bar and the tip is not firm enough, and extra lining on the handle moves easily. Based on these faults, this study will analyze and develop new sorting tools based on the characteristics needed by workers by applying QFD method and Kano model. Kano model is used to clarify element design according to the needs and wishes of workers, and identify a technical characteristic of sorting tool to improve workers performance using QFD. Palm fruit workers need towards a convenient FFB sorting tool to lift palm fruit is correlated with its technical characteristic making.

2. Method

This study is conducted in a palm factory in Tebing Tinggi, Sumatera Utara. This is a descriptive study, describing an object characteristic systematically and factually. The object observed in this study is the previous sorting tool design used by palm fruit workers. Variables used in this study are technical characteristics, product attributes, difficulty level, cost estimation, and importance degree. The sampling method used is functional and dysfunctional Kano questionnaire with a total sampling of 6 workers.

Palm fruit lifting activity is observed using Canon camera for four work days from 12.00 to 17.00 o'clock. The preliminary questionnaire is used to gather complaints from workers regarding the usage of sorting tool. Kano questionnaire is used to categorize sorting tool attributes based on the satisfaction level of palm fruit workers. Kano model has three categories, i.e. dissatisfaction, satisfied, and delighted. Palm fruit workers' attributes will be categorized into attractive (A) must be (M), one-dimensional (O), indifferent (I), reverse (R), and questionable (Q) characteristics [14]. This questionnaire contains 6 questions regarding attributes, i.e. coating paint color, a bar material, tip material, main handle coating material, extra coating material, and handle shape. Attributes quality scoring of sorting tool uses a Likert scale, i.e. like, wish, neutral, tolerate, and does not like. Total sampling is the sampling method used, so questionnaire is distributed to all workers. Modus in Kano questionnaire is turned into question in a closed questionnaire with 5 Likert scale categories, i.e. very important, important, quite important, less important, and not important. Technical characteristics questionnaire is filled by the production manager. The critical part questionnaire is given to factory engineering division who understand attributes affecting sorting tool quality, so it is worth choosing to determine the relationship between variables. The sampling method used is judgment sampling [15]. Pearson method is used for validation test of sorting tool performance data and expectation, whereas Alpha Cronbach with a significant level of 5% is used for reliability test of Kano model data. House of Quality (HOQ) matrix is made based on technical characteristics questionnaire scores 6 points. HOQ is made based on palm fruit workers needs obtained from the semantic differential questionnaire. Determination of customer importance from technical characteristics is based on modus score from each question item in a closed questionnaire. Determination of sales point and absolute value from workers need are input to make the 2nd phase of QFD. The relation between 5 critical part can strongly positive, moderate positive, strong negative, moderate negative, or not related. HOQ is made by calculating working performance consists of three aspects, i.e. difficulty level, importance level, and cost estimation.

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3. Results and Discussions

The results will be discussed in 3 subsections, they are Kano questionnaire, QFD matrix, QFD method analysis of 1st and 2nd phase.

3.1. Kano questionnaire

Kano questionnaire categories attributes of sorting tool according to its ability to satisfy the need of palm fruit workers. Based on validity test conducted on functional and dysfunctional Kano data of sorting tool, r counted> r table = 0.706, which means it is valid. From reliability test for Kano model data, r counted = 0.935 > r table = 0.706, which means the questionnaire is reliable. Data from Kano model questionnaire is processed to categorize each attribute based on Kano model. Kano category values on each attribute to all respondents who have been obtained will be determined its Kano categories by using Blauth's formula as shown in Table 1.

Table 1. Kano category mapping of each attribute.

No	Attribute	Kano Category
1	Coating paint color: gray	R
2	Sorting toolbar material: stainless pipe	A
3	Material tip sorting tool FFB: steel spring	R
4	Main handle coating material: grip	R
5	Extra handle coating material: rubber	I
6	Handle shape: triangle	R

Assessment using Blauth's formula shows that workers do not satisfy with the attributes of coating paint, tip material, main handle coating material, and material shape of the sorting tool, which is then categorized as a reverse. Extra handle coating material does not affect workers satisfaction, therefore categorized as indifferent. Bar material greatly affects workers satisfaction, hence categorized as attractive. Meanwhile, calculation using the method of customer satisfaction (CS) and customer dissatisfaction (CD) obtain attribute's score as shown in Table 2.

Table 2. Score point of CS and CD for each attribute.

CR	Kano Kategory	CS	DS	CS Point $(1, CS_i)$	DS Point $(0,DS_i)$
1	R	0.0000	0.0000	(1, 0.0000)	(0, 0.0000)
2	A	0.7500	-1.5000	(1, 0.7500)	(0,-1.5000)
3	R	0.0000	0.0000	(1, 0.0000)	(0, 0.0000)
4	R	0.6667	0.0000	(1, 0.6667)	(0, 0.0000)
5	I	0.5000	0.0000	(1, 0.5000)	(0, 0.0000)
6	R	0.0000	-1.0000	(1, 0.0000)	(0, 1.0000)

Kano category mapping is made using Minitab software and the output obtained is shown in Figure 1.

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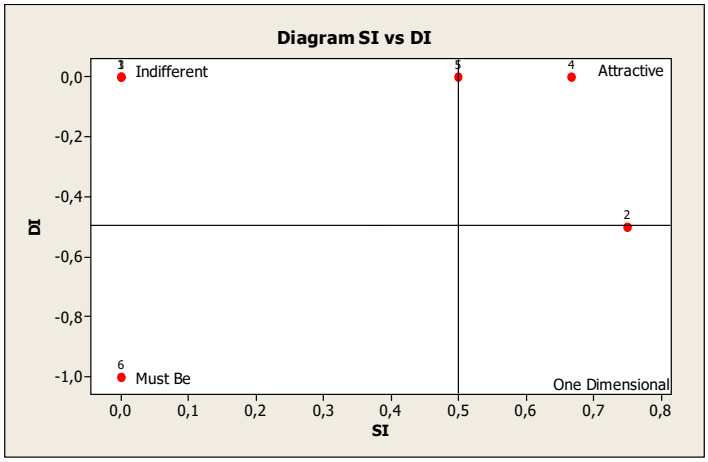

Figure 1. Kano category mapping

The 1st quadrants are attractive category area containing factors that increase selling points, even though does not decrease satisfaction level if the product is not there. Attributes of main handle coating material made of fabric and extra handle coating material made of rubber are categorized as attractive. This means that if the sorting tool has both attributes, workers satisfaction will increase and if not, workers satisfaction will not decrease. The 2nd quadrant is in different category area containing factors that do not affect consumer satisfaction. The attribute of tip material made of spring steel and coating paint color is categorized as indifferent, which does not affect workers satisfaction. The 3rd quadrant is must be category area containing attributes that product must meet and is an absolute requirement for a good assessment of the product. Triangle handle shape attribute is categorized as must-be, thus this is an absolute requirement of sorting tool. If this attribute does not exist, then consumers will lose interest altogether. The 4th quadrant is a one-dimensional area showing the level of performance of linear attributes with customer satisfaction. The attribute of bar material made of a stainless pipe is categorized as one-dimensional, which means The performance level of the attribute is linear with workers satisfaction.A good attribute performance level will increase the satisfaction level of the palm oil loading worker and vice versa.

3.2. Quality Function Deployment (QFD) Matrix

The needs and wishes of palm fruit workers toward the sorting tool are determined using Customer Requirement (CR). Workers wishes in form of attribute will be adjusted to technical characteristics of sorting tool using HOQ. Importance level of workers need will be determined based on modus score from each question in the closed questionnaire. Workers satisfaction level for each attribute is determined by multiplying the scale by frequency and then divided by the number of workers. The number of customer requirement, customer importance, and workers satisfaction level are shown in Table 3.

Table 3. Sorting tool designing process.

No	Customer Requirement	Customer Importance (CI)	Level of Satisfaction
1	Coating paint color: gray	2	1.500
2	Sorting toolbar material: stainless pipe	4	1.833
3	Material tip sorting tool FFB: spring steel	1	2.056
4	Main handle coating material: grip	2	1.500
5	Extra handle coating material: rubber	4	2.167
6	Handle shape: triangle	2	2.571

Attributes importance level of sorting tool is indicated by scores of net sales, importance level, relative weight. Net sales score is obtained from an interview with the manufacturer of Fresh fruit bunches sorting tools, while importance weight and relative weight score are obtained from a closed questionnaire distributed to 6 workers. The questionnaire contains 6 questions regarding importance level of sorting tool attributes. Net sales, importance weight, and relative weight scores are shown in Table 4.

Table 4. A score of net sales, importance weight, and relative weight.

Customer Requirement	Importance Weight	Relative Weight	Net Sales Point
Coating paint color: gray	1.333	3.200	1.2
Sorting toolbar material: stainless pipe	2.182	13.091	1.5
Material tip sorting tool FFB: spring steel	0.486	0.370	1.5
Main handle coating material: grip	1.333	3.200	1.2
Extra handle coating material: rubber	0.385	1.538	1.0
Handle shape: triangle	0.429	1.286	1.5

A variable with the highest score of relative weight, importance level, and net sales is bar material that uses a stainless pipe. This is the most important variable to improve company performance.

3.3. QFD method analysis

QFD 1st phase is used to determine the difficulty level and cost estimation of technical characteristics. The level of relationship between the technical characteristics is determined based on the interview with the manufacture of FFB sorting tools. The most important technical characteristics are the heating process and the printing process with each difficulty level 5, a degree of interest 21% and 32% as well as the estimated cost of each 25%. Technical characteristics obtained from the QFD 1st phase used as inputs to carry out the processing on QFD 2nd phase. QFD 2nd phase is used to determine the critical part affecting the quality of FFB sorting tools. The critical part is the most important part or component characteristic of FFB sorting design obtained from an interview with the workshop that makes FFB sorting tool. Calculation of performance measures of QFD 2nd phase characteristics is aimed at obtaining a value of difficulty level, a degree of importance, and cost estimation. The degree of difficulty, a degree of importance and highest cost estimate is the melting point of material with difficulty level 5, a degree of interest 25% and estimated cost 28%.

4. Conclusions

Based on KANO model mapping, the design attributes of FFB sorting tools categorized as attractive, indifferent and must be. The attractive category is the attributes of the main grip coating material made of fabric and the additional grip coating material made of foam. Indifferent category is the attributes of the material of FFB sorting tool made of As iron and black coating paint. The category must be is the attribute of the triangle-shaped handle, whereas the one-dimensional category is the attribute of FFB material made of a hollow iron bar. Based on difficulty level, a degree of importance, cost estimation, the highest technical characteristics of the QFD phase I are heating and casting process. Meanwhile, based on difficulty level, a degree of importance, and cost estimation, the highest technical characteristics of QFD phase II is the melting point of the material.

In the next study, a sampling of palm fruit workers from several palm oil companies can be done to obtain a more accurate ergonomic FFB soring tool. More studies need to be conducted using the method of QFD Phase III to evaluate the “manufacturing product” and phase IV to review the “production product”.

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