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FOUR PHASES QUALITY FUNCTION DEPLOYMENT (QFD) BY CONSIDERING KANO CONCEPT, TIME AND MANUFACTURING COST

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Abstract : *Each company must carry out product development to maintain or build sales. Relationship between specifications and parameters of quality products to the wishes of the customer is an important consideration in doing product development. Product development methods QFD (Quality Function Deployment) has been widely applied in industry to maximize customer satisfaction based on quality, cost, time and other, become source of constraints. Quality, time and cost are important factors for a company to maintain existency of the company in the industry. This study will provide customer deployment requirements to consider not only the quality factors are more often a point of view assuming the successful development of a product, but also on the factors of time and cost. Factors to be considered in stages creating new products or improving old products are not only detailed data about the four phases of phasing as product planning, product design, process planning, process control and planning is needed, but also a complete view of the overall technical response . The final integration of the four phases of QFD is influential in producing and marketing the products. Team of product development must plan how to design new products to exploit existing technical response. Matters relating to the quality characteristic and the voice of stakeholders is very relevant and should be well understood and thoroughly. Technical approach to a more detailed response can lead a team of product developers to pay attention to the changes of each phase to obtain the allocation of resources for each of the responses are perfectly.*

Key words*- cost, four-phase QFD, quality, and time*

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1. INTRODUCTION

QFD product development methods have been widely applied in industry to maximize the customer satisfaction based on quality, cost, time and other, these factors are considered as constraints. Quality, time and cost are important factors for a company to maintain its existence in the industrialized world. In some previous studies focus more on the quality factor is how to help the company to obtain satisfaction of the consumer, while the cost and time factors have received less attention, if any, are not calculated and discussed in detail.

The things that must be considered in stages creating new products or improving old products not only detailed data on product planning, product design, process planning, process control and planning is needed, but also a complete view of the overall technical response. Where the end result is the integration of the four phases of QFD influential in producing and marketing the products. Product development team should plan how to design new products to exploit existing technical response. Matters relating to the quality characteristic and the voice of stakeholders is very relevant and should be well understood and thoroughly. Approach to a more detailed technical response can lead a team of developers to pay attention to changes in product product planning, product design, process planning, process control and planning. However, most of the existing research has been discussed about the issues of new product development requirements are dominated by the respective technical framework respond regarding product planning (Chen and Weng, 2006; Kwong et al., 2007; Chend and Ko, 2008) and product design (Zhai et al., 2010), among several issues that it is called a research topic that is often discussed and considered. While the technical response and the process planning, process control and integration of the four phases of QFD less attention (Chen and Ko, 2009).

This study will provide customer deployment requirements to consider not only the quality but also factor in the time and cost factor in developing a product. In this case QFD is considered able to support the success of this research. QFD four phases may provide some short-term benefits such as reducing barriers associated with cross-functional product development team and help change corporate culture. In the long run, QFD has been shown to have tangible benefits such as further reducing cycle time, reduce development costs, and increased productivity. An important benefit of QFD is its effectiveness in capturing, prioritizing and stabilizing customer needs (Delgado and Aspinwall, 2003).

According to Cohen (1995), QFD benefits for companies seeking to improve their competitiveness and productivity through improved quality is continuously improving product reliability, improve product quality, increase customer satisfaction, shorten time to market, reduce design costs, improve communications, increase productivity and increase corporate profits.

Departing from problems such as those described above, developed a new concept of how to respond to customer requirements is a good category to integrate all technical respond that there is commonly called the QFD 4 phases to

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obtain the form of resource allocation for each response is perfect.

2. FLOWCHART INTEGRATION MODEL FOUR PHASE QFD

Four phases of the integration process of QFD is described in the flowchart in Figure 1. illustrates the process of the integration is done. In the first phase of QFD using Kano method to classify customer requirements and design requirements. Kano questionnaire will be calculated based on the value of the influence of consumer satisfaction and dissatisfaction.

Values influence consumer satisfaction and dissatisfaction will be input in the planning matrix. So we get the output fulfillment requirements engineering. In the phase two QFD using Kano method to classify the design requirements and part characteristics. Output important weight in phase one will be used as design input requirements in phase two. Kano classification process on the part characteristics similar to that carried out in phase one until finally found fulfillment part characteristics. In the third phase QFD using Kano method to classify part characteristics and process parameters. Output important weight in phase two will be used as input phase three on the part characteristics. In addition to the results of operation time and manufacturing cost will also be used as input process parameters. So that they become input to the planning matrix and to obtain fulfillment process parameters. In the fourth phase QFD using Kano method to classify process parameters and production requirements. Output from phase three (important weight) will be used as the input process parameters on phase four. Kano and classification process on the production requirements as well as performed in phase three to finally obtain fulfillment production requirements. At this integration process we will get a good important weight for quality, cost and time, so we get a trade off between the three. More specifically we will get a comparison between the cost and time of manufacturing processes.

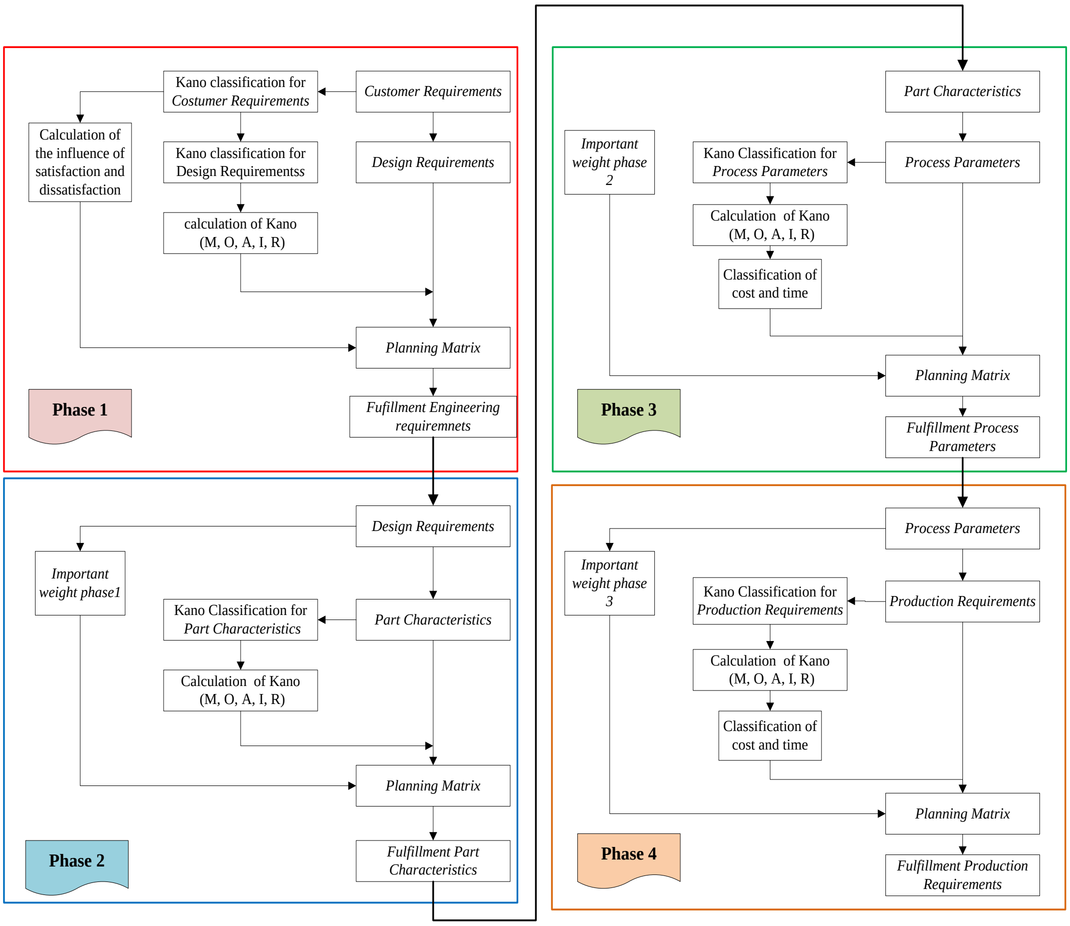

Figure 1. Flowchart Integration Model Kano Concept in Four Phase QFD Framework

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3. FRAMEWORK INTEGRATION FOUR PHASE QFD

Framework Four Phase QFD Integration that has been modified with a development Integration Model QFD - concept Kano Model from research Singgih, Tansiah dan Immanuel (forthcoming). Integration of the results of four Phase QFD - Kano can be seen in Figure 3 to Figure 6 which consists of the following parts:

***Customer requirement* (CR$_i$)**

Column customer needs / customer requirements is the main column of the HOQ (House of Quality), which contains the desires of consumers and the basic characteristics of the product. Part is still the same as the conventional QFD. The term Customer needs / customer requirement is symbolized by CR$_i$.

Planning Matrix

There are some parts that are the same as part of the planning matrix of QFD Conventional namely:

- Importance to customer *(d_i)*
- Current satisfaction performance *(CSP_i)*
- Competitive satisfaction performace *($CoSP_i$)*
- Goal *(G_i)*
- Improvement Ratio *(IR_i)*
- Sales Point *(SP_i)*
- Raw weight *(RW_i)*

Some additional columns integration Kano Model is as follows:

- **Kategory Kano to CR$_i$ (Q_i)**

  Kano Category for CR$_i$ that include categories must be, one-dimensional and attractive, and then reverse and indifference categories does not include the input of the HOQ. This categorization process will be the basis of classification of technical response in the next section.

- ***Extent of satisfaction***

  This section shows the effect of the value of each customer requirement on the level of customer satisfaction that is symbolized by the letter S. That is, it measures how much the value of customer satisfaction will increase when the relevant customer requirements embodied in a product. The more positive value, then this indicates that customer requirements are referred to the effect on the level of consumer satisfaction. Extent of satisfaction can be generated using the following equation.

$$S_i = \frac{A+O}{A+O+M+I} \qquad (1)$$

S_i : Extent of satisfaction

A : Atrractive Category

O : One-dimensional Category

M : Must-be Category

I : Indifference Category

The values S_i indicate that the customer requirement (CR) i will increase customer satisfaction when i met CR. Each CR$_i$ will have all the elements of Kano categories, i.e., must-be, one-dimensional, attractive, indifference or reverse the proportions vary by consumer preferences. Proportion to the value of each category is derived from the questionnaire Kano.

The value S_i indicates the magnitude of the positive effect on customer satisfaction customer requirements in the product when it is raised. The value is in the range of numbers from 0 to 1. Value of 1 indicates the existence of a very large influence on the level of customer satisfaction as customer requirement i displayed. Vice versa when the S_i is 0 which indicates that no significant effect on the level of customer satisfaction as customer requirement i displayed.

- ***Extent of dissatisfaction***

This section will show the impact of each CR_i to levels of consumer dissatisfaction. This value can be generated by the following equation.

$$S_i' = \frac{O+M}{(A+O+M+I)\times(-1)} \quad (2)$$

where:
S_i' : Extent of dissatisfaction

Extent of this dissatisfaction is basically a value that measures how much influence the disappearance of the level of consumer dissatisfaction CR_i. Unlike S_i, S_i' value aims to measure the negative impact on the level of satisfaction that can be interpreted as the level of consumer dissatisfaction with the product.

The value S_i' will be in the range -1 to 0. A value of -1 indicates a strong influence on the level of consumer dissatisfaction when a customer requirement is not shown. Vice versa, the value of 0 indicates no influence on the rate of disappearance customer requirement of consumer dissatisfaction. By looking at the magnitude of thiss value, the company can look at customer requirements which need to be given special attention. Customer requirements with value S_i' approaching -1, remembering to note the disappearance customer requirements will significantly affect consumer dissatisfaction.

Technical response (TR_j)

This section describes the translation CR_i on Technical Response (TR_j) will be elected as the concept of product design. There is one additional columns:

- **Kategory Kano to TR_j (Q_j)**

As in the CR_i, this section will contain the Kano categories for each of the TR_j is derived directly from CR_i category. Decrease in Kano on technical response categories is done so that the product development team to learn more about the technical response which will affect the focus of the development of CR_i, CR_i suppose that category attractive. In addition, the cost allocation process, the model will consider the Kano categories.

- **Relationship Matrix (R_{ij})**

This section will contain inter - CR_i. As is the case with conventional QFD, at even this section will use a value of 1, 3 and 9 to denote the relationship or relationship. The value 9 shows the value of the most robust positive relationship.

- **Technical Correlation (γ_{kj})**

Correlation are shown in this model is limited to the positive correlation as has been done on the model Bode and Fung (1998). Positive relationship when the relationship in question is the value TR_1 will go up by a certain prosesntase, TR_2 also raised the value. Symbol correlation used in this study were 1, 3 and 9 for the relationship is weak, medium and strong and 10 to illustrate the value of correlation with TR_j same.

Technical Matrix

In the technical part of this matrix are the combination of the conventional QFD models and QFD models Bode and Fung (1998). Sections are as follows:

- **Threshold Value (T_Q)**

Threshold value (T_Q) is the part that contains the value limits the extent to which the allocation of technical response development costs allocated to meet a category of Kano. T_Q value of this will be the percentage of the amount of funds that can be allocated on a set of TR_j for certain categories. Where these categories denoted by the letter Q in which the value is 1, 2 and 3. A value of 1 indicates the category must-be, a value of 2 indicates the category of one-dimensional and 3 show values attractive category.

T_Q value will depend on the type of company concerned. Each company will have its own decisions in the product development process. For a company that offers innovative products, sometimes attractive category will get more attention, while for companies with the type of follower can be a category of must-be and one-dimensional first importance. However, that would be the order of the parameters is that the allocation will follow the rules of the category of interest must-be > one-dimensional > attractive. Must-be is the basic function of the product so that the basic function must exist in the product, while the one-dimensional is a performance improvement of the basic functions and attractive are the additional features that will be related to the competitive advantage of a product.

- **Technical Importance (w_{Qj}), Technical Manufacturing Cost, Technical Manufacturing Time, Technical Assembly Cost, Technical Assembly Time.**

The value of relationship (R_{ij}) is the importance to the customer (d_i) for the entire CR_i. w_{Qi} value calculated for each TR_j in each category Kano Q. This value indicates the value of each TR_j effect on the fulfillment of CR_i. R_{ij} values used in this calculation is the value of R_{ij} has been done the normalization process or R_{ij}^{norm}. Normalization process used is a normalization process Wasserman.

w_{Qi} value can be determined using the following equation.

$$w_j = \sum_{i=1}^{m} d_i R_{ij} \quad (3)$$

- **Resource Importance (w^*_{Qj})**

Resource importance is the contribution of technical response to the fulfillment of customer requirements j, i when allocated a resource unit. This value provides information about the contribution of technical response to customer satisfaction with regard to the value of each correlation the technical response. Bode and Fung (1998) calculated the resource importance by the following equation:

$$w^*_{Qj,k} = \sum_{j=1}^{n} w_j \gamma_{jk} \quad (4)$$

w^*_{Qj} value will increase when j technical response has a lot of correlation with other technical response. This suggests that the more a technical response has correlation with the other technical response, it indicates that the j realizing the technical response will increase another technical response. Thus, to show an increasing contribution to realizing customer requirements.

- **Technical Satisfaction (ws_{Qj})**

This value is the theoretical value of R_{ij}^{norm} normalization was done with grades Extent to satisfaction (S). This value indicates how much influence j technical response to customer satisfaction when it developed a technical response will cause realization of CR_i in a product.

Each CR_i will have a different amount of impact on the level of

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consumer satisfaction. Furthermore, the influence of satisfaction on the value of each CR$_i$ is associated with the relationship at any technical response will then generate values influence satisfaction TR$_j$ technical response to the realization of the entire CR$_i$. ws_{Qj} value can be calculated by the following equation:

$$ws_{Qj} = \sum_{i=1}^{m} S_i . R_{ij}^{norm} \quad (5)$$

m : Number of customer requirements
Q : Kano category

- **Technical Dissatisfaction (ws'_{Qj})**

ws'_{Qj} value is a value that states TR$_j$ influence on the level of consumer dissatisfaction if the technical response is not embodied in a product. ws'_{Qj} value can be calculated using the following equation:

$$ws'_{Qj} = \sum_{i=1}^{m} S_i ' . R_{ij}^{norm} \quad (6)$$

- **Technical Satisfaction/Technical Dissatisfaction**

This value indicates the absolute value of the ratio between technical satisfaction and dissatisfaction technical. This ratio is calculated in order to determine how much impact an increase in the ratio between satisfaction and dissatisfaction impact. By knowing the value of such comparisons, the development team will get information about the extent of the effects when an attribute is raised or not in a product. Here are the equations used.

$$\text{Influence Index} = \left| \frac{ws_{Qj}}{ws'_{Qj}} \right| \quad (7)$$

Value of influence index will always be positive while the value ws'_{Qj} will always be negative. Therefore, the value of this ratio using the absolute sign to avoid negative ratio values that are difficult to interpret. Value ratio > 1 would indicate that the emergence of technical response will greatly affect the level of satisfaction.

- **Raw weight technical response (*RW$_j$'*)**

This value is the weighted value of each technical response based on the value of sales points, improvement ratio and the level of interest. This calculation aims to determine the contribution of each technical response when seen from the sales point and the improvement ratio which will be done by the company to the customer specific requirements. Here is the equation to calculate this value:

$$RW_j ' = \sum_{i=1}^{m} RW_i . R_{ij} \quad (8)$$

- **Primary resource commitment (c^*_{Qj}), Primary Manufacturing Cost, Primary Assembly Cost**

Primary resource commitment (c^*_{Qj}) is part of the technical matrix that contains the amount of the costs incurred by the company to realize a technical response TR$_j$. In this case, the value of each TR$_j$ considered as independent variables. Independent variable in question is the value of a variable that does not consider the value of TR$_j$ correlation with other TR$_j$.

Allocation Process Product Development

Allocation process steps are as follows:

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1) Grouping technical response by Kano category
2) The determination of the threshold value

The calculation of the value of $\left|\frac{ws_{Qj}}{ws'_{Qj}}\right|$

1)
2) The calculation of the value of $\left[w^*_{Qj} \times \left|\frac{ws_{Qj}}{ws'_{Qj}}\right|\right] / c^*_{Qj}$

3) The calculation of the value of RW'$_j$

1.1 Trade-off between Time and Cost

In the product development process or produce new products will usually arise problems in achieving a particular goal (the trade-off). During the process would take time and cost, where the time and costs associated with being a problem to determine the manufacturing cost of the product being made. In determining the cost of the product and the estimated time of completion is influenced by many factors such as product below.

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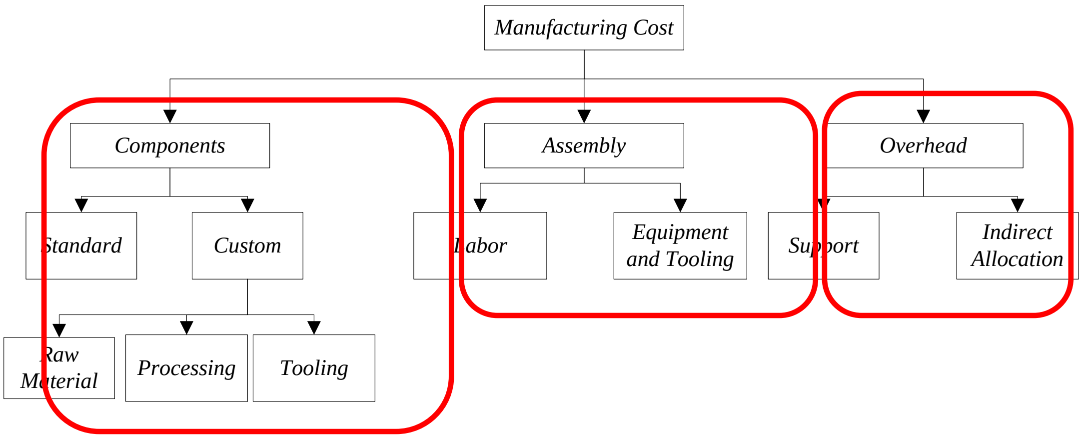

Figure 2. Structure of Manufacturing Cost by Boothroyd and Dewhurst

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The manufacturing cost is the cost of manufacturing (production process) + assembly cost + overhead (cost of product development). To get the value of the amount of labor, labor time and the output can be calculated with the following formula :

$$Amount\ of\ Labor = \frac{(Standard\ Time\ x\ Output)}{Working\ Time} \qquad (5.1)$$

$$Working\ Time = \frac{(Standard\ Time\ x\ Output)}{Amount\ of\ Labor} \qquad (5.2)$$

$$Output = \frac{(Working\ Time\ x\ Amount\ of\ Labor)}{Standard\ Time} \qquad (5.3)$$

where,

Amount of Labor : Labor used by the production or assembly parts per hour

ST (Standard Time) : Standard time production or assembly process

Output : Output is issued by the production or assembly per hour

Working time : hours of production or assembly process used in one day

With the application is expected to produce products in accordance with the specifications and manufacturing costs and optimum time. Where the time and costs associated with quality, and manufacturing has actually always been closely associated with quality, whether the products are produced according to the specifications are expected to cost and time estimates are in accordance with the product so that it can be easier to sell (marketable).

4. APPLICATIONS

This study used a product that have quite complex manufacturing process. This is done because the process of model development is the integration of QFD 4 phase, researchers will focus on the calculation of the cost and time in the manufacturing process. Thus the expected behavior of the model will be more apparent with the increasing complexity in parts of the manufacturing process. Products chosen as an object of observation which meets these criteria is the city bike products bike brands XX. Bike is a product that has a manufacturing process and also have a spare parts are quite complex. Therefore, the product is able to Bike perceived as an object of observation on the development of the integration model of the QFD Four Phase.

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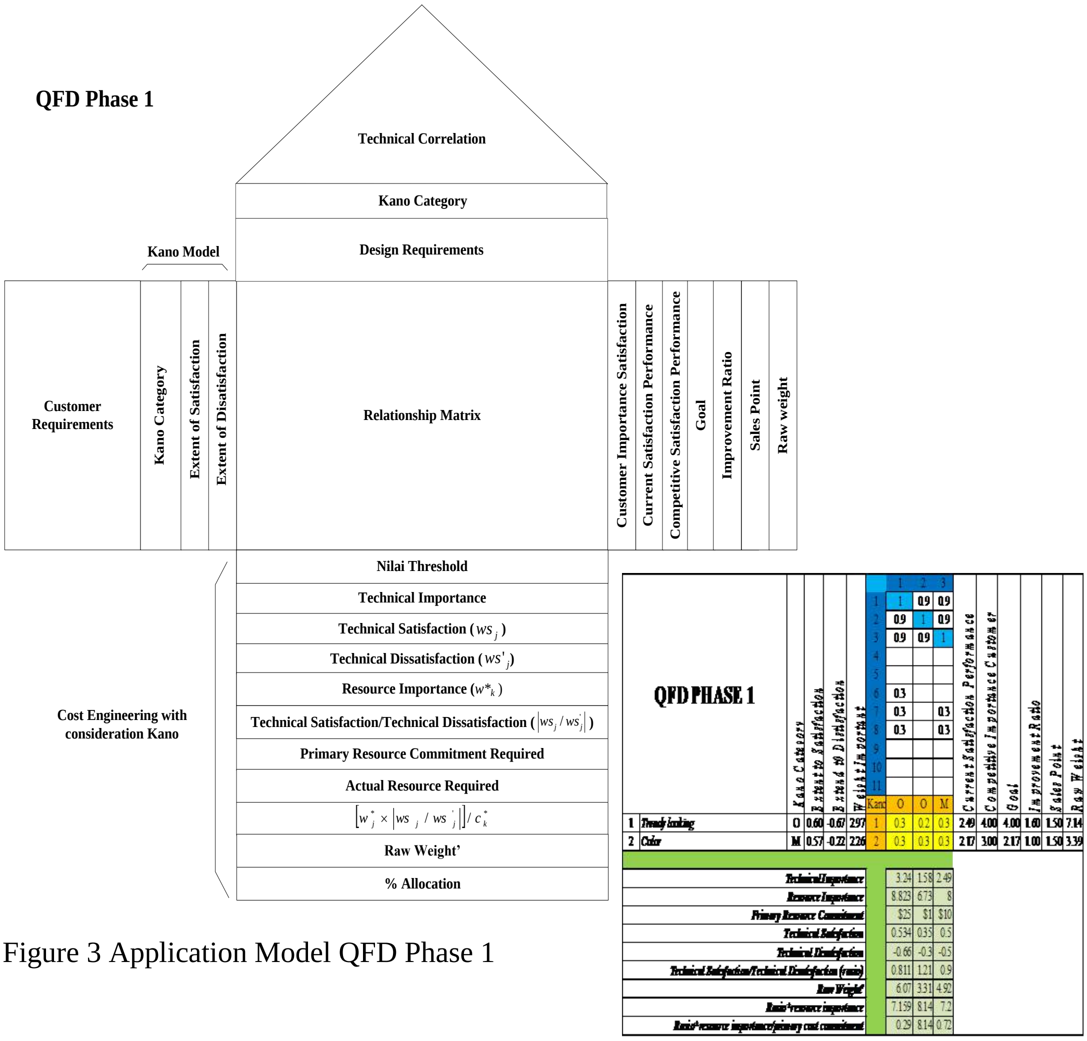

Figure 3 Application Model QFD Phase 1

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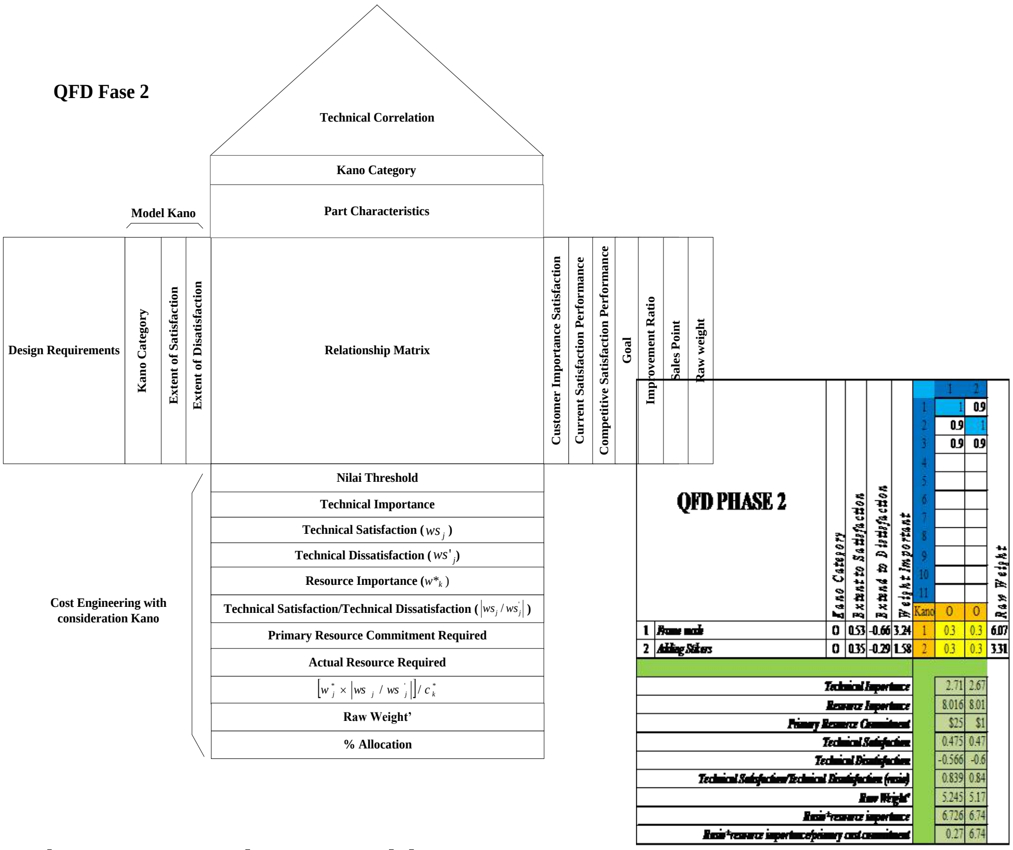

1.2

Figure 4 Phase 2 QFD Application Model

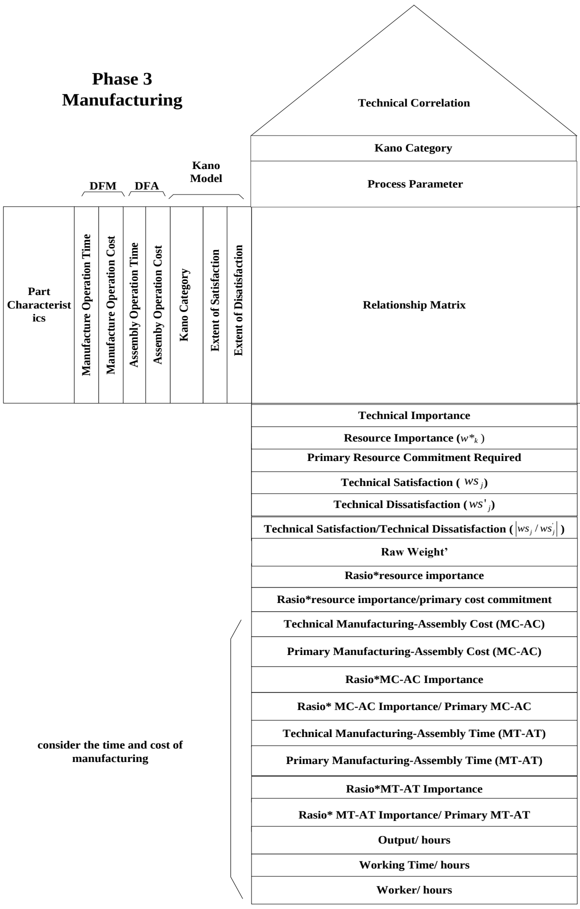

Figure 5 Application Model QFD Phase 3 (Productio

	1	2
1	1	0.9
2	0.9	1
3	0.9	0.3
4		
5	0.9	
6		

	QFD PHASE 3 *MANUFACTURING*	Estimation Manufacturing Time	Estimation Manufacturing Cost	Kano Category	Extent to Satisfaction	Extend t0 Distisfaction	Weight Important	Kano	M	M	Raw Weight
1	Some models of the pipe diameter	1.00	1.00	0	0.47	-0.57	2.71	1	0.3	0.2	5.25
2	Animated images	1.00	1.00	0	0.47	-0.56	2.67	2	0.0	0.0	5.17

	1	2
Technical Importance	0.91	0.54
Resource Importance	2.31	1.52
Technical Satisfaction	0.16	0.09
Technical Disatisfaction	-0.19	-0.11
Technical Satisfaction/Technical Disatisfaction (rasio)	0.84	0.84
Raw Weight'	1.76	1.05
*Rasio*resource importance*	1.93	1.28
Technical Manufacturing Cost	0.34	0.20
Primary Manufacturing Cost (MC)	$75.00	$0.49
*Rasio*MC Importance*	0.78	0.30
Rasio MC Importance/ Primary Manufacturing Cost*	0.01	0.62
Technical Manufacturing Time	0.34	0.20
Primary Manufacturing Time (MT)	1	1
*Rasio*MT Importance*	0.78	0.30
Rasio Time Importance/Primary Manufacturing Time*	0.78	0.30
Output/ hours	1000000	1000000
Working Time (hours)	8	8
Worker/hours	125000	125000

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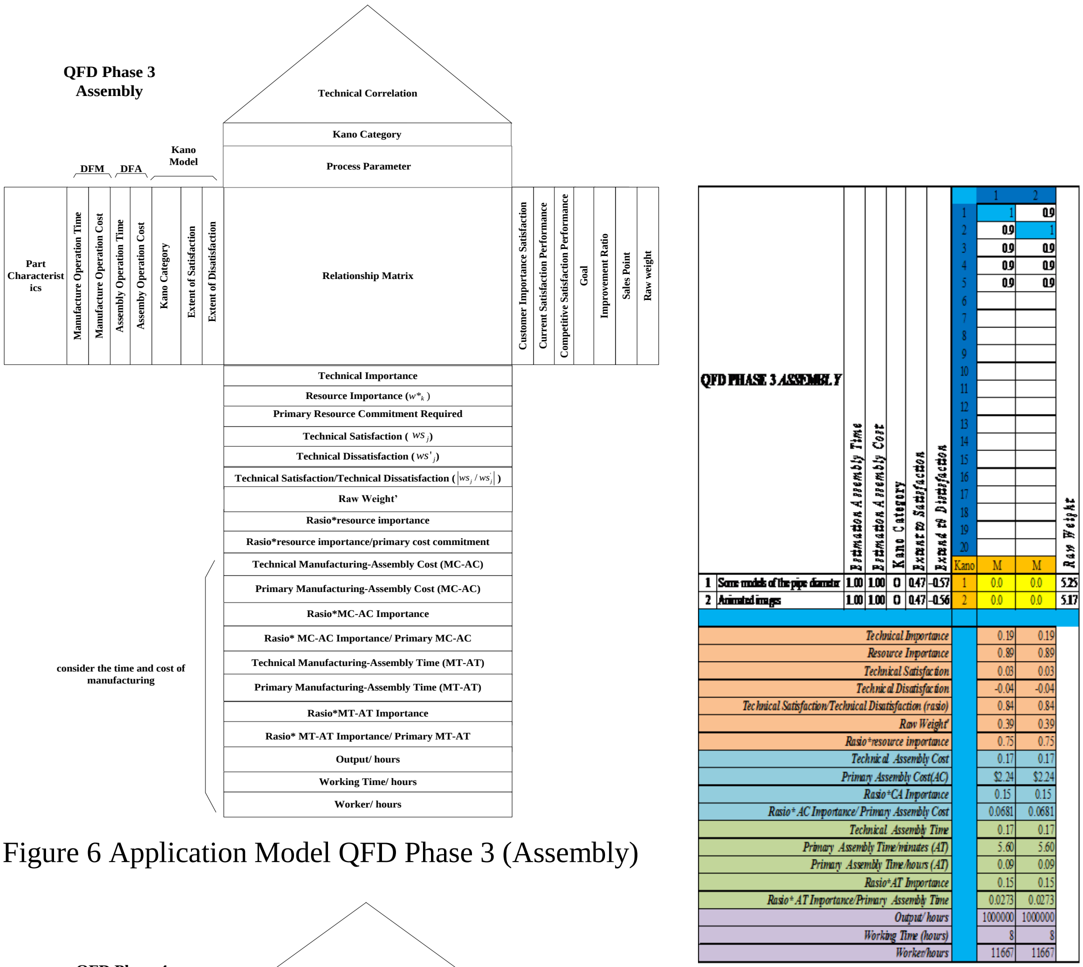

Figure 6 Application Model QFD Phase 3 (Assembly)

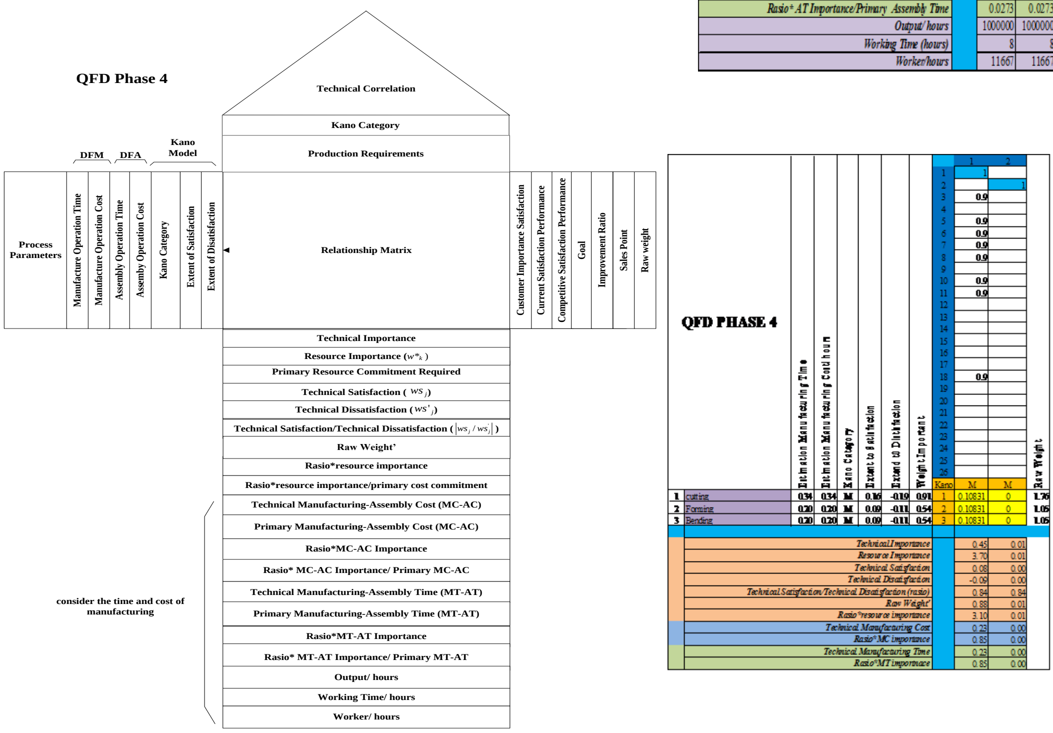

Figure 7 Application Model QFD Phase 4

5. CONCLUSION

Integration model development four phase QFD in this research aims to get engineering characteristics, getting part characteristics, process parameters get, get production requirements, determine the cost and length of time required to develop the final product and determine the ratio of cost and time. Where in this study, the cost and time is divided into two parts, namely the cost and time of manufacturing process itself which of them is the time and cost of the assembly process. Based on model development and implementation process that has been done, it will get the following conclusion

1) In the first phase of engineering characteristics is obtained, where the engineering characteristics used as input integration framework QFD and Kano concept in phase one. Kano theory application will serve as the basis of grouping customer requirements and technical importance so as to know how the effect of each design requirements on the level of consumer satisfaction.
2) In the phase two, part characteristics are obtained, where the part is used as an input characteristics framework integration of QFD and Kano concept in phase two. Kano theory application will serve as the basis of grouping design requirements and technical importance so as to know how the effect of each part characteristics on the level of design requirements.
3) In the third phase, the process parameters is obtained, which is used as an input parameter process integration framework QFD and Kano concept in phase three. Kano theory application will serve as the basis of grouping part characteristics and technical importance sehingga so as to know how the effect of each process parameters on the level of part characteristics.
4) In the fourth phase of the obtained production requirements, where production requirements are used as input integration framework QFD and Kano concept in phase four. Kano theory application will serve as the basis of grouping parameter process and technical importance so as to know how the effect of each production requirements on the level of process parameters.
5) To make the kind of bike products XX at PT. XYZ takes the value of the manufacturing cost of Rp. 835,842.50, assembly fee of Rp. Rp. 1,659,170.30 and product development costs amounting to Rp. 1,027,600.00. while the time required for manufacturing is 6 hours / 1 million output and the time required for the assembly is at 7.53 hours / 1 million output.
6) The trade off level interest of expense and the time when the production of the satisfaction will be used in accordance with the conditions of the company at that time.

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