Propose design of smart clothesline with the tree diagram approach analysis and quality function deployment method for Indonesia weather

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Abstract. Tropical countries such as Indonesia have uncertain rainfall levels every year. This requires innovation in technology. One example is innovation in design of clothesline in accordance with the conditions of society and the seasons that exist in Indonesia. During the rainy season, the majority of people feel anxious when hanging clothes. This is because they are afraid that if they are not at home and it rains their clothes will get wet. People, therefore, are unwilling to hang their clothes in an exposed place. Whilst, current electric clothesline are a solution, they need more power and therefore cost a lot to operate. This has an impact on the household economy. The aim of this research is to understand consumer desire for a model or design of a clothesline that will be developed with tree diagram analysis and a QFD Method (Quality Function Deployment). The outcome of this research is priority and attribute of product that will be used to design based on customer demand, among other percentage of feature “additional rain sensor on clothesline” is 21.518 %, attribute “structure of material not easy bend and break” is 12.971 %, and main priority is “Clothes dryer are easily removed and can be folded” with a value of 8.544 %.

1. Introduction

The Tropical countries such as Indonesia, the weather cannot be completely predicted, but people can sense when it will rain, especially in the rainy season in Indonesia. During the rainy season, the majority of people feel anxious when hanging clothes. This is because they are afraid that if they are not at home and it rains, their clothes will get wet. People, therefore are unwilling to hang their clothes in an exposed place. Current electric clothesline are a solution but they need more power and high cost to operate. So, it have an impact to the household economy.

The rainy season that occurs in Indonesia has an erratic frequency every year where the rain fall is unpredictable. This has led to the need for an innovation in clothes dryer design in accordance with the existing seasons in Indonesia, especially in the Pekanbaru area. The following table shows the amount of rainfall that occurred in Riau province from 2006 to 2013.
Table 1. Rainfall in 2006-2013 in Riau Province.

| Year | Number of Rainfall (mm) | Number of Rainy Days (mm) |
|------|-------------------------|---------------------------|
| 2006 | 537.60                  | 33.00                     |
| 2007 | 3216.30                 | 235.00                    |
| 2008 | 3026.20                 | 206.00                    |
| 2009 | 3390.00                 | 198.00                    |
| 2010 | 3390.00                 | 198.00                    |
| 2011 | 2405.00                 | 211.00                    |
| 2012 | 2636.00                 | 217.00                    |
| 2013 | 2628.70                 | 214.00                    |

Clothes is very important for daily life. We always wash, dry and fold them for maintenance of clothes. Washing and drying were already automated by washing machine and drying machine. But, not for folding[1].

On the other hand, study of the design clothes dryer many have conducted. Clothes dryer For example, first research have conducted by nurhadi and widiantoro on clothes dryer using light sensor (LDR) and rain sensor. These researchers created a prototype with a driving system that pulled clothes to a plan protect from rain[2]. Rismawan also conducted a study which designed and implemented a prototype clothes dryer based on microcontroller ATMEGA8525 which produced a clothes dryer that protects clothes from the rain[3].

Further research by sugijono led to the development of a cloth dryer roofis design of the cloth dryer roof that can protect wears from rain. The program application would working every time it receives reports from light sensors and humidity sensors that detect sunlight and rain to move the motor through a magnetic contactor to shift the protective roof of cloth dryer to close and open. The application just was tested by simulation[4]. Even research conducted by siswanto and winardi has made towing clothesline that work automatically. The device are controlled by microcontroller and equipped by rain sensor and LDR. It is less effective and efficient because the tool will only pull clothes to a place that protected from rain water and exposed to the sun. Thus, it is requires a large area for the installation of the tool[5].

To overcome the problem, the researcher will propose a new design of automatic clotes dryer that more ergonomic for consumers using the QFD method and to decrease use of electric power. Thus, it can provide solutions and innovations to develop new designs of clothing dryer products based on consumer demand. The QFD method is a systematic method for binding product and service design decisions directly to customer wants and needs[6][7][8]. According to Wignjosoebroto ,Product is an artefact that is something has be man-made object creativity which can saw, heared, felt and which can be seen, heard, felt and realized to meet certain functional needs, which are produced through a long process[9].

2. Methods

Subject of this research are a womans who live in the village of Jadirejo, Sukajadi District Pekanbaru. The activities of drying clothes uses a tradisional model. The research methodology for wastesolving in General Administration is shown in Figure 1:
3. Result and Discussion
3.1 Tree Analysis Diagram

Problem tree or called Tree Analysis is an approach or method used to identify the causes of a problem. Problem tree analysis is done by forming a more structured mindset about the cause and effect component associated with priority issues[10].

Objective data collection in doing by the researcher is to grouping data in accordance with the objectivity of the tree diagram. Figure 2 shows the data collection objectivity.
3.2 Planning Matrix

3.2.1 Determining the degree of interest (Importance to Customer)
To determine the degree of interest the most attention by the respondents (potential users), the higher the value the higher the level of importance. The Equation 1 is an example of calculating the importance of the first product with the attributes of "clothes that have a large capacity".

\[ IC = \frac{\sum (14 \times 5)+(22 \times 4)+(0 \times 3)+(0 \times 2)+(0 \times 1)}{36} = \frac{158}{36} = 4.389 \]  

(1)

3.2.2 Determining Customer Satisfaction Performance
To find the most expected questionnaire attribute of the user (in order to meet the respondent's expectation), the higher the value the higher the level of importance. Equation 2 calculates the attributes of "clothes that have the large capacity"

\[ CSP = \frac{\sum (Skala \ tingkat \ persepsi \ i)(Jumlah \ responen \ i)}{Total \ Jumlah \ Responden} \]  

(2)

So to calculate the performance of the first product attribute:

\[ CSP = \frac{\sum (0 \times 5)+(0 \times 4)+(7 \times 3)+(29 \times 2)+(0 \times 1)}{36} = \frac{79}{36} = 2.194 \]
3.2.3 Determining the Expected Satisfaction Performance

To determine the attribute of the questionnaire most expected users (prospective users), the higher the value, the higher the level of importance. Equation 3 shows the calculations on the attributes of "clothesline that capacity its capacity is great".

\[ ESP = \frac{\sum (\text{Skala tingkat ekspektasi } i)(\text{Jumlah responden } i)}{\text{Total Jumlah Responden}} \]  

(3)

So, to calculate results overall performance (ESP) each item statement attributes of the product are presented in the calculation below.

\[ ESP = \frac{\sum (7 \times 5)+(29 \times 4)+(0 \times 3)+(0 \times 2)+(0 \times 1)}{36} = \frac{151}{36} = 4,194 \]

ESP is a ratio between ESP and CSP. Equation 4 shows of the calculations on the attributes of "clothesline that capacity its capacity is great".

\[ IR = \frac{\text{Expected satisfaction performance}}{\text{Costumer satisfaction performance}} \]  

(4)

Calculation of the ratio of repair services first (IR) becomes:

\[ IR = \frac{\text{Expected satisfaction performance}}{\text{Costumer satisfaction performance}} = \frac{4,194}{1,472} = 1,911 \]

3.2.4 Determine Weight Product Attributes (RawWeight)

Raw Weight is a value that describes the level of the overall importance of each consumer needs based on the use of the importance degree (IC) and improvement ratio (IR). The following is an example of calculating the attributes of "clothesline have a large capacity.

\[ \text{Raw weight} = \text{Importance to costumer} \times \text{Improvement ratio} \]

So, the calculation of Raw Weight for each product attribute is.

\[ \text{Raw Weight} = 4,388 \times 1,911 = 8,388 \]

3.2.5 Determining Normalization Weight (Normalized Raw Weight)

From the calculation of the weight that has been obtained need to be normalized. Normalize the weight aims to facilitate in determining the priority development of which attributes that need immediate development. To determine the value of weight normalization can be done by the Equation 4.

\[ NRW = \frac{\text{Raw Weight}}{\text{Total Raw Weight}} \]  

(5)

So, the calculation of the weighted normalization (NRW) attribute "clothes that the capacity of large capacity" is:

\[ NRW = \frac{8,388}{90,275} = 0,092 \]
3.2.6 Determining Each Product Attribute (Goal)
The target value (Goal) is the target level of achievement desired by a company based on value to improve the performance of a technical response.

3.3 Technical Response
Technical response is the response given by manufacture to meet customer needs and is given to improve the product quality against the variables complain. Table 2 illustrates the technical response of the selection of smart clotheslines.

| Table 2. Technical Respons (Hows) |
|-----------------------------------|
| Technical response (Hows)         |
| 1 Material made of light and sturdy steel |
| 2 Added a special clothesline that uses hangers |
| 3 Clothes that can be folded or shifted when not in use |
| 4 There are wheels or pads on every clothesline |
| 5 The clothesline size is adjusted to the average standard size of the user |
| 6 The addition of automatic cover when it rains |
| 7 There is a clothesline space without hangers |
| 8 Color variations on the clothesline. |
| 9 There are additional polycarbonates on the left and right of the clothesline |

3.4 Determine the relationship betweenWhats and Hows
Interaction matrix is to connect between attribute statements that are considered important by consumers with engineering parameters that have been prepared. The weak and strong interaction that occurs is influenced by the level of proximity between product attributes with technical parameters. The subsequent interactions are expressed in numbers and symbols.

3.5 Determining the technical correlation
Identification of relationships between processes needs to be done in order to know the existence of the exchange between each attribute on the parameters of the technique is:
1 The strong positive relationship when two attributes support each other in the implementation and the relationship is very strong.
2 Moderately positive relationships when two attributes support each other in their execution and the relationship is moderate.
3 There is no relationship when two attributes do not have any relationship.
4 Priority determination of the requirement process to be developed needs to consider the interaction between requirements parameters

3.6 Technical Aspect and Production Process
In this research, the right technical aspect is to produce with the service technician in the workshop to assemble clothes that have been designed according to consumer desire. Then add the moisture sensor and the light sensor assembled on the clothesline.

1. Production Process
Is a process needed to make a certain product from raw materials into finished products that consumers need[]. The following is a standard measure of anthropometric data for users of a clothesline product.

| Table 3. Planning Matrix Recapitulation |
|----------------------------------------|
| No | Attributequestion | IC  | CSP | ESP | IR  | SP  | RW  | NRW | Priority |
|----|--------------------|-----|-----|-----|-----|-----|-----|-----|----------|
| 1  | The clothesline with large capacity. | 4,108 | 3,641 | 4,625 | 1,270 | 1,5 | 8,388 | 0,04579 | 6         |
2. The clothesline are difficult to bend and break.

3. Clothesline that use hangers.

4. Clothesline with additional rain sensor. Safe clothes (clothes not carried by the wind)

5. The clothesline view is interesting.

6. Clothesline heights can be customized to user needs.

7. Clothesline made of stainless steel. The clothes are easy to move and can be folded.

8. The clothes are suitable and affordable.

9. Costs of Production

3.7 Cost of Production
Calculation of cost of production is a very important profit of product development to be marketed. The point is to determine the selling price of the product. Whether to follow market prices or below market prices in accordance with the wishes of consumers.

1. Collection of Fees
In conducting production activities, various unexpected costs are required to produce the product in addition to the costs for the finished product or the final product result. The cost will be used as an element of cost of production. In this study, the collection is taken from every time made the clothesline. The cost components incurred in every manufacturing are as follows:

a. Raw Materials Cost
Table 6 shows the cost of raw materials for the construction of the clothesline framework used as a reference calculation of the cost of production.
Table 6. Raw Material

| No | Material Type       | Capacity | Price  |
|----|---------------------|----------|--------|
| 1  | Hollow stainless 15 x 15 | 3 bar    | Rp. 56000 |
| 2  | Paint               | 1 Cans   | Rp. 58000 |
| 3  | Wheel               | 6 pcs    | Rp. 9000  |
| 4  | Cover               | 4 meter  | Rp. 20000 |
| 5  | Dynamo              | 2 pcs    | Rp. 60000 |
| 6  | Cable               | 12 pcs   | Rp. 48000 |
| 7  | LED Light           | 2 pcs    | Rp. 2000  |
| 8  | Humidity Sensor     | 1 pcs    | Rp. 6000  |
| 9  | Light Sensor        | 1 pcs    | Rp. 3000  |
| 10 | Battery 7.5 A       | 1 pcs    | Rp. 150000 |
| 11 | Solar Panel         | 1 pcs    | Rp. 200000 |
|    | Total               |          | Rp. 612000 |

b. Costs Labor

Costs Labor are the cost incurred to pay the direct labor wage of the production process. In this case, the required workforce is on the welding technician and the sensor assembly technician. The required workforce is 3 Persons, like as shown in Table 7 with a total wage of Rp.700.000.

Table 7. Cost Labor

| No | Information         | Price  |
|----|---------------------|--------|
| 1  | Las Technician      | Rp. 400.000 |
| 2  | Sensors Technician  | Rp. 300.000 |
|    | Total               | Rp. 700.000 |

c. Costs Production

Table 8 is shown the Costs Production that can be determined by summing up the overall costs incurred during product manufacturing. The total costs required are as follows:

Table 8. Costs of Production

| No | Information        | Price  |
|----|--------------------|--------|
| 1  | Raw material costs | Rp. 612.000 |
| 2  | Labor Cost         | Rp. 700.000 |
|    | Total              | Rp. 1.312.000 |

3.8 Determining the Selling Price with the Mark Up Method

In using the markup method, the percentage of markup should be multiplied by production cost, then added to the production cost resulting in a markup price. The reason for using markups is because of the lack of certainty of costs rather than on demand. The following results processing using the method mark up.

\[
\text{Selling price} = \text{production costs} + \text{mark up} \\
= \text{production cost} + (\% \times \text{production cost}) \\
= \text{Rp. 1.312.000} + (50\% \times \text{Rp 1.312.000}) \\
= \text{Rp. 1.312.000} + (\text{Rp. 656.000}) = \text{Rp. 1.968.000} \approx \text{Rp. 1.97 million}
\]

4. Conclusion

Specification of product design clothesline based on statements voice of the customer by tree diagram analysis is that at the features (function main) there is a waterproof rain sensor and there is a hook for the hanger, as well as for the reliability (safety) there is a bearing or wheel on the clothesline. Durability is not easy to bend or break, portability (Easy to set up) laundry Portable, Aesthetics (design) Colors, and models vary as well as designs more attractive and also the capacity of clothing should be increased, and the last of
thereview price (price) that is the suitable and affordable price. The design of clothesline products based on consumer wishes using the Quality Function Deployment (QFD) method which has been processed using house of quality hence can be seen that highest percentage of value or that become priority of product attribute that is on "there are additional features of rain sensor on clothesline" percentage value of 21.518%, followed by "clothesline that is not easily bent" with a value of 12.971%, and then on the priority order of three that "clothesline are easily removable and can be folded" with a value of 8.544%.

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