Technical characteristics’ determination of crumb rubber product by using quality function deployment (QFD) phase I

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Abstract. Products that have the best quality are products that are produced by researching consumer’s need. Product indicators that have the best quality are the linkages between technical characteristics and consumer’s need. PT XYZ is a company engaged in the production of crumb rubber products. However, the products produced are not by the needs of consumers because there are differences between the indicators required and the indicators produced by the company. The purpose of this study is to identify technical characteristics that are by consumer needs. The method that can be used is the Quality Function Deployment (QFD) method. The QFD method is a method that relates the relationship between consumer needs and product characteristics to obtain the products quality. In other words, by using the QFD method, consumer needs can be translated into technical characteristics so that improvements can be made to prioritized technical characteristics. The results obtained from this study are stating that the priority characteristics obtained are the speed of production with a difficulty level is 4, the degree of importance is 21%, and the estimated cost is 18%.

1. Introduction
PT XYZ is a company located in Medan Amblas, North Sumatra. The company is engaged in the production of crumb rubber products with the SIR (Standard Indonesian Rubber) standard. The standard types produced are SIR 20 and SIR 20CV. However, the company most produce on crumb rubber products with SIR 20 standards. The company is an export-oriented company because the company's customers are mostly from Europe and America. The company produces with the make to order system so that the production process goes according to the demands of the regular customers of the company.

The problem that arises in this company is that there is a gap between the products produced by the company and the requirements set by the company's customers. This was indicated by the difference between the initial plasticity levels produced and the levels determined by consumers. The gap is caused by the absence of further research on the products produced by the company. To be able to solve the problem, the method that is used is the Quality Function Deployment (QFD) method. And to achieve the determination of priority characteristics is by developing a phase I QFD matrix. Phase I QFD is a consumer need identification matrix about product characteristics. So that from the priority technical characteristics, an appropriate repair ratio can be developed.
Based on the research of Rosnani, et al. [1], a quality function deployment (QFD) was developed using kano model to determine the need of costumer and turn it to technical characteristics, so that each of functional areas and level of organization can be understood and do improvements to achieve the purpose. Beside that research, M.H. Karimi Gavareshki [2] did the design of an automotive product using quality function deployment (QFD) and value engineering methods. The using of QFD is to determine the priority of the critical part that can be improved using value engineering method. The using of value engineering method is to modify the materials of product that can be used to reduce the production cost and to increase the quality of crumb rubber products.

In this research, the model of quality function deployment that conducted is based on theory from a textbook implemented by Lou Cohen [3], quality function deployment. This method is complemented to the theory from a textbook that implemented by Rosnani Ginting [4], product design. The complementation between each book eases the research to developed the model of research to be conducted.

2. Methods
This research was conducted by surveying a rubber company crumbs to the respondents in the company. Respondents surveyed were employees of the production process and production department supervisors at the company. The sampling method used is purposive sampling with quota sampling type. The sample of research is 27 people who are the total employee of production. The determination of this method of research is referred from Sukaria Sinulingga [5], Methods of Research. The first step is to identify consumer needs by distributing open and closed questionnaires. The using of this method is based on the reference of Rosnani Ginting [6], questionnaires. The second step is to determine the degree of importance of the results of the questionnaire. The third step is to determine the technical characteristics of the product. The fourth step is to determine the relationship between fellow technical characteristics of the product. The fifth step is to determine the degree of relationship between technical characteristics and consumer needs. The sixth step is to compile a planning matrix from QFD. The seventh step is to build a House of Quality matrix. And the last step is to calculate the priority of the technical characteristics of the product.

3. Result and Discussion
3.1. Identifying Consumer Needs
Identification of consumer needs is done through questionnaires [3][6] to obtain 20 factors of consumer needs for crumb rubber products. The results of the identification of consumer needs can be seen in Table 1.
Table 1. The result of the identification of consumer needs

| No | Group                | Results of Questionnaires                                                        |
|----|----------------------|----------------------------------------------------------------------------------|
| 1  | Constituent products | The level of water in rubber affects the length of the drying process            |
| 2  | Constituent products | Dirt level affects the length of the rubber washing process                      |
| 3  | Constituent products | Metal content in rubber affects the working level of the machine                  |
| 4  | Constituent products | Thick rubber size causes the old enumeration process                               |
| 5  | Constituent products | The availability of pallet affects the ease of moving the product to the warehouse|
| 6  | Constituent products | The color of the rubber raw material does not affect the production process       |
| 7  | Constituent products | Plastic availability prevents products from contaminants                         |
| 8  | Constituent products | The availability of water affects the process of separation of impurities         |
| 9  | Constituent products | The breaker machine facilitates the enumeration process                          |
| 10 | Constituent products | Creeper machine facilitates the process of forming rubber sheets                  |
| 11 | Machines/equipment  | The dryer machine affects the product maturity level                               |
| 12 | Machines/equipment  | Press machine affects rubber stiffness                                            |
| 13 | Machines/equipment  | The availability of cutting tools makes the cutting process easier                |
| 14 | Machines/equipment  | The washing process makes it easy to separate dirt                               |
| 15 | Machines/equipment  | The enumeration process facilitates the grinding process                          |
| 16 | Machines/equipment  | The grinding process affects the reduction in rubber thickness                    |
| 17 | Process              | The drying process affects the level of DRC in rubber                            |
| 18 | Process              | The cooking process affects the white spot product level                          |
| 19 | Process              | The compaction process affects the product dimensions                            |
| 20 | Process              | The packaging process affects rubber resistance                                  |

3.2. Determination of the Degree of Importance

Assessment of the level of importance to the attributes is obtained based on the value of the mode in the closed questionnaire based on the frequency of the respondent's most answers to each attribute. For example [3], in attribute 1, the highest mode is 5, so the level of importance 1 is 5. The level of importance of all attributes can be seen in Table 2.
Table 2. Degree of importance

| No | Consumer’s needs                                                                 | Degree of Importance |
|----|----------------------------------------------------------------------------------|----------------------|
| 1  | The level of water in rubber affects the length of the drying process             | 5                    |
| 2  | Dirt level affects the length of the rubber washing process                       | 4                    |
| 3  | Metal content in rubber affects the working level of the machine                  | 4                    |
| 4  | Thick rubber size causes the old enumeration process                              | 4                    |
| 5  | The availability of pallet affects the ease of moving the product to the warehouse| 5                    |
| 6  | The color of the rubber raw material does not affect the production process        | 5                    |
| 7  | Plastic availability prevents products from contaminants                          | 4                    |
| 8  | The availability of water affects the process of separation of impurities          | 5                    |
| 9  | The breaker machine facilitates the enumeration process                           | 4                    |
| 10 | Creeper machine facilitates the process of forming rubber sheets                  | 5                    |
| 11 | The dryer machine affects the product maturity level                              | 5                    |
| 12 | Press machine affects rubber stiffness                                            | 4                    |
| 13 | The availability of cutting tools makes the cutting process easier                 | 5                    |
| 14 | The washing process makes it easy to separate dirt                               | 4                    |
| 15 | The enumeration process facilitates the grinding process                           | 5                    |
| 16 | The grinding process affects the reduction in rubber thickness                     | 4                    |
| 17 | The drying process affects the level of DRC in rubber                             | 5                    |
| 18 | The cooking process affects the white spot product level                           | 4                    |
| 19 | The compaction process affects the product dimensions                             | 5                    |
| 20 | The packaging process affects rubber resistance                                   | 5                    |

3.3. Technical Characteristics’ Determination
The next step in building HoQ is to determine the characteristics needed by the PT XYZ company in meeting the variables of consumer needs for crumb rubber products. Determination of product characteristics [3] based on interviews and discussions with supervisors of factory production. The technical characteristics of the product are as follows.

- **Production time (second)**
  Production time is the time needed to carry out the crumb rubber production process of the SIR 20 type thoroughly from the beginning of the washing process to packaging.

- **The speed of count (Kg / s)**
  The speed of chopping is some rubber raw materials that can be chopped in units of time during the enumeration process.

- **Production costs (Rupiah)**
  Production costs are some costs that occur due to the processes of producing crumb rubber products.

- **Milling speed (Rpm)**
  Milling speed is some rubber raw materials that can be milled in units of time during the grinding process.
- Drying time (Hour)
  Drying time is the length of the process of drying rubber blankets by drying in the KGB until it reaches the ripe age for cooking.
- Cooking temperature (°C)
  The cooking temperature is the amount of temperature needed to process the crumb rubber product.
- Production speed (Tons/day)
  Production speed is some crumb rubber products that can be produced in a certain time unit.
- Engine capacity (kg / day)
  The capacity of the engine is how well the engine can accommodate materials that will be subjected to the production process.

3.4. Establish Relationships Between Technical Characteristics
At this stage determined the level of relationship between each technical characteristics that exists to be analyzed whether between the technical characteristics there is a strong relationship, weak or unrelated. This determination is determined [3] by interviewing the supervisor of the company that skilled in this case, especially the production supervisor. Determining the level of relationship between each of the existing technical characteristics based on the following symbols:
V: shows a strong positive relationship = 4
v: shows a weak positive relationship = 3
x: shows a weak negative relationship = 2
X: shows a strong negative relationship = 1
O: no relation = 0
Level of the relationship between each technical characteristics can be seen in Figure 1.

3.5. Establish Level of Relationship Between Technical Characteristics of Products and Consumer Needs
The next step is to determine the level of relationship between the technical characteristics and consumer needs of the product. This determination is determined [3] by the researcher to corresponding the result of the relationship between each technical characteristics, and consumer need once using the literature review. The level of relationship in question starts from the scale of strong, medium, weak, and not related at all. Assessments will be based on rules:
- Value 9: shows a strong relationship
- Value 3: indicates a moderate relationship
- Value 1: shows a weak relationship
- Value 0: shows no connection at all
The correlation score between the technical characteristics and consumer needs can be seen in Figure 2.

![Figure 1. Relationship between each technical characteristic](image)
The level of water in rubber affects the length of the drying process
Dirt level affects the length of the rubber washing process
Metal content in rubber affects the working level of the machine
Thick rubber size causes the old enumeration process
The availability of pallet affects the ease of moving the product to the warehouse
The color of the rubber raw material has no effect in the production process
Plastic availability prevents products from contaminants
The availability of water affects the process of separation of impurities
The breaker machine facilitates the enumeration process
Creeper machine facilitates the process of forming rubber sheets
The dryer machine affects the product maturity level
Press machine has an effect on rubber stiffness
The availability of cutting tools makes the cutting process easier
The washing process makes it easy to separate dirt
The enumeration process facilitates the grinding process
The grinding process affects the reduction in rubber thickness
The drying process affects the level of DRC in rubber
The cooking process affects the white spot product level
The compaction process affects the product dimensions
The packaging process has an effect on rubber resistance

Figure 2. Relationship between technical characteristic and consumer needs

3.6. Compile a Planning Matrix
This planning matrix is done to get the order or priority variables for consumer needs. This planning matrix is the result [3] of calculation of several types of data and therefore in compiling this matrix several stages are needed, namely sales points, customer importance weight, and relative weight. The planning matrix can be seen in Table 3.
Table 3. Planning matrix

| No | Consumer’s needs                                                                 | Sales Point | Importance Weight | Relative Weight |
|----|----------------------------------------------------------------------------------|-------------|-------------------|-----------------|
| 1  | The level of water in rubber affects the length of the drying process             | 1,5         | 170               | 8,4493          |
| 2  | Dirt level affects the length of the rubber washing process                       | 1,2         | 88                | 4,3738          |
| 3  | Metal content in rubber affects the working level of the machine                  | 1,2         | 80                | 3,9761          |
| 4  | Thick rubber size causes the old enumeration process                              | 1,2         | 124               | 6,1630          |
| 5  | The availability of pallet affects the ease of moving the product to the warehouse| 1           | 45                | 2,2366          |
| 6  | The color of the rubber raw material does not affect the production process       | 1           | 15                | 0,7455          |
| 7  | Plastic availability prevents products from contaminants                          | 1,2         | 36                | 1,7893          |
| 8  | The availability of water affects the process of separation of impurities         | 1,2         | 135               | 6,7097          |
| 9  | The breaker machine facilitates the enumeration process                           | 1,2         | 108               | 5,3678          |
| 10 | Creeper machine facilitates the process of forming rubber sheets                   | 1,2         | 165               | 8,2008          |
| 11 | The dryer machine affects the product maturity level                              | 1,2         | 110               | 5,4672          |
| 12 | Press machine has an effect on rubber stiffness                                    | 1,2         | 88                | 4,3738          |
| 13 | The availability of cutting tools makes the cutting process easier                 | 1,2         | 125               | 6,2127          |
| 14 | The washing process makes it easy to separate dirt                                | 1           | 76                | 3,7773          |
| 15 | The enumeration process facilitates the grinding process                           | 1,2         | 155               | 7,7038          |
| 16 | The grinding process affects the reduction in rubber thickness                     | 1           | 68                | 3,3797          |
| 17 | The drying process affects the level of DRC in rubber                             | 1,5         | 155               | 7,7038          |
| 18 | The cooking process affects the white spot product level                           | 1,5         | 144               | 7,1571          |
| 19 | The compaction process affects the product dimensions                             | 1,2         | 50                | 2,4851          |
| 20 | The packaging process affects rubber resistance                                   | 1,2         | 75                | 3,7276          |

3.7. Building a House of Quality Matrix (HOQ) Phase, I Crumb Rubber Product Type SIR 20

Before building a house of quality (HOQ) Phase I, it is necessary to calculate the performance measures of the HoQ consisting of three aspects [3]: difficulty level, importance level, and cost estimation.

3.7.1. Determination of difficulty level

The degree of difficulty is determined from the critical part relationships. The calculation is done by translating all the weight of the relationship value and then dividing the weight of each critical part with the amount of weight was. Furthermore, the difficulty level is given based on the percentage range obtained.

3.7.2. Determination of Degree of Interest

The value of the degree of importance can be calculated by calculating the total weight for each relationship between the attribute of technical characteristics with the consumer needs.
3.7.3. **Cost estimation**

The difficulty level factors serve as the basis for cost estimates because the more difficult a technical characteristic is made, the more costly the allocation will be. Determination of Difficulty, Degree of Interest and Cost Estimation can be seen in Table 4.

| Table 4. Difficulty Level, Degree of Importance, Cost Estimation |
|---------------------------------------------------------------|
| Difficulty Level     | 3 | 2 | 3 | 3 | 2 | 3 | 4 | 2 |
| Degree of Importance | 13| 9 | 19| 11| 9 | 11| 21| 9 |
| Cost Estimation      | 14| 9 | 14| 14| 9 | 14| 18| 9 |

The Phase I HoQ matrix is based on the data that has been obtained in the previous steps. QFD Phase I of SIR 20 type crumb rubber products can be seen in Figure 3.

4. **Conclusion**

The results of QFD Phase I SIR 20 crumb rubber products show that the attributes that have a degree of difficulty from the highest to the lowest are the production speed, production costs, production time, milling speed, cooking temperature, speed of count, drying time, and engine capacity. The value of the difficulty level of production speed is four the degree of importance is 21%, and cost estimation is 18%.
Figure 3. Quality Function Deployment (QFD) Phase I

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