The implementation of value engineering using Zero-one Method to redesign the conventional tool for molding the cassava cracker

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Abstract. This research aims to develop the model of decision making to select the best alternatives design of the molding tool in producing cassava crackers. This design is implemented to improve the production capability in SMEs of cassava crackers in Tulungagung, East Java, Indonesia. This cassava cracker is one of traditional food which includes in the strategies of Tulungagung government in empowering the local wisdom in the region. Even though this product becoming the favorite local food, the number of the product is not much in the market. This is because the production process is undertaken manually. In addition, the thickness and diameter are not precise, because the tool used is a molding machine using manual handle. It still needs a long time to yields the products. Also, it can cause a delay in order to fulfill market demands. Therefore, the researcher redesign machining tool in molding the cassava crackers to increase the production speed. There are four design alternatives, i.e. machine design A; machine design B; machine design C; and machine design D. The best alternative is depending on some criteria which are time efficiency, output quantity, the construction strength, hygienic, the dimension of machine, machine operational, and output quality. In selecting the best design, this research applies zero one method. The result shows that the best alternative was machine design B. It has the biggest weighted number by 28.158 among others. It means that the machine has a thick plain plate and the type to press in the molding machine utilises the pneumatic model.

Keyword: Zero-one method; cassava crackers; SMEs; decision making

1. Introduction
Cassava cracker is traditional snacks that have a savory flavour. It made from steamed cassava, salt and chives [1]. Cassava has several benefits for the body, including a source of fiber, a source of carbohydrates, high protein, vitamin K, vitamin B complex, essential minerals, improve the digestion.
In addition, cassava has health benefits. It can reduce the risk of stroke, heart disease, colon cancer, controlling diabetes, and Alzheimer's disease by limiting nerve damage in the brain [1]. Cassava crackers are one of the products produced by several SMEs in Tulungagung. In this case, the researchers investigate the production problem in the SMEs located at Pecuk Village, in Tulungagung. The business has been established since 2012 by the community around Pecuk Village. The existence of this business has helped and improved the economy of the people directly involved in the production of cassava crackers. This is because cassava crackers have a lot of customers such as people around East Java, Cooperation shops, Souvenir shops, and Traditional market. The SMEs deal with some problem such as the lack of capacity of production since the machine to mold the cracker is still manual. The machine has a holder to press the dough that has been put on the tray. However, the capacity is a half kg cracker each tray. Then, the process molding is 5 minutes each tray. In a day, the SMEs can produce 24 kg of a raw cracker. Since 10 distributors need 5 kg per day, the SMEs need to increase the production capacity more than twice. So, it will be better if the capability of machine is increased by redesign of the molding machine. This study aims to propose four designs which consist of machine A (thick plain plates and Hydraulic type); machine B (thick plain plate and Pneumatic type); machine C (profile plate and Hydraulic type); and machine D (profile plate and Pneumatic type).

2. Methodology
There is five phase job plan as follows.

1. Information stage. The information stage is the starting point to collect all information regarding cassava crackers and the tool utilised. At this stage, all data will be extracted to redesign the tool.

2. Creative stage. The second stage that is created based on the creative idea collected from the design and mechanic experts, customers, the owners and employers of cassava crackers-SMEs. After all information about the tool specifications are gathered, then alternatives design of tools are decided. Some alternatives will be evaluated at the next step to choose the best alternative.

3. Analysis stage. In this stage, the researchers utilise Zero One Method to decide the best alternative among all alternatives selected. In this stage, the ways to weight the attribute are:

   a. Define the rank (importance degree) each adjective.

   b. Define the weighted of each criteria by scaling with the total number 100

   c. The weighted of criteria (Bi%) is:

   \[
   \text{Rank} \times 100\% \quad (1)
   \]

   d. Define the rank from the adjective by the following formula.

   \[
   \sigma = \frac{\sum(X_i-\bar{X})^2}{(n-1)} \quad (2)
   \]

   \[
   Z = \frac{\bar{X}-3}{\sigma} \quad (3)
   \]

   \[
   f(z) = 100 + 25z \quad (4)
   \]
Δ = V_{actual} - V_{ideal} \tag{5}
V_{actual} = B_{i}\% \times F(z) \tag{6}

Where

\begin{align*}
\Sigma &= \text{Standard Deviation} \\
\mu &= \text{Ideal Average} \\
F(z) &= \text{Z function} \\
B_{i}\% &= \text{The Weighted} \\
Z &= \text{Ideal product}
\end{align*}

Source: [2]

e. Ranking in reverse

f. Overview for each adjective

4. Development stage. In this phase, the best design alternatives will be selected based on the biggest weighted.

5. Presentation stage. This stage disseminates the result by explaining the best alternative based on some criteria selected.

Each stage has its own objectives and has key questions that must be answered. The five stages of value analysis should be undertaken step by step. Further, the process might be returned to the previous stage. The process of value engineering stage is illustrated by the following figure.

![Figure 1. The relationship among the stages in value engineering](image)

3. Analysis and discussion

3.1. Information stage

This stage initialed by describing the existing molding machine as the initial design. This machine utilises 1 peer, hollow/canal material, and stainless steel as the material of pressing plate. Then, the aluminum tray with the dough on it is covered by plastic to keep hygiene. Afterward, the tray is put in
the machine. Then, the lever is pressed to make the dough thinner and mold with some small circle shape.

![Figure 2. The initial design of molding machine of cassava crackers](image)

Then, some specification of machine needed was gathered from the following respondent.

a. The users of molding machine are cassava cracker makers who are directly using the machine.

b. Mechanical Workers (machining workshop workers)

c. Experts (Academics) are the lecturers of the Faculty of Engineering majoring in Mechanical Engineering, Widyagama University, Malang.

In this study, we collect the data from the population because the population is less than 100 [3]. After defining the relevant respondents, the researchers identify the needs attribute, i.e. time efficiency, output quantity, the construction strength, hygienic, the dimension of machine, machine operational, and output quality.

1. Time Efficiency
   The basic consideration of this criterion is how the machine works fast. It means that the time used to mold is faster than before, with approximately 1-2 minutes.

2. Output Quantity
   The basis for consideration of this criterion is the amount produced for one molding machine that can run a process by 16 pieces.

3. Construction Strength
   The basis for consideration of this criterion is the construction of machine in accordance with the needs of both the manufacture of frames and plates with quality materials. The frames and plates are not easily damaged, durable and strong.

4. Hygienic
   The basic consideration of this criterion is healthy conditions and safe for consumption.

5. The dimension of machine
   The basis for consideration of this criterion is that the size of the cassava cracker molding machine is easier for the operator to operate.

6. Machine operational
   The basic consideration of this criterion is the simple and understandable procedure of guidance to operate molding machine for cassava crackers.
7. Output Quality
The basic consideration of this criterion is the machine can produce the high quality of products.

Determination of the initial product performance in terms of the attributes of this requirement is undertaken to get a graph of the current condition of the initial product. Therefore, it can be identified which attributes need to be improved to get an ideal product. The summary of the needs attribute can be shown at Table 1.

| No | Attribute               | Weighted | Rank |
|----|-------------------------|----------|------|
| 1  | Time efficiency         | 22.88    | 7    |
| 2  | Output Quantity         | 8.42     | 6    |
| 3  | Construction Strength   | 5.54     | 5    |
| 4  | Hygienic                | 0.83     | 4    |
| 5  | The dimension of machine| 0.69     | 3    |
| 6  | Machine operational     | -12.23   | 1    |
| 7  | Output Quality          | -11.06   | 2    |

3.2. Creative Stage
The creative stage is the second stage in which the value stage in this stage can be obtained from alternative designs based on the ideas obtained. Based on the analysis of needs and analysis of the functions set in the previous sub-chapter, then, to redesign the cassava opaque printing machine needed there are several kinds of elements needed, namely:

1. Plate Press: Thickness, Profile.
2. Type of Suppressor: Hydraulic, Pneumatic.

3.3. Analysis Stage
In morphological analysis, there are two ways to create alternative designs. Namely the matrix and generator. Matrix of each element consists of element 1. Plate Press ((a) Thickness; and (b) Profile) and element 2. Pressure Type ((a) Hydraulics; (b) Pneumatic).

From the elements defined, there are four alternatives of molding machines design, i.e. machine A (thick plain plates and Hydraulic type); machine B (thick plain plate and Pneumatic type); machine C (profile plate and Hydraulic type); and machine D (profile plate and Pneumatic type).

The alternatives obtained in the creative phase are evaluated and analyzed at this stage. The evaluation and analysis process is carried out based on technical and economic factors to determine the strengths and weaknesses of each design alternative so that the chosen design alternatives are obtained.

In order to know the best alternative, zero one method was applied [4]. The result of each attribute can be shown as follow.

| Alternative | A | B | C | D | DA | Total | Index |
|-------------|---|---|---|---|----|-------|-------|
| A           | X | 0 | 1 | 0 | 1  | 2     | 0.2   |
| B           | 1 | X | 0 | 1 | 1  | 3     | 0.3   |
| C           | 0 | 1 | X | 0 | 1  | 2     | 0.2   |
| D           | 1 | 0 | 1 | X | 1  | 3     | 0.3   |
Table 3. Zero – One method for output quantity

| Alternative | A  | B  | C  | D  | DA | Total | Index |
|-------------|----|----|----|----|----|-------|-------|
| A           | X  | 0  | 0  | 1  | 1  | 2     | 0.2   |
| B           | 1  | X  | 1  | 0  | 1  | 3     | 0.3   |
| C           | 1  | 0  | X  | 1  | 1  | 3     | 0.3   |
| D           | 0  | 1  | 0  | X  | 1  | 2     | 0.2   |
| DA          | 0  | 0  | 0  | 0  | X  | 0     | 0     |
| Total       | 10 | 1.0|

Table 4. Zero – One method for construction strength

| Alternative | A  | B  | C  | D  | DA | Total | Index |
|-------------|----|----|----|----|----|-------|-------|
| A           | X  | 1  | 1  | 0  | 1  | 3     | 0.3   |
| B           | 0  | X  | 1  | 1  | 1  | 2     | 0.2   |
| C           | 0  | 0  | X  | 1  | 1  | 2     | 0.2   |
| D           | 1  | 0  | 0  | X  | 1  | 2     | 0.2   |
| DA          | 0  | 0  | 0  | 0  | X  | 0     | 0     |
| Total       | 10 | 1.0|

Table 5. Zero – One method for hygienic

| Alternative | A  | B  | C  | D  | DA | Total | Index |
|-------------|----|----|----|----|----|-------|-------|
| A           | X  | 1  | 1  | 0  | 1  | 3     | 0.3   |
| B           | 0  | X  | 0  | 1  | 1  | 2     | 0.2   |
| C           | 0  | 0  | X  | 1  | 1  | 2     | 0.3   |
| D           | 1  | 0  | 0  | X  | 1  | 2     | 0.2   |
| DA          | 0  | 0  | 0  | 0  | X  | 0     | 0     |
| Total       | 10 | 1.0|

Table 6. Zero – One method for the dimension of machine

| Alternative | A  | B  | C  | D  | DA | Total | Index |
|-------------|----|----|----|----|----|-------|-------|
| A           | X  | 0  | 0  | 1  | 1  | 2     | 0.2   |
| B           | 1  | X  | 1  | 1  | 1  | 4     | 0.4   |
| C           | 1  | 0  | X  | 1  | 1  | 3     | 0.3   |
| D           | 0  | 0  | 0  | X  | 1  | 1     | 0.1   |
| DA          | 0  | 0  | 0  | 0  | X  | 0     | 0     |
| Total       | 10 | 1.0|

Table 7. Zero – One method for machine operational

| Alternative | A  | B  | C  | D  | DA | Total | Index |
|-------------|----|----|----|----|----|-------|-------|
| A           | X  | 1  | 1  | 0  | 1  | 3     | 0.3   |
| B           | 0  | X  | 1  | 1  | 0  | 2     | 0.2   |
| C           | 0  | 0  | X  | 1  | 1  | 2     | 0.2   |
| D           | 1  | 0  | 0  | X  | 0  | 1     | 0.1   |
Table 8. Zero – One method for output quality

| Alternative | A | B | C | D | DA | Total | Index |
|-------------|---|---|---|---|----|-------|-------|
| A           | X | 0 | 1 | 0 | 1  | 2     | 0.2   |
| B           | 1 | X | 0 | 1 | 0  | 3     | 0.3   |
| C           | 0 | 0 | X | 0 | 0  | 0     | 0.0   |
| D           | 1 | 1 | 1 | X | 0  | 3     | 0.3   |
| DA          | 0 | 1 | 1 | 1 | X  | 2     | 0.2   |
| Total       | 10| 1 | 1 | 1 | X  | 10    | 1.0   |

Where:
1 = More important; X = equal; 0 = Less important.
A = machine design A; B = machine design B; C = machine design C; and D = machine design D

Furthermore, the researchers implement evaluation matrix as shown in Table 9.

Table 9. Evaluation matrix

| Alternative | Attribute | Total  | Rank |
|-------------|-----------|--------|------|
|             | 1 | 2   | 3   | 4 | 5 | 6 | 7 |     |      |
| Weighted    | 31.2 | 10.4 | 6.65 | 5.81 | 2.97 | 15.67 | 27.33 |
| Machine A   | 0.2  | 0.2  | 0.3  | 0.3  | 0.2  | 0.3  | 0.2   | 22.774 | 3     |
| Machine B   | 0.3  | 0.3  | 0.3  | 0.2  | 0.4  | 0.2  | 0.3   | 28.158 | 1     |
| Machine C   | 0.2  | 0.3  | 0.2  | 0.3  | 0.3  | 0.2  | 0     | 16.458 | 4     |
| Machine D   | 0.3  | 0.2  | 0.2  | 0.2  | 0.1  | 0.1  | 0.3   | 23.995 | 2     |
| DA          | 0    | 0    | 0    | 0    | 0    | 0    | 0.2   | 11.333 | 5     |

According to Table 9, the biggest weighted number is machine B. It means that machine B with a thick plain plate and the pneumatic model is the best alternative.

4. Conclusion
This research aims to decide the best design of a molding machine for cassava crackers. The result shows that the best alternative was machine design B. It has the biggest weighted number by 28.158 among others. It means that the machine has a thick plain plate and the type to press in the molding machine utilises the pneumatic model. This study is limited in implementing value engineering which is only the stage of analysis. The next study should investigate the value of each design in the developing stage.

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