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Value Engineering Towards the Design of Bread Production Process Tools

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Abstract. In a bakery, an operator needs a working tool for bread production process. To avoid injury and inconvenience the tool should be suitable and appropriate for the operator's body posture and workload. Operators' assistive device produced is trolley rack. Value engineering approach is carried out on this tool to identify and develop its functions in achieving the balance among cost, reliability and appearance of the product. The work-plan is divided into several development stages: creative stage, analysis stage, development stage and recommendation stage. Product value is determined by comparing between product benefits and product costs. This study employs Function Analysis System Technique (FAST) method which consists of 5 stages, namely information, creative, analysis, development and presentation/recommendation stages. The recommendation stage explains the best alternative design. The results show that alternative II has the highest performance value which is 97.16 and the highest rating of 0.45. It is rated as the best design and has good product durability.

Keywords: work tools, value engineering, FAST method, performance

1. Introduction

The research focused on home industries that produce various types of bread. In bread production process, workers are found inconvenient during the process of transferring bread from the oven (baking) to the cart, where the design has not considered ergonomic aspects, so if workers work for a long period of time, he/she will have musculoskeletal problems. This also affects work productivity of operator. Productivity is comparison between the results achieved with the role of workers in certain period of time. If there is no improvement in the development of work system using assistive devices suitable with the workers' wishes, there will be no progress in work productivity. Referring to these problems, a solution was developed in form of new alternatives with the aim of creating a safe, comfortable and easy to use tool. This bread production process employs 6 workers. During the production process, some operators work in standing position and perform the same hand movements repeatedly (repetitive). To minimize non-ergonomics problem from the bread production process, work risk identification was carried out with Rapid Upper Limb Assessment (RULA) method [1] and work risk identification with OCRA method [2]. Assessment of work posture using the OCRA and RULA methods showed that operator used the right hand more dominant while working so the right hand experiences fatigue faster. The identification results with RULA method showed that work stations that have the highest risk are in the stirring, milling, printing and burning work stations. This is due to bent body posture and unbalanced legs of operator while doing his work [1]. The identification results using OCRA method



showed that work stations with the highest risk are found in 3 work stations namely milling, printing and baking work stations [2].

The operator aid tool is designed in form of trolley rack. The design of this trolley rack is made by considering value engineering calculations, to identify and develop the function of the rack. This is to get a balance among cost, reliability and appearance of the trolley rack. The important thing discussed in this research is functional value of the product components and how to increase the value or benefits that will be obtained from a product. This utilization can be achieved if there is production costs reduction, additional product value or both. For cost reduction, focus will be on designing product components using materials, product forms, manufacturing processes and assembly processes. This value engineering method can be developed to minimize existing products or design new products. For the industry to become more competitive we must act upon the challenges faced by the market more and more demanding and competitive in a globalized world [3].

The purpose of this value engineering technique is to improve efficiency and effectiveness in product design and development to minimize possible errors. Lack of understanding of consumer needs characteristics is because information quality received is not good enough so that it can lead to errors in designing the product. In addition, product development process will not run well if the aspects of habit, an environment that does not support creativity, lack of understanding and knowledge of costs are still the same. It will hamper the design process. Therefore, to anticipate errors in designing the bread production process aid, value engineering concept is applied to control costs by analyzing value towards its function without eliminating the desired quality and reliability. Value Engineering is a systematic system design technique to identify the functions needed, applying values and developing alternatives to achieve the best functional balance among cost, condition, and performance of system or product [4]. Value engineering concept aims to improve efficiency and effectiveness in carrying out the design by describing errors in design. According to Lawrence D. Miles [5], value engineering is a creative and systematic approach with the aim of reducing or eliminating unnecessary costs. Whereas according to the Society of American, value engineering is a technique that is applied systematically to determine the function of a product or service that determine monetary value of the function and fulfill it with minimum total cost.

However, according to Zimmerman and Hart [6], value engineering is a technique and management that uses a systematic approach to achieve the best functional balance between costs and performance of a product. Value Engineering is a system approach aimed to achieve the desired functions of a product, process, system or service at minimum overall cost, and having maximum performance with consistency without in any way affecting the quality, reliability, performance and safety of the product, process, system or service [7]. Value is defined as the ratio between product performance and the costs needed to get performance. Product's good performance will not necessarily produce high value if the cost required is very high. Therefore, product value can be increased in three ways, namely reducing costs while maintaining performance, improving performance while maintaining costs, improving performance and lowering costs [8]. By referring to several definitions, value engineering can be interpreted as creative and systematic management technique by identifying and developing the functions of object or service to achieve cost balance, reliability and appearance of a product or system. Value engineering is a method that emphasizes the analysis of various item functions or system through systematic and directed approach to achieve optimum use and financing for each rupiah spent [8] [5] [10][6][4]. So the results achieved in value engineering can be in form of alternative use of materials, new designs, etc. by considering alternative that have more value. Value engineering is a powerful problem solving tool that can reduce while maintaining or improving performance and quality requirements [11].

The main purpose of creating a product is basically to sell products quickly, with maximum benefits and provide satisfaction to consumers. Thus the product designers should not create excessive product functions or use of production materials that is not useful and raise the price. So the idea must be developed with a starting point from minimize cost, time, and material [12]. Information stage of value engineering is basic foundation for any value investigation. In this stage, all important information is collected to understand carefully the object being investigated. The information is then analyzed to find object functions, so that it can be clarified as a primary or secondary function [13]. In this study the

function stage for problem solving techniques is by identifying the functions needed using Function Analysis System's Technique (FAST). Objective of value engineering job plan creative stage is to produce various alternatives that can fulfill or carry out the main functions by using creative techniques. This creative stage can only be started if the desired function has been determined and evaluated. At this stage there is no analysis to ideas issued by each team member so that all ideas will be accommodated to fulfill basic functions without seeing progress first [13]. Ideas can be developed more broadly by doing so in a group whose members are from different fields of work known as brainstorming. Analysis stage of value engineering job plan is to evaluate alternatives provided in creative stage. Evaluation results are used to determine useful alternatives for further study which will be given the greatest potential for cost savings. Thought based on strict rules that do not apply in previous stages, at this stage the ideas and thoughts that have emerged before will analyzed and criticized.

In this development stage, development program was made until it became a complete proposal. The development program is based on detailed plan from evaluated ideas that is useful to obtain all relevant information in order to develop the program into an acceptable proposal and to implement it. Every aspect that is relevant to capability, design, quality, manufacturing, packaging, and marketing must be understood as an effort to change the idea that has been evaluated into a proposal that can be submitted [9]. Recommendation stage is the final stage in value engineering work plan which aims to convince decision makers to be able to decide whether the selected design is capable and good to do [13]. Analytical Hierarchy Process (AHP) is a decision support model that will disentangle multi-factor or multi-criteria problems into a hierarchy. According to [14], hierarchy is defined as representation of complex problem in multi-level structure where the first level is the goal, followed by the level of factors, criteria, and sub criteria and so on down to the last level of the alternative. The procedure in AHP method consists of several stages according to Suryadi and Ramdhan in Taminanto [15], namely arranging hierarchy of the problems faced and determining priority of the elements.

2. Method

Research stage was carried out to create value engineering work plan through several stages, namely:

a. Information stage using FAST method

Information stage is regarding matters relating to the design of bread production process aids. The components of this tool are trolley frames, trolley pads and trolley handles. Then from information obtained, it is analyzed using FAST Method to find object functions, so that it can be clarified as primary or secondary function. This function analysis is viewed from the tools that operator is expected to provide comfort and practicality at work.

b. Creative stage with Brainstorming

At this stage, several designs are made that help to develop and repair existing components, regarding materials, dimension, and shape that is possible to be repaired. At this stage other alternative ideas are raised, to master the same function.

c. Analysis stage with AHP method

This process is related to the selection and decision making that will allow solutions that can be implemented. In this analysis stage, several mechanisms of Hurt (2003) are carried out as follows:

- Profit and loss Analysis.
- Determination of priority criteria.
- Weighting analysis on criteria.
- Evaluation matrix.
- Weighting criteria on modification alternatives
- Performance of selected alternative.

d. Development stage

The aim of development is to choose the best alternative from selected alternatives in previous stage by comparing the results of performance calculations in previous stage. The success of this stage depends on two aspects, namely product performance, and the costs spent. So that at this stage value calculation will be taken by comparing performance value to the cost.

e. Recommendation stage.

This stage is to explain the best alternative designs.

3. Result and Discussion

3.1 Information Stage

Information obtained from initial design analysis, where initial conditions of bread production process aids have weaknesses in components; material, dimensions or shape of the component, the size and shape dimensions are not yet in accordance with anthropometry. From the results of interviews conducted, information data obtained based on design requirements analysis that the system and operator's work position are not good enough and cause work complaints. The equipment that is used now does not last long because its dimensions are not ergonomic. Then the information is analyzed using Function Analysis System Technique (FAST) method with the following results in Table 1 and also shown in Figure 1.

Table 1. Function of the Bread Production Process Tools

Component	Function		Type
	Verb	Noun	
The Bread Production Process Tools	To Give	Comfort and Practicality	Secondary (S)
	Give	The Place for Bread Production Process Tools	Primary (P)

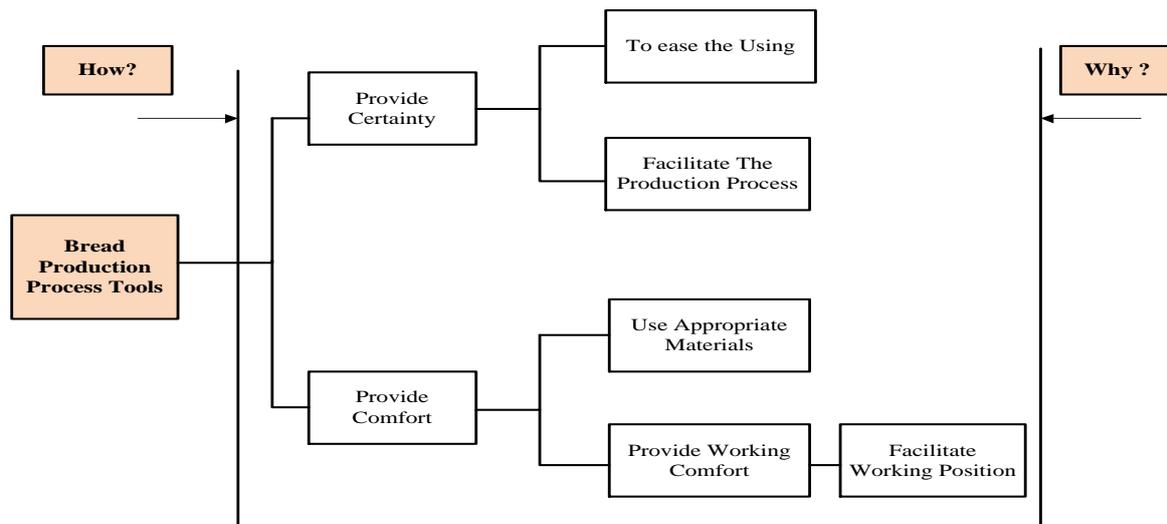


Figure 1. Chart of FAST for Production Process Tools

3.2 Creative Stage

Imperfection to generate new ideas is one of main causes in proposed alternative comparison. The proposed alternative is obtained from component reduction, simplification or modification while maintaining the object's main function. Based on the weaknesses and conditions of existing equipment, alternative design of assistive devices is developed in accordance with anthropometric data. This is shown in Figure 2.

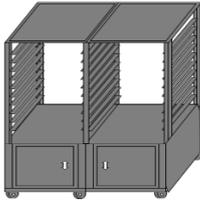
Alternatives	Improvements
<p>Alternative I</p> 	<ol style="list-style-type: none"> 1. The design tool is made from iron plate and iron ace 2. The design tool is made with a size of 90 cm x 80 cm x 103 cm 3. The design tool is painted in silver 4. The design tool has economic life > 4 years 5. Rectangular design tool 6. The design tool is made to move & place items 7. 14. The design tool is given a rubberized grip
<p>Alternative II</p> 	<ol style="list-style-type: none"> 1. The design tool is made of steel plate 2. The design tool is made with a size of 80 cm x 80 cm x 262cm 3. The design tool is painted in gray 4. The design tool has economic life > 4 years 5. The design tool has a square shape 6. The design tool serves to move goods 7. The design tool is given a foamy push handle

Figure 2. Modification alternatives

3.3 Analysis Stage

The process at this analysis stage uses AHP method to give weighting to selection criteria for the design of this aid. A characteristic of operator necessity for this bread production process is based on customer’s voice, namely the trolley rack. It has good design and size as needed, the material used is stronger and sturdy, and trolley frame is made permanent so it is not easily damaged during production process, and the trolley has wheels so that it is easier to push, providing a baking sheet. Assessment of criteria priority determination is carried out through questionnaires containing questions concerning the order of priority level. This is shown in Figure 3. The criteria considered for profit and loss analysis are form design, size design, material type, performance, material costs and ease of obtaining material with the following results:

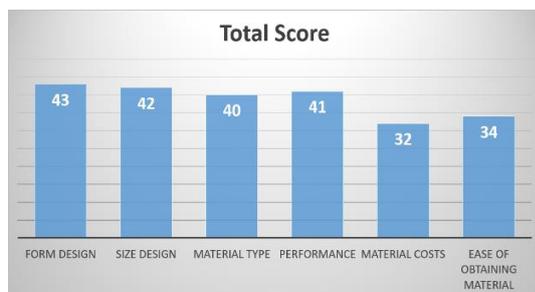


Figure 3. Criteria Priority Determination



Figure 4. Feasibility Assessment Matrix

The evaluation matrix has two alternative modifications and initial design alternative, by converting from verbal language to nominal language on Likert scale. This is shown in Figure 4. The evaluation matrix results of the best ranking alternatives and other modification alternatives as well as initial design, based on questionnaires that have been distributed and filled directly by respondents are as follows in Figure 5.

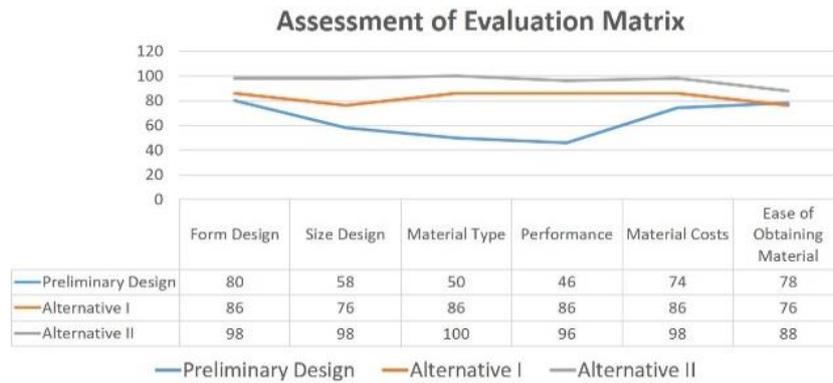


Figure 5. Evaluation Assessment Matrix

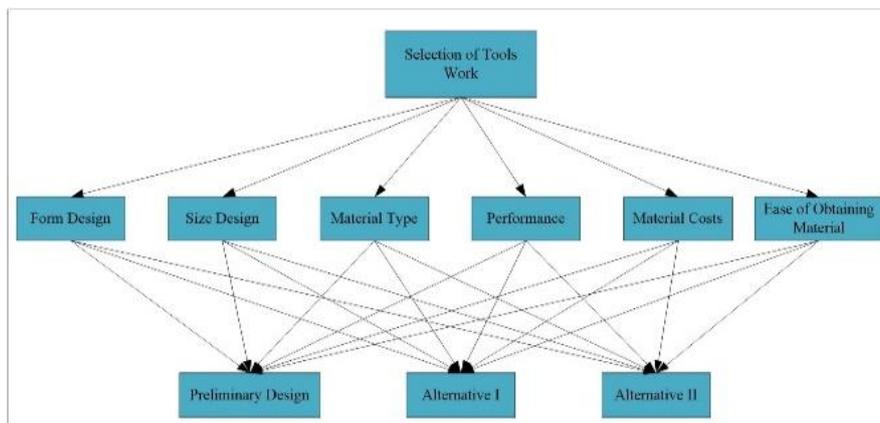


Figure 6. Alternative Selection Hierarchy

Calculation of weighting criteria in modified alternative is conducted to calculate the performance of each criterion based on pairing comparison method in accordance with importance level referring to qualitative scale in the decision support system [14]. Pairing matrix is used to normalize weighting by dividing each entry with the number of columns so that the weight of each criterion (Eigen Vector) is finally obtained. Furthermore, it is determined how well the consistency value of the data is. This is shown in Figure 6. Processing with AHP method uses manual formulation with data sources from questionnaire. Calculation of hierarchical weighting factors for all criteria. This is the results of a combined preference analysis of 10 respondents. After the paired geomean comparison values on the criteria are obtained, then a pairing matrix is made for all criteria as shown in table 2.

Table 2. The Paired Comparison Matrix

Criteria	1	2	3	4	5	6
1	1	1.1161	1.4051	2.2333	2.0939	1.7118
2	0.89605735	1	1.5683	3.8730	1.6438	2.8071
3	0.71169312	0.63763311	1	3.2746	1.6808	1.3904
4	0.44776788	0.25819778	0.30538081	1	3.1958	2.5561
5	0.47757773	0.60834651	0.59495478	0.129107	1	1.9663
6	0.58418039	0.35623954	0.71921749	0.391221	0.0856939	1
Total	4.11727646	3.97651694	5.59295308	11.0850317	10.1228694	11.4317

With the elements in each column divided by the number of columns concerned, the normalized relative weights will be obtained. The value of eigen vector is generated from average relative weights for each row shown in table 3.

Table 3. Priority Matrix for All Criteria

Criteria	1	2	3	4	5	6	Vector Eigen	% Weight
1	0.2428790	0.2806728	0.2512269	0.2014699	0.2068485	0.1497415	0.21504313	21.5
2	0.2176335	0.2514764	0.2804064	0.3493901	0.1623848	0.2455540	0.24405243	24.41
3	0.1728553	0.1603497	0.1787964	0.2954074	0.1660399	0.1216267	0.17730443	17.73
4	0.1087534	0.0649306	0.0546010	0.0902117	0.3157010	0.2235975	0.17426427	17.43
5	0.1159936	0.1529848	0.1063758	0.0282282	0.0987862	0.1720042	0.10524145	10.52
6	0.1418852	0.0895858	0.1285935	0.0352927	0.0502396	0.0874761	0.08409428	8.41
Total	0.1666667	0.1666667	0.1666667	0.1666667	0.1666667	0.1666667	1	100

The maximum eigen value (λ maximum) is shown in table 4.

Table 4. Maximum Eigen Value

Criteria	Sum of Entry	Matrix Priority	λ Max (A/B)
1	1.4900381	0.21504313	6.92901977
2	1.6980303	0.24405243	6.95764554
3	1.3078646	0.17730443	7.37637858
4	0.9389969	0.17426427	5.38835012
5	0.6817816	0.10524145	6.47826118
6	0.5458783	0.08409428	6.49126552
Total			39.6209207
Y Maximum			6.60348678

The consistent index values obtained are:

For n = 6, RI = 1.24 (Saaty table, 1993), then:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} = \frac{(6.6035 - 6)}{(6-1)} = 0.1207 \qquad CR = \frac{CI}{RI} = \frac{0.1207}{1.24} = 0.0973$$

Because CR < 0.100 means that the respondent is consistent.

Performance value calculation for each selected modification alternative and initial alternative through multiplication of the weight obtained for each criterion with the final results obtained from questionnaire is shown in Table 5.

Table 5. Performance Value Calculation

Modification Alternative	Criteria						Pn	Rank
	Form Design	Size Design	Material Type	Material Performance	Material Costs	Ease of Obtaining material		
Weight	0.2150	0.2441	0.1773	0.1743	0.1052	0.0841		
Preliminary Design	80	58	50	46	74	78	63.02	3
Alternative I	86	76	86	86	86	76	83.73	2
Alternative II	98	98	100	96	98	88	97.16	1

3.4 Development Stage

The development stage depends on product performance and the costs spent so value calculation takes performance value when compared to the cost. Calculation of initial design costs is based on costs calculation required in bread production process. Calculation of alternative design cost components is taken from the results of the best alternative design tools selection. Value calculation is based on comparison between performance (Pn) and the costs incurred in making alternative modifications (C)

so performance value of modification design of bread production aid tool is obtained. The value of all alternative design tools for the bread production process is shown in table 6.

Table 6. Modification Alternative Value

Modification Alternative	Pn (Performance)	N	Cn (Cost)	Vn (Value)	Rank
Preliminary Design	63.02	8251	440,000	1	3
Alternative I	83.73	8251	5,000,000	0.38	2
Alternative II	97.16	8251	1,800,0000	0.45	1

3.5 Recommendation Stage

The final results of this stage get the best alternative design, namely alternative II. This is the best alternative tool to help bread production process, compared to other alternatives. Alternative II gets the highest performance value of 97.16 with a value of 0.45. Alternative II gets the best design and has good durability.

4. Conclusion

- Results of the value engineering approach through FAST analysis shows the recommended bread production process tools have the best values based on functional descriptions.
- The criteria that affect the modification tools based on the level of importance are form design (18.53%), size design (18.10%), material type (17.24%), performance (17.67%), material costs (13.79%), and ease of obtaining material (14.66%).
- For selected alternatives shows best weighting criteria: form design size (0.2150), size design (0.2441), material type (0.1773), performance (0.1743), material costs (0.1052), and ease of obtaining material (0.0841).
- The highest performance is obtained by alternative II with a Pn value of 97.16 and Vn value of 0.45.

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