Vertical Sterilizer Design of Building Palm Oil Processing Plant to Cost Efficiency

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Abstract. Research is carried out in the Palm Oil Processing Plant is being built. The establishment of a factory experienced cost problem due to the increasing price of products import. This study describes the application of value engineering to find the highest cost components and alternative designs are able to replace the initial design and the building cost in the factory can be reduced. Vertical sterilizer is known to be the largest cost component followed by the cost of the Valves and Hydraulic System Control Unit. The company is currently designing to replace 4 units vertical sterilizer capacity 10 tons fresh fruit bunches with 3 units vertical sterilizer capacity 15 tons fresh fruit bunches. The change in the quantity and capacity of the vertical sterilizer is followed by a reduction quantity of Control Units c / w Valves and Hydraulic Systems used. As a result of this design change, the initial life cycle cost is IDR 7.531.154.360,- decrease to IDR 6.642.162.754,-. By using value engineering, it is able to make the cost efficiency in a factory about 11.8%.

1. Introduction
Indonesia is the first country in the world's largest palm oil industry. The total land area planted to palm oil in Indonesia has reached 9.7 million hectares [1]. Indonesian country produces around 40-50% of the total world palm oil production. Indonesia is the largest producer and exporter of palm oil and its derivatives. Palm oil is one of the most consumed and produced oils in the world. The palm oil industry as one of Indonesia's leading sectors has a significant contribution to national non-oil and gas exports and every year tends to increase significantly. Indonesia also shows an increasing trend every year with an average increase of 12.97%. This industry contributes US $ 17.6 billion through exports in 2012 [1].

In the long term, the world demand for palm oil shows a tendency to increase in line with the increasing world population. This increase will have an impact on increasing consumption of products with palm oil raw materials. Therefore, companies need to produce value engineering to minimize cost in the development of manufacturing industries [2,3].

Value engineering is one of the techniques applied to analyse the function of an item or process to determine the best value, or the best relationship between worth, resources and cost. The best value is showed by an item or process that consistently performs the required basic function. Value engineering has the lowest life-cycle cost [4]. Value engineering is related to the development of new products or services with an emphasis on the ease and production and delivery costs. While value analysis deals with design modification of existing products or services with the goal of reducing manufacturing costs and product delivery. Value Engineering is currently used in industry particularly in building.
Value Engineering is used to find alternatives or ideas that aim to produce costs are better or lower than previously planned cost with functional limits and work quality [5]. Value engineering can be applied at any time throughout the project duration from the beginning to the completion of the project development until the replacement stage. Value Engineering must begin early in the concept stage and continuously at each stage until the completion of planning [6]. Application of Value Engineering helps in on-going and upcoming construction projects that improve decision-making and leads to optimal expenditure of owner funds. Owner funds directed to meeting required function and quality level [7]. The theory of Value Engineering was introduced into China since 1978. Value engineering has been widely adopted by many companies and has a great effect on economic benefits. 35 years practice experience, the theory and methodology of Value Engineering has been recognized by the many sector especially to academic community, business circles, which has been one of the significant methods to improve product quality and cost reduction [8].

Research on the benefits of value engineering application to costs minimization has been done previously. VE can be used in manufacturing sectors such as bridge construction and various economic activity development processes are aimed at consumer-oriented [9]. Value engineering has been used at drainage project discussed to assess the initial design of the stream viewed from the cost budget plan. Next to find out whether the alternative design is required, find out the ideal alternative design, and get a comparison between the initial design and the alternative design. After comparison between initial design and some alternative design, it is known that alternative designs that can be recommended are the smallest costs alternative while maintaining the main function. [10]. The same research was also carried out by Amruta Chougale, A.K. Gupta and Sneha Patil that presented a cost minimization of residential building is having more cost on existing and the comparing cost from actual and recommendation of the lowest cost of building [11].

Researches about value engineering have been done before, especially in the construction sector. However, there are still few studies discuss of value engineering that applied to manufacturing industries, especially in the Palm Oil Processing Plant. Value engineering carried out in the manufacturing industry is used to obtain alternative design machines and equipment used for the production process. In Palm Oil Processing Plant, plant start-up costs mostly come from bank loans, and the rest of the owners. Increasing interest rates and declining rupiah exchange rate in US dollar have resulted in increased building costs. Value engineering aims to find alternative designs is able to minimize costs without changing the main functions that the company expected. This paper will discuss the changes in the vertical sterilizer design and Sterilizer Valves and Hydraulic System Control Unit as an alternative to reduce the building cost in palm oil processing plant.

2. Methodology
The study was conducted at one of the palm oil processing plants are being built. Value Engineering is a solution method to the problem of specific engineering, science, expert teams, creative approach organized. Value engineering aim is to define and eliminate costs that are not needed as costs that do not contribute to the quality, usability, age, and the appearance of the product and the consumer appeal. To use the value engineering method, five stages are generally used, namely the information stage, the creative stage, the evaluation stage, the development stage and the presentation stage. Assessment in value engineering has standard methodology and the tools used to study that can be seen in Figure 1.

The first stage is information which is collecting project information including the structure, functions, and costs of the object being studied. The function analysis phase is done by analyzing the primary and secondary functions of basic design. The creative stage is to develop possible alternatives to fulfill primary and secondary functions. Next step is evaluating the alternatives that have been formed and selects the best alternatives based on costs and changes to functions. The development phase is done by perfecting and adjusting to selected alternatives. The final stage is presentation and recommendations. This stage explains the results of team work to management and answers the questions about which alternative is best, what are the influences of developing alternative ideas, how much they cost, and how they are performed.
3. Result and Discussion

3.1. Building Information

Information collection about project data in general such as, project type, name, location, project scope, and project costs. The research was carried out on the building cost of a Palm Oil Processing Plant into Crude Palm Oil and Palm Kernel, located in Pekan Baru, Riau. The palm oil processing plant is planned to process 40 tons of fresh fruit bunches in one hour. The following is a summary of the building cost in Palm Oil Processing Plant.

![Summary of Project Cost](image)

**Figure 1. Stage of Value Engineering [12]**

**Figure 2 Summary of Project Cost**
Figure 1 shows the costs amount that will be spend to build a Palm Oil Processing Plant for a 40 tons capacity of fresh fruit bunches per hour.

3.2. Pareto Analysis
Pareto analysis is used to find out high-cost items that consume most of the budget plan. The Pareto principle states that 80% of the highest total costs occur in 20% of work activities. Pareto diagram of the work on building cost of a palm oil processing plant can be seen in Figure 3.

Based on the results of high costs identification, it shows as many as 4 work items that spend almost 80% of the total cost, namely Vertical Sterilizer 10 T FFB, Sterilizer Control Unit Valves and Hydraulic System, Inclined FFB Conveyor W 800 mm, and Fruit Loading Ramp 5 Door. Based on the high cost analysis above, two items of work that spend the highest cost chosen are Vertical Sterilizer 10 T FFB and Sterilizer Control Unit Valves and Hydraulic System, to do a function analysis at the investigation stage.

The investigation was carried out by analyzing the functions of the vertical sterilizer and sterilizer control unit. Vertical Sterilizer is Steam pressure Vessel upright secondary shaped used to boil fresh fruit bunches. Sterilizer Control System serves to control the boiling process, which is opening and closing the door to the entry of fresh fruit bunches when boiled and opening-closing the door to the expenditure of fresh fruit bunches. Sterilizer Control System consist of controllers that can be programmed in a Programmable logic Control and hydraulic system. This system can be operated in full-automatic and semi-automatic. The vapor pressure in the stew and the boiling cycle time is controlled by this system.

3.3. Alternative Design
At the creative stage brainstorming is carried out with experts and stakeholders. This creative stage aims to reduce the quantity of ideas that must be generally identified to a short list of ideas with great potential to reduce the cost of building coat in Palm Oil Processing Plant. At the evaluation stage, an analysis of the advantages and disadvantages is carried out to get the most appropriate alternative. One design alternative that is possible to minimize the building cost in Palm Oil Processing Plant is to replace Vertical Sterilizers with a 10 tons capacity of fresh fruit bunches of 4 units with a Vertical Sterilizer
with a 15 tons capacity of 3 units. Changes in the quantity of vertical sterilizers will also have an impact on reducing the quantity of Sterilizer Control Unit Valves and Hydraulic Systems.

3.4. Analysis of Life Cycle Cost
Life Cycle Cost is a technique to analyze economically by calculating all relevant costs during the investment period at the time value of money. LCC analysis is based on the assumption of project economic life (\(n\)) 10 years, interest value (\(i\)) of 13%, and annual maintenance costs of 6% of the work value. Changes in the design of vertical sterilizers and sterilizer control units do not affect the other cost items. The cost calculation is only focused on the vertical sterilizer and sterilizer control unit. The following is a comparison of the actual cycle cost of the actual design and using alternative design.

| Table 1. Comparison of Basic and Alternative Design Cost |
|---------------------------------------------------------|
| NO | DESCRIPTION | BASIC DESIGN (IDR) | Alternative (IDR) |
|----|-------------|--------------------|------------------|
| 1. | Construction Cost of Vertical Sterilizer | 4,364,160,000 | 3,886,920,000 |
| 2. | Redesign Cost of Vertical Sterilizer | | 85,000,000 |
| 3. | Construction Cost of Sterilizer Control Unit | 1,424,040,000 | 1,068,030,000 |
| 4. | Redesign Cost of Sterilizer Control Unit | | 65,000,000 |
| 5. | Total Initial Cost/IC (1+2+3+4) | 5,788,200,000 | 5,104,950,000 |
| 6. | Annual Maintenance Cost (6% of Total initial cost) | 347,292,000 | 306,297,000 |
| 7. | Present value of maintenance cost by \(n=10\) and \(i=15\%\) (5,0187) | 1,742,954.360 | 1,537,212.754 |
| 8. | Total Cost Present Value (5+7) | 7,531,154.360 | 6,642,162.754 |

In calculation of the life cycle cost, replacement cost, savage cost and operation cost items are not considered. The absence of a replacement cost is because because of the planned 10 years there has been no design change. Savage cost and operational cost are considered non-existent because the estimated operational costs and residual values at the end of the project are the same for the initial design and alternative design.

3.5. Analysis of Cost per Worth
Value engineering analysis is able to provide input in the lowest cost determination to carry out functions, and provide information about costs that can be reduced and eliminated without affecting performance or constraints. Table 2 shows an analysis of cost per worth to see whether the alternatives offered are feasible to apply.

| Table 2. Cost per Worth Analysis |
|---------------------------------|
| NO | DESCRIPTION | BASIC DESIGN (IDR) | Alternative (IDR) | C/W | Summary |
|----|-------------|--------------------|------------------|-----|---------|
| 1. | Construction Cost of Vertical Sterilizer | 4,364,160,000 | 3,886,920,000 | 1,122 | Worth |
| 2. | Construction Cost of Sterilizer Control Unit | 1,424,040,000 | 1,068,030,000 | 1,330 | Worth |
| Total | | 5,788,200,000 | 5,104,950,000 | 1,134 | Worth |
The main objective in building this palm oil processing plant is to be able to process 40 tons of fresh fruit bunches per hour. Utility value gives an value indication. Value indication means the lowest cost needed for the implementation of a specific function. Utility value is used as a tutorial to identify areas with potential and important savings to the high value objective [12].

Based on the life cycle cost analysis and cost per worth analysis, it is known that the alternate offered is feasible. Design of actual 4 units Vertical Sterilizer 10 tons FFB and 4 units Sterilizer Control Unit Valves and Hydraulic System requires a cost of IDR 7,531,154,360,-. While the alternative design is it can be replaced with 3 units Vertical Sterilizer 15 tons FFB and 3 units Sterilizer Control Unit Valves and Hydraulic System requires a large cost of IDR 6,642,162,754,-. There is a reduction in costs by value engineering application [7,12]. The recommendation offered is to apply an alternative design 3 units Vertical Sterilizer of 15 tons FFB and 3 units Sterilizer Control Unit Valves and Hydraulic Systems due to able of the efficiency costs up to 11,8%.

4. Conclusion
With value engineering, it is known that the cost of vertical sterilizer and sterilizer control unit is the largest cost item with cost of 41,06% and 13,40%. Therefore, in the design of actual 4 units Vertical Sterilizer of 10 tons FFB and 4 units Sterilizer Control Valves and Hydraulic System Units can be replaced with 3 units Vertical Sterilizer of 15 tons FFB and 3 units Sterilizer Control Unit Valves and Hydraulic Systems. The replacement for replacing the vertical sterilizer and Sterilizer Control Unit is known to save costs by 11,8%.

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