Identification and Analysis of Influence of Quality Costs on the Percentage of Damaged Cans (A Case Study in PT Margo Redjo, Yogyakarta)

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ABSTRACT

In the present study, quality cost elements, such as: prevention cost including the prevention costs during can exhausting, seaming and sterilization; appraisal costs including the appraisal cost during can seaming, sterilization and product quality control; internal failure costs including rework costs and those due to thrown away product, are identified to obtain normal or undamaged (not inflating, croocked, and leak) can quality. Whereas the external failure cost is assumed to be inexist.

The result of the research shows that the index of quality cost of Margo Redjo mushroom canning factory during 1997 has tended to decrease. For every Rp1.000.000,00 increase in prevention cost cause the percentage of the buckled can to decrease in exhausting phase (1,29%), in can seaming phase (9,78%), in sterilization (1,03%), and in cost or wage for quality control manager (2,94%). Whereas for every Rp.1.000.000,00 increase in appraisal cost during the can seaming will increase the damaged can to 1,73%. This shows that the increase in final product for the appraisal causes the rework cost to increase. The appraisal of the final product as fire fighting action is not capable of improving the damaged can percentage. The most influential quality cost element for the damaged can is the prevention cost during the can seaming phase (48,83%), QC manager salary (24,45%), appraisal cost during sterilization and final product quality control (22,60%) appraisal cost during the can seaming phase (20,14%), and prevention cost during the sterilization phase (17,64%). The optimum quality cost is obtained at Rp11.538.461,00 with the percentage of damaged can of 2,3%. This amount of quality cost gives the company to avoid the damaged can to 17%.

INTRODUCTION

To face the economy globalization in 2000, every company should excell in winning every competition. Therefore, a key to obtain new markets and to keep the existing markets is by maintaining and increasing the product quality as expected by the customers and by decreasing the existing production cost. This will inhibit the new entry and even defeat the existing companies.

Nowadays there are more and more companies in our country realising the importance of quality and they endeavor hard to control the quality of their products. Quality control needs a certain amount of cost. Since its first introduction by Armand V Feigenbaum in 1956, the cost measurement and control have become the important elements in company's accounting system. Therefore, it is important to understand the concept of cost in quality control in order to be able to decide the quality level that is capable of giving maximum benefit. Sometimes companies (producers) have a limitation in deciding its product quality because they have a goal of obtaining the equlibrium between the cost incurred and certain quality obtained to give the most benefit of their selling. This also means to obtain the optimum productivity. Thus the ballance between quality increase and productivity will be obtained.

This is also the case in PT Margo Redjo, an agriculture industry in mushroom cannery. Most of its product (85-95%) is exported. In production, the factory decided

the requirements on the quality of the canned mushroom including physical, chemical, and microbiological requirements. Certainly, in quality control the factory incurs a lot of money. To date, the factory has not carried out the analysis on quality cost. In the company financial report, the costs related to the handling of quality problem has been joined in the monthly financial report. Therefore, it is urgent that the quality cost be conducted in the company.

According to Feigenbaum (1992), quality cost is defined as the costs related to defining, creating, and controlling of quality and the evaluation and feedback of conformity with quality requirement, reliability and safety and the costs related to the result of failure to meet the requirements in the company or in the customers' side.

Besterfield (1990) notes that quality cost is the most important managerial tools because it is: 1) a method to evaluate the effectiveness of quality control program, 2) a method to decide the problem scope and action priority, 3) a technique to get the optimal ammount of business, and 4) information to decide the product price.

Gasperz (1992) has defined Quality Cost into two major categories, which are control costs and faliure costs. Control costs consist of prevention costs and appraisal costs. Failures cost consist of internal failure costs and external failure costs.

The American Society for Quality Control has defined four major categories for quality costs, which include prevention, apraisal, internal failure and external failure costs.

Prevention costs are the costs incurred for planning, implementing and maintaining a quality system. They include salaries and developmental costs for product design, process and equipment design, process control techniques, information system design and other costs associated with making the product right in the first time.

Appraisal cost are the cost incurred for measuring, evaluating or auditing products, component or purchased materials to determine compliance to requirement or specified standards. Appraisal costs typically occur during or after production but before the product are released to market or customers.

Internal failure costs are the costs incurred when products or services fail to meet quality requirement prior to the transfer of ownership to the customers. Internal failure costs include scrap and rework costs (all cost required to correct or replace incorrect or incomplete product or service description, they may include mate-

rials, labors and overhead associated with production). Internal failure cost would disappeared if there were no nonconformities in the products.

External failure costs are the cost incurred when product does not perform satisfactorily after ownership or tranferred to the customers. They include all costs due to defective or suspected defective products. They consist of warranty, claims or costs, costs due to customer complains, returned goods, liability costs, retroit and recall costs, penalties, consumer goodwill and losts sales.

From various type of quality cost elements above, it can be understood that if quality control system is less effective, the cost will be very high. Therefore, the control efforts should be based on the minimum level of total cost. The control efforts and quality cost has a relationship as depicted in Figure 1.
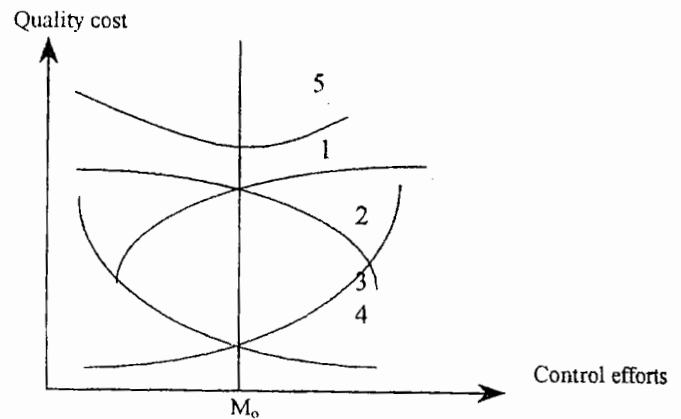

Figur 1. The Relationship between Control Efforts and Quality Cost Source: Gaspersz (1992)

where:
1 = prevention cost curve
2 = appraisal cost curve
3 = internal failure cost curve
4 = external failure cost curve
5 = total quality control cost curve
M_o = optimum control effort.

Juran notes that the structure of quality cost is influenced most by the interaction among the four quality costs above. The relationship when it is plotted will become a U-shaped total quality cost curve (Figure 2). It is suggested that the management find the proper quality level so that the total quality cost will be minimized.
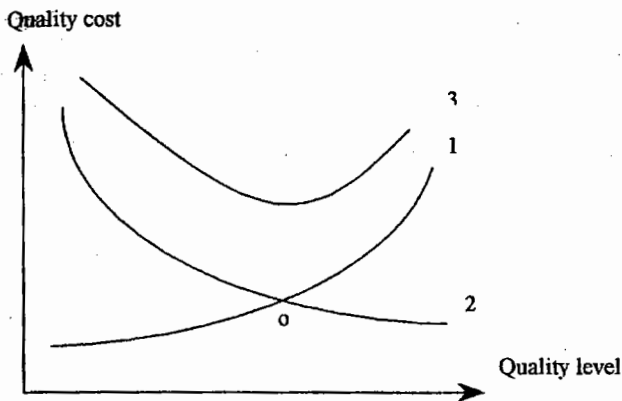
Figure 2. **The relationship between Quality Level and Quality Cost Source: Juran (1989).**

where:
1 = control cost (prevention and appraisal costs) curve
2 = (internal and external) failure cost curve
3 = total quality cost curve
o = optimum point.

Whereas the prediction on the trend in quality cost as a function of time by the American Society for Quality Control can be obtained in Figure 3 as follows:
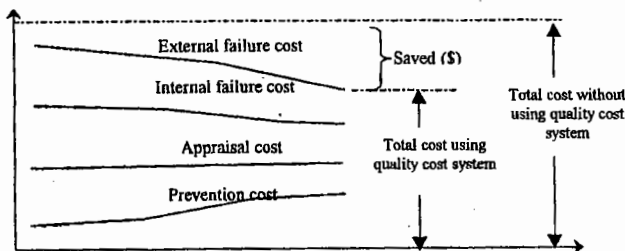

Figure 3. **The Prediction on the Trend in Quality Cost as a Function of Time. Source: The American Society for Quality Control (1971).**

A base that is capable of relating the quality cost to some conditions is required to measure the quality cost. To compare the quality cost from period to period, the amount of the quality cost may change due to the change of some conditions. As already understood, the number of production unit may change from time to time so that it causes the change in employee and material costs. Thus, the total cost cannot be compared. To overcome this condition, there are some basic indeces used to measure the quality cost, as stated by Amitava (1993) and Besterfield (1990), such as labor base index, cost base index, sales base index, and unit base index.

MATERIALS AND METHODS

Data Gathering Method

To date, the factory has not conducted the quality cost analysis yet. In the financial report of the company, the costs related to the handling of quality problem is included in the monthly financial report. Therefore, the data used in this study was obtained from:

– the data at the quality assurance department, including the realization of quality control in the factory
– the financial data, including the costs incurred to achieve the stated quality (prevention cost, appraisal cost, internal damage cost) and net sale of the company.
– the data at the production department, including production process, product damage, and rework.

Where the external damage data are supposed to be inexistent because of the inavailability of data on the number of product returned, cost to handle customer feedback related to the product quality.

Data Analysis

The type of data analysis penformed were:

1. Multiple Linear Regression Analysis

The regression analysis was used to decide the relationship between two or more variables. Generally the multiple regression model is:

$Y = f(xi)$, where $i = 1, 2, \ldots \ldots i$

In the present study, the multiple linear regression analysis is used to examine to what extent is the influnece of the independent variables xi on the dependent variable Y, where:
the regression model:

$$Y_i = \beta_o + \beta_1 X_{1i} + \ldots \beta_p X_{pi}, i = 1, 2, \ldots n$$

2. Partial Correlation Coefficient Analysis

This analysis was used to examine the pure relationship between each independent variabel (x_i) and the dependent variable Y. In this case, the partial corelation coefficient occurs when there are more than two random variables.

Generally, the formula for the partial correlation coefficient between two variables, controlled by a third variable ($r_{12\ldots3}$) is:

$$r_{12.3} = \frac{r_{12} - r_{13}r_{23}}{[(1-r_{13}^2)(1-r_{2.3}^2)]}$$

Optimum Quality Cost Analysis

Steps to be completed are as follows:

a). Make the control cost curve equation

The control curve equation may be assumed as a quadratic equation of the form:

$$Y = ax^2 + bx + c$$

The independent variable is x (control cost) and the dependent variable is Y (the damaged can percentage).

b). Make the failure cost curve equation

This equation was assumed as a hyperbolic equation of the form:

$$Y = a + bx^{-1}$$

The independent variable is x (internal failure cost) and the dependent variable is Y (damaged can percentage).

c). Calculate the optimum quality cost

This cost was obtained from the intersection between the control cost and the failure cost curve. The similar result may be obtained from the first derivative of the total quality cost equation. The total quality cost is the sum of the control cost and the failure cost.

RESULTS AND DISCUSSION

To identify the quality cost elements to obtain a normal criteria of the can condition quality, first, the authors identified the process phase influencing the damaged can condition. Whereas the process phases influencing the damaged can conditions were brinning and exhausting, seaming, and sterilization.

Brinning and Exhausting

Brinning is a process of filling salt solution. This solution in a can will accelerate the heat penetration at sterilization, decrease can corrosion, and make the can become not easily damaged due to light collision at handling.

Air exhausting is a proces of removing product air and gas (in this case, due to the mushroom) from the can before seaming the can. The formed vacuum may prevent the product from chemical changes, such as vitamin C oxidation by fat, color change of the product, and corosion or othres (Lopez, 1975). The quality costs that may arise during this phase are:

a. Prevention cost

This cost includes direct labor/operator cost in controlling the phase process of brinning and exhausting. This operator should ascertain that exhausting has been perfectly carried out. When the optimal temperature at the exhaust box is not obtained, the operator should stop the exhausting process for a while waiting for the desired temperataure. The operator should also pay attention to the head space of the can before it is forwarded to the seaming phase. Other prevention cost is water and salt cost for brinning.

b. Appraisal cost

There is no appraisal cost during this phase.

Seaming phase

Imperfect seaming causes water to enter into the can during sterilization process and allows microbes to grow so that the quality cost will include.

a. Prevention cost

This cost includes direct labor/operator cost for seaming the cans and the cans used to experiment the seaming.

b. Appraisal cost

This cost includes cost or wage for the quality control of can seaming, tools and evaluation forms and cans and the cost incurred for seam quality testing. The appraisal and evaluation of seam was conducted using two methods. i.e., visual observation (non-destructive) and physical observation (destructive). The visual observation was conducted, such as sharp seam, cut over, droop, sharp vee or lip, false seam, deadhead or spinner, knock down flange, mismatch and body buckle.

Sterlilization and final product quality control phase

During this phase the quality costs are as follows:

a. Prevention cost

This cost includes the cost for direct labor/operator at the sterilization phase. They should make sure that the sterilization process has been done properly complying with the standard. The role of the

direct worker/operator is important, especially when the sterilization process is approaching the final phase, the pressure in the can increases. This high pressure is ballanced with the vapor pressure at retort. If the pressure at retort is decreased by releasing the vapor, the the top of the can will suffer a high pressure difference that is too high for the can ends to indure, so that the can ends will distort permanently, called buckle. This distortion may cause leak during freezing and the cans will be damaged. Thus, the operator/supervisor role during the sterilization process is important, therefore the prevention cost in the form of cost or salary for the operator/supervisor of the sterilization process is inevitable. Other prevention cost is water used to the sterilization process.

b. Appraisal cost

This cost includes the cost or salary for the direct labor/supervisor of the sterilization process (the calculation is based on the time percentage used to make the appraisal on the sterilization process multiplied by the salary or income at the current month), the salary for the final product quality control, the cost incurred in relation with all examination of the final product (such as appraisal instruments and forms), and the cost incurred to test the quality of the final product.

Beside the prevention and appraisal costs during the above processes, the control cost that should not be underestimated is the cost or salary for the Quality Control manager. He/she has full responsibility for the quality and any deviation. The other quality cost is the internal failure cost. This cost includes the cost that should be incurred due to the rework of the product or the thrown-away product and other minor damages. Whereas the thrown-away product is the inflating product during incubation period (ten days).

Quality Cost Index

The quality cost index is used to examine the trend in the quality cost incurred from time to time. In the present study, the quality cost index is used using sale income basis. The advantage of this method is that the data is available and it is easily understandable. For the top level management, this method can be used as the input for decision making.

Figur 4 (Quality Cost Index Graph) illustrates the decreasing trend in the quality cost index. This is because the amount of sale income in PT Margo Redjo

experienced a big increase due to the weakening of rupiah currency. As already understood, because PT Margo Redjo is export oriented, its sale income is received as foreign currency (US dollar). Although the quality cost incurred increased, the increase of the quality cost was not as high as the increase in sale income. Thus, the quality cost index using sale income base shows a decreasing trend since July 1997.
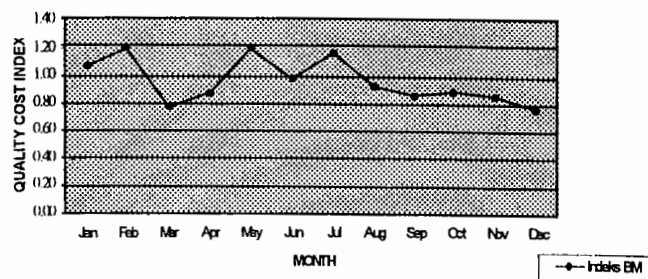

Figure 4. **Trend of Quality Cost Index during 1997.**

Quality Cost Analysis

a. Multiple Linear Regression Analysis

From the multiple regression analysis the following estimation regression equation is obtained.

$$Y = -1,29.10^{-6}x_1 - 9,78.10^{-6}x_2 - 1,03.10^{-6}x_3 - 1,73.10^{-6}x_4 + 2,42.10^{-6}x_5 - 2,94.10^{-6}x_6 + 17,64$$

where:
Y = damaged can percentage
x_1 = prevention cost during exhausting phase
x_2 = prevention cost during can seaming phase
x_3 = prevention cost during sterilization phase
x_4 = appraisal cost during can seaming phase
x_5 = appraisal cost during sterilization and final product quality control
x_6 = cost or salary for quality control manager.

From the above regression equation, it is revealed that if the company did not incur the control cost, then the damaged can would be 17,64%. Besides, it can also be shown that the relationship between the independent variables (xi) and the dependent variable Y (damaged can percentage) has positive and negative correlation. The negative correlation has significance that the increase of 1 unit in variable x_i will cause the decrease in Y to the

amount of its regression coefficient. Whereas the positive correlation has significance that the increase of 1 unit in variable x_i will cause the increase in Y to the amount of its regression coefficient. Whereas the positive correlation has significance that the increase of 1 unit in variable x_i will cause the increase in Y to the amount of its regression coefficient. The negative correlations are shown by variable x_1, x_2, x_3, x_4, and x_6. Whereas the positive correlation is shown by variable x_5.

Table 1. **The Influence of Increase of Rp1,00 in Variable Xi on Y.**

Variable (Xi)	ΔY	
x_1 (prevention cost during exhausting phase)	Decrease $1,29.10^{-6}$%	Other variables are constant
x_2 (prevention cost during can seaming phase)	Decrease $9,78.10^{-6}$%	
x_3 (prevention cost during sterilization phase)	Decrease $1,03.10^{-6}$%	
	Decrease $1,73.10^{-6}$%	
x_4 (appraisal cost during can seaming phase)	Increase $2,42.10^{-6}$%	
x_5 (appraisal cost during sterilization and final product quality control)	Decrease $2,94.10^{-6}$%	
x_6 (cost or salary for quality control manager)		

From the above result, it is obvious that there is unsuitability in x_5 where the increase of Rp1,00 will cause the percentage of damaged can to $2,42.10^{-6}$% (Table 1). Generally, the increase in the cost should increase the quality level (in this case, decrease the percentage of damaged can) but the contrary occurs. This may arise because at the present time the appraisal cost during the sterilization and product quality control phase has achieved its optimum level. When the number of final product for the appraisal is added, this action would not be able to improve or decrease the condition of the damaged can but even this will cause the cost for rework to increase.

To obtain the performance of the damaged can equals zero percent, using the regesion equation it can be predicted (randomly with one of the data) that the condition will be obtained when the company increases:

* prevention cost during exhausting phase (assuming that other vaiables are constant or other costs are constant) to Rp2.519.379,84

* prevention cost during the can seaming phase (assuming that other costs remain constant) to Rp332.310,83
* prevention cost during the sterilization phase (assuming that other costs remain constant) to Rp3.155.339,81
* appraisal cost during the can seaming phase (assuming that other costs remain constant) to Rp1.878.615,72
* quality control salary or cost (assuming that other costs remain constant) to Rp1.144.366,20.

From the above result, it can be shown that to obtain the performance of the damaged can equals zero percent, the cost that should be incurred will be very high -- the company should increase its control cost to 31-248% from the present cost. Therefore, the optimum cost analysis is needed in order to obtaine the ballance between the quality cost and the performance of the company. Using F-test with the confidence level = 95% (α = 5%), F_{calc} = 22,85 and F_{table} = 4,95; and $F_{calc} > F_{table}$, therefore, Ho is rejected. This means that all variables xi are significant and have influence on the percentage of the damaged can. The multiple determination coefficien R^2 = 0,7433 means that the influence of xi (x_1, x_2, x_3, x_4, x_5 and x_6) altogether is 74,33%.

b. Partial Corelation Analysis

Using partial corelation analysis pure relations between variable xi and Y can be obtained. The result is as follows:

Table 2. **Partial Corelation between Variable Xi and Y.**

Variable (Xi)	Correlation
x_1 (prevention cost during exhausting phase)	18,57 %
x_2 (prevention cost during can seaming phase)	48,83 %
x_3 (prevention cost during sterilization phase)	17,64 %
x_4 (appraisal cost during can seaming phase)	20,14 %
x_5 (appraisal cost during sterilization and final product quality control)	22,60 %
x_6 (cost or salary for quality control manager)	24,45 %

c. Optimum Quality Cost Analysis

Using SPSS computer program, the estimation of control cost equation is obtained. The complete equation can be written:

$$Y = 9,1.10^{-14} x^2 - 2.10^{-6}x + 18,45$$

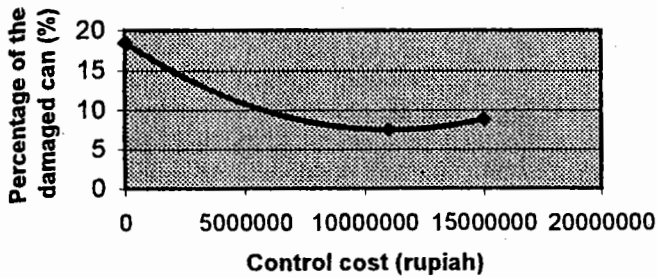The curve of control cost is illustrated in Figure 5.

Figure 5. Curve of Control Cost.

From the above graph/equation, it can be shown that the increase with no control cost results in the damaged can of 18,45%; simultaneously, the increase of control cost will decrease the percentage of the damaged can but at a certain condition the increase of the control cost will not decrease the damaged can any longer, on the contrary, it even increases the damaged can.

Using the SPSS program, the estimation of failure cost equation is obtained. The complete equation can be written as follows:

$$Y = 5862399 - 6.10^6 x^{-1}$$

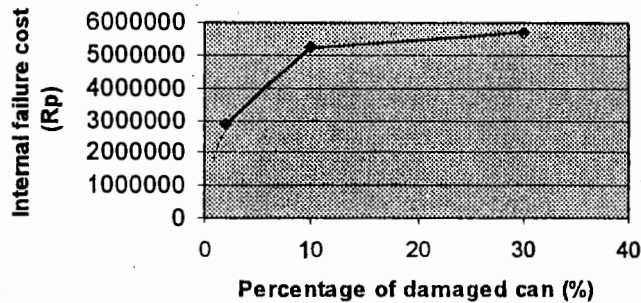The curve of the internal cost is represented in Figure 6.

Figure 6. Curve of Internal Failure Cost.

From the above equation/graph it can be shown that the failure cost curve is not linear. Initially, this cost increases sharply with the increase of the percentage of damaged can, but later it will tend to become stable. When there are some damaged cans not caused by microbe, the company will choose to rework rather than to directly throw them away. In case of small number (low percentage) of damaged cans, the rework cost per per unit will be higher than that for big number. However, at a certain condition when there is a high number of cans that should be reworked, the rework cost per can will give no significant difference. The company is also limited in finance to rework the damaged can.

Optimum quality cost calculation

Theoritically, the optimum quality cost can be obtained by intersecting the control cost and failure cost curve. This can also be obtained by first-deriving the total quality cost equation. The total quality cost is the sum of the control cost and failure cost. In the present study, the optimum quality cost is obtained by first-deriving the total quality cost equation.

The complete equation of the total quality cost may be written as follows:

$$Y = 1,3.10^{-13} x^2 - 3.10^{-6} x + 19,61$$

The curve of the total quality cost is illustrated in Figure 7.
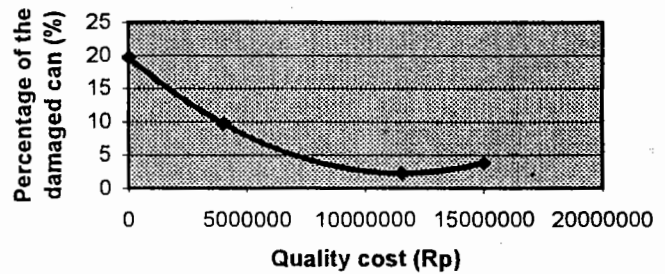

Figure 7. Curve of total Quality Cost.

From the figure and the calculation result, the optimum quality cost is obtained at the level or percentage of damaged can of 2,30%, i.e., Rp11.538.461,00. Figure 8 shows the comparison between the incurred (actual) and optimal quality cost. It can be shown that in 1997 the actual quality cost has been getting better and better (approaching the optimum value) from month to month. Nevertheless, the company should always increase the performance of its present quality control, especially to achieve the normal can quality criteria.
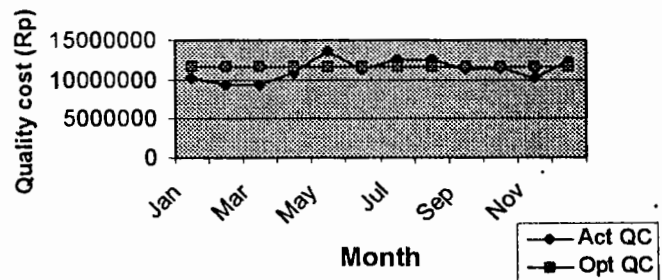

Figure 8. Comparison Between Actual and Optimal Quality Cost.

CONCLUSION

Using the normal can quality criteria (good and undamaged), the quality cost may be defined as: (a) Prevention cost, (including the cost incurred during exhausting, seaming, and sterilization phase), (b) Appraisal cost, (including the cost incurred during seaming, sterilization, and end product quality control phase), (c) Cost or salary for the quality control manager, and (d) Internal failure cost, including the cost incurred for reworking and for thrown-away product.

The index of quality cost based on the sale income shows the decreasing trend. This is because the number of sale income in PT Margo Redjo Experiences the increase more than the increase in the quality cost incurred. Using the multiple regression analysis, it can be shown that there are positive and negative relationships between the quality cost elements and the percentage of damaged can.

Using the partial corelation analysis, it can be shown that corelation or pure relationship between:

* the independent variable x_1 (prevention cost during exhausting phase) and the dependent variable Y (percentage of damaged can) is 18,57%.
* the independent variable x_2 (prevention cost during seaming phase) and the dependent variable Y (percentage of damaged can) is 48,83%.
* the independent variable x_3 (prevention cost during sterilization phase) and the dependent variable Y (percentage of damaged can) is 17,64%.
* the independent variable x_4 (appraisal cost during seaming phase) and the dependent variable Y (percentage of damaged can) is 20,14%.
* the independent variable x_5 (appraisal cost during sterilization and endproduct quality control phase) and the dependent variable Y (percentage of damaged can) is 22,60%.
* the independent variable x_6 (cost or salary for quality control manager) and the dependent variable Y (percentage of damaged can) is 24,45%.

Based on the company data in 1997, the optimum quality cost is achieved at Rp11.538.461,00 with the percentage of damaged can of 2,3%.

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